Features New Tools for Analyzing, Valuing, and Managing Fixed Income Instruments

THE HANDBOOK OF FIXED INCOME SECURITIES

EIGHTH EDITION

EDITED BY

Frank J. Fabozzi

PROFESSOR OF FINANCE, EDHEC BUSINESS SCHOOL

WITH STEVEN V. MANN

THE HANDBOOK OF FIXED INCOME SECURITIES

Eighth Edition

FRANK J. FABOZZI, Ph.D., CFA, CPA

Editor

With the assistance of

STEVEN V. MANN, Ph.D.

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PREFACE

This book is designed to provide extensive coverage of the wide range of fixed income products and fixed income portfolio management strategies. Each chapter is written by an authority on the subject.

The eighth edition of the *Handbook* is divided into ten parts. Part One provides general information about the investment features of fixed income securities, the risks associated with investing in fixed income securities, and background information about fixed income primary and secondary markets. The basics of fixed income analytics—bond pricing, yield measures, spot rates, forward rates, total return, and price volatility measures (duration and convexity)—are also described in Part One.

Parts Two and Three cover the basic characteristics of the instruments traded in the market. Government securities and corporate debt obligations (both bonds and loans) are covered in Part Two. An important addition to the eighth edition is more extensive coverage of leveraged loans and covered bonds, as well as coverage of fixed income exchange traded funds. Part Three focuses on securitized products—mortgage-backed securities and asset-backed securities. The coverage of the nonagency residential mortgage-backed securities and commercial mortgage-backed securities reflects market developments that followed the subprime mortgage crisis in 2007. Unlike the seventh edition, this edition includes separate chapters on planned amortization class bonds, support bonds, accrual (Z) bonds, and stripped mortgage-backed securities.

The focus in Part Four is on the term structure of interest rates, both the use of the information contained in those rates and the modeling of the term structure.

Part Five builds on the analytical framework explained in Part One. In this part, two methodologies for valuing fixed income securities are discussed: the lattice model and the Monte Carlo model. A by-product of these models is the option-adjusted spread. The valuation of convertible bonds is also covered in this part.

The topic of credit risk and its analysis is the subject of Part Six. Traditional methods of credit analysis for corporate bonds and municipal bonds are explained and illustrated. There is also coverage of the various approaches to credit risk modeling.

Multifactor risk models and their applications are explained in Part Seven. The more popular fixed income portfolio management strategies are covered in Part Eight. A framework for classifying the types of bond portfolio strategies is provided in the first chapter in Part Eight, Chapter 49. There is then coverage of quantitative management strategies versus a benchmark, global credit bond portfolio management, high-yield bond portfolio management, international bond portfolio management, and investing in distressed structured credit securities. In addition, there are several specialized chapters related to bond portfolios strategies, such as transition management and financing positions in the bond market, and hedge fund strategies.

Part Nine covers derivative instruments: interest-rate derivatives (futures/forward contracts, options, interest-rate swaps, and caps and floors) and credit derivatives (primarily credit default swaps). The basic feature of each instrument is described as well as how it is valued and used to control the risk of a fixed income portfolio. The basics of credit derivatives are also explained.

Performance evaluation and return attribution analysis are covered in the last three chapters of the *Handbook* in Part Ten. Coverage includes how these models are built and used, as well as the underlying principles in building these models.

There is one appendix that covers the various methodologies for calculating currency exposures in bond portfolios and the major international bond indexes.

Revisions to the Seventh Edition

The eighth edition is a substantial revision over the seventh edition. The seventh edition had 60 chapters and an appendix. The eighth edition has 71 chapters and one appendix. The following 31 chapters (as well as the appendix) are new:

4 Electronic Trading for the Fixed Income Market
5 Macro-Economic Dynamics and the Corporate Bond Market
10 Agency Debt Securities
13 Leveraged Loans
15 Structured Notes and Credit-Linked Notes
21 Fixed Income Exchange Traded Funds
22 Covered Bonds
27 The Effect of Agency CMO PAC Bond Features on Performance
28 Agency CMO Z-Bonds
29 Support Bonds with Schedules in Agency CMO Deals
30 Stripped Mortgage-Backed Securities
31 Nonagency Residential Mortgage-Backed Securities
32 Commercial Mortgage-Backed Securities
34 Securities Backed by Auto Loans and Leases, Equipment Loans and Leases, and Student Loans

35 Collateralized Loan Obligations
38 Empirical Yield-Curve Dynamics and Yield-Curve Exposure
39 Term Structure Modeling with No-Arbitrage Interest Rate Models
46 Introduction to Multifactor Risk Models in Fixed Income and Their Applications
47 Analyzing Risk from Multifactor Fixed Income Models
52 Elements of Managing a High-Yield Bond Portfolio
55 Managing the Spread Risk of Credit Portfolios Using the Duration Times Spread Measure
56 Investing in Distressed Structured Credit Securities
57 Hedge Fund Fixed Income Strategies
63 The Valuation of Interest-Rate Swaps and Swaptions
65 Interest-Rate Caps and Floors
66 Credit Derivatives
67 Credit Derivative Valuation and Risk
68 Hedging Tail Risk
69 Principles of Performance Attribution
70 Performance Attribution for Portfolios of Fixed Income Securities
71 Advanced Topics in Performance Attribution

Moreover, the following seven chapters have been substantially revised:

14 Convertible Securities and Their Investment Application
19 International Bond Markets and Instruments
25 Agency Mortgage-Backed Securities
42 Convertible Securities: Their Structures, Valuation, and Trading
43 Credit Analysis for Corporate Bonds
53 International Bond Portfolio Management
54 Fixed Income Transition Management

When a comprehensive book of this type must be expanded to accommodate the introduction of new products, analytical tools and methodologies, and strategies, some chapters in the prior edition had to be removed due to real "binding" constraints—there are physical limitations on the number of pages that can be bound. Deleted from the revised handbook are chapters on dedicated portfolio strategies (immunization and cash-flow matching) and collateralized debt obligations (cash and synthetic). The former topic, although an important one, involves bond portfolio strategies wherein a manager seeks to lock in prevailing interest rates. In the low interest-rate environment as of this writing, few institutions appear to be pursuing such strategies. As for collateral debt obligations, although there are securities of this type outstanding, there is basically no new issuance except for collateralized loan obligations (a chapter on this product is included in the eighth edition).

Frank J. Fabozzi, Ph.D., CFA, CPA
Editor

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The first edition of *The Handbook of Fixed Income Securities* was published three decades ago. Over the years and eight editions of the book, I have benefited from the guidance of many participants in the various sectors of the bond market. I would like to extend my deep personal appreciation to the contributing authors in all editions of the book. Steven Mann, in particular, contributed eight of the chapters in the current edition.

There are two individuals whom I would like to single out who contributed to the first six editions and are now retired from the industry: Jane Tripp Howe and Richard Wilson. Jane was widely recognized as one of the top corporate credit analysts. She contributed not only to the *Handbook* but also to several other books that I edited. She was my "go to" person when I needed a chapter on any aspect of corporate credit analysis. In the eighth edition, Martin Fridson, Adam Cohen, and I revised the chapter by Jane on corporate bond credit analysis and we thank her for granting us permission to use the core of her chapter that appeared in the sixth edition.

Richard Wilson contributed several chapters to earlier editions of the *Handbook*. When I began my study of the fixed income market in the late 1970s, he served as my mentor. At that time, there were so many nuances about the institutional aspects of the market that were not in print. His historical perspective and his insights helped me form my view of the market. In addition, from his many contacts in the industry, he identified for me potential contributors to the first edition.

Frank J. Fabozzi, Ph.D., CFA, CPA

CONTRIBUTORS

George L. Albota
Director
Capital Markets/Market Risk Manager
Bank of America Merrill Lynch, London

Stephen J. Antczak, CFA
Consultant

Tim Backshall
Chief Credit Derivatives Strategist
Credit Derivatives Research Ltd.

Eknath Belbase, Ph.D.
Senior Consultant
Andrew Davidson & Co., Inc.

William S. Berliner
Executive Vice President
Manhattan Capital Markets

Vineer Bhansali, Ph.D.
Managing Director
PIMCO

Mihir Bhattacharya, Ph.D.
Managing Director
UBS Financial Services

Anand K. Bhattacharya, Ph.D.
Professor of Practice
Department of Finance
Arizona State University

Jane Sachar Brauer
Director
Merrill Lynch

John B. Brynjolfsson, CFA
Managing Director and CIO
Armored Wolf, LLC

Gerald W. Buetow, Jr., Ph.D., CFA
Chief Investment Officer
Innealta Capital

Mark O. Cabana
Senior Trader/Analyst
Federal Reserve Bank of New York

Anne Ching, CFA
Senior Analyst
Andrew Davidson & Co., Inc.

Moorad Choudhry, Ph.D.
MD, Head of Business Treasury,
Global Banking & Markets
Royal Bank of Scotland

Adam B. Cohen, J.D.
Founder
Covenant Review

Bruce M. Collins, Ph.D.
Professor of Finance
Western Connecticut State University

Alexander Crawford
Linda Lowell
Principal
OffStreet Research LLC

Ravi F. Dattatreya, Ph.D.
Managing Director
Exellex Financial Engineering

Andrew Davidson
President
Andrew Davidson & Co., Inc.

Chris P. Dialynas
Managing Director
Pacific Investment Management Company

Arik Ben Dor, Ph.D.
Director
Barclays Capital

Michael Dorigan, Ph.D.
Director & Senior Quantitative Analyst
PNC Capital Advisors LLC

Steven I. Dym, Ph.D.
President
Mariner Capital Partners

Lev Dynkin, Ph.D.
Managing Director
Barclays Capital

Frank J. Fabozzi, Ph.D., CFA, CPA
Professor of Finance
EDHEC Business School

Sylvan G. Feldstein, Ph.D.
Director
Investment Department
Guardian Life Insurance Company of America

Michael G. Ferri, Ph.D.
Professor of Finance
George Mason University

John D. Finnerty, Ph.D.
Professor of Finance
Fordham University
Managing Principal
Finnerty Economic Consulting, LLC

Wayne M. Fitzgerald II
Managing Director
BlackRock

Michael J. Fleming
Vice President
Federal Reserve Bank of New York

Sergio M. Focardi, Ph.D.
Professor of Finance
EDHEC Business School

Martin Fridson, CFA
Global Credit Strategist
BNP Paribas Asset Management

Radu C. Găbudean, Ph.D.
Vice President
Barclays Capital

Daniel Gallegos
Director
BlackRock

William J. Gartland, CFA
Managing Director
Benchmark Solutions

James M. Gerard
Quantitative Research Analyst
Fidelity Management and Research Company/Pyramis Global Advisors

Kay Giesecke, Ph.D.
Assistant Professor of Management Science and Engineering
Stanford University

Lisa Goldberg, Ph.D.
Executive Director of Research
MSCI
Adjunct Professor of Statistics
University of California at Berkeley

Robert Goldstein
Managing Director
BlackRock Solutions

Alexander Grant
Portfolio Manager
RS Tax-Exempt and RS High Yield Municipal Bond Funds

Robin Grieves, Ph.D.
Clinical Professor
Moore School of Business
University of South Carolina

Brian J. Henderson, Ph.D., CFA
Assistant Professor of Finance
The George Washington University

Curt Hollingsworth
Portfolio Manager
Fidelity Investments

Jonathan L. Horne
Executive Vice President
Pacific Investment Management Company

Dapeng Hu, Ph.D., CFA
Managing Director
BlackRock Solutions

Jay Hyman, Ph.D.
Managing Director
Barclays Capital

Antti Ilmanen, Ph.D.
Managing Director
AQR Capital Management (Europe) LLP

Robert R. Johnson, Ph.D., CFA
Senior Managing Director
CFA Institute

Andrew Kalotay, Ph.D.
President
Andrew Kalotay Associates

Vadim Konstantinovsky, CFA
Director
Barclays Capital

Vinod Kothari
Financial Consultant and Visiting Faculty
Indian Institute of Management
Calcutta, India

David Kwun
Managing Director
HSBC

Stephen Laipply
Director
BlackRock

Anthony Lazanas, Ph.D.
Managing Director
Barclays Capital

Jung Lee
Consultant

Nicholas C. Letica
Managing Director
Citigroup Global Markets, Inc.

Gary Li
Senior Vice President
HSBC

Ananth Madhavan, Ph.D.
Managing Director
BlackRock

Jack Malvey, CFA
Chief Global Markets Strategist
BNY Mellon Asset Management

Steven V. Mann, Ph.D.
Professor of Finance
The Moore School of Business
University of South Carolina

Lionel Martellini, Ph.D.
Professor of Finance
EDHEC Business School
Scientific Director, EDHEC Risk Institute

John McElravey, CFA
Director, Head of Consumer ABS Research
Wells Fargo Securities, LLC

Cyrus Mohebbi, Ph.D.
Managing Director
Morgan Stanley
Adjunct Professor
New York University

Alfred Murata, Ph.D., J.D.
Executive Vice President
Pacific Investment Management Company

Marshall Nicholson
Managing Director
Knight BondPoint

Dominic O'Kane, D.Phil. (OXON)
Affiliated Professor of Finance
EDHEC Business School

Mark D. Paltrowitz
Managing Director
BlackRock

Rachael W. Park
Senior Associate
Finnerty Economic Consulting, LLC

Bruce D. Phelps, Ph.D., CFA
Managing Director
Barclays Capital

Wesley Phoa, Ph.D.
Senior Vice President
Capital International Research, Inc.

Mark Pitts, Ph.D.

Mark R. Shenkman
President, Chief Investment Officer
Shenkman Capital Management, Inc.

Philippe Priaulet, Ph.D.
Head of Fixed Income Sales for
Shareholders Networks Natixis
Associate Professor
Mathematics Department
University of Evry Val d'Essonne

Ellen Rachlin
Managing Director
Mariner Investment Group, LLC

Shrikant Ramamurthy
Consultant

Karthik Ramanathan
Senior Vice President and Director of Bonds
Fidelity Management and Research
Company/Pyramis Global Advisors

David Ratner, CFA
Industry Consultant

Frank K. Reilly, Ph.D., CFA
Bernard J. Hank Professor of Finance
University of Notre Dame

Scott F. Richard, DBA
Practice Professor of Finance
Wharton
University of Pennsylvania

Peter Ru
Director, Fixed Income Investment Department
Morgan Stanley Huaxin Fund Management Company Limited

Nicholas R. Sarchese, CFA
Senior Vice President
Shenkman Capital Management, Inc.

António Baldaque da Silva, Ph.D.
Director
Barclays Capital

Arne D. Staal, Ph.D.
Director
Barclays Capital

Chris Sturhahn
Vice President
Barclays Capital

Matthew Tucker, CFA
Managing Director
BlackRock

Radu S. Tunaru, Ph.D.
Professor of Quantitative Finance
University of Kent, Business School

Kenneth E. Volpert, CFA
Head of the Taxable Bond Group
The Vanguard Group, Inc.

Todd White
Managing Director
Columbia Management Investment Advisors, LLC

Eric P. Wilson
Vice President
Barclays Capital

David J. Wright, Ph.D.
Professor of Finance
University of Wisconsin–Parkside

Pam Zhong, CFA
Vice President
Barclays Capital

PART

ONE

BACKGROUND

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CHAPTER
ONE

OVERVIEW OF THE TYPES AND FEATURES OF FIXED INCOME SECURITIES

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

MICHAEL G. FERRI, PH.D.
Professor of Finance
George Mason University

STEVEN V. MANN, PH.D.
Professor of Finance
The Moore School of Business
University of South Carolina

This chapter will explore some of the most important features of bonds, preferred stock, and structured products and provide the reader with a taxonomy of terms and concepts that will be useful in the reading of the specialized chapters to follow.

BONDS

Type of Issuer

One important characteristic of a bond is the nature of its issuer. Although non-U.S. governments and firms raise capital in U.S. financial markets, the three largest issuers of debt are domestic corporations, municipal governments, and the federal government and its agencies. Each class of issuer, however, features additional and significant differences.

Domestic corporations, for example, include regulated utilities as well as less regulated manufacturers. Furthermore, each firm may sell different kinds of bonds: Some debt may be publicly placed, whereas other bonds may be sold directly to one or only a few buyers (referred to as a *private placement*); some debt is collateralized by specific assets of the company, whereas other debt may be unsecured. Municipal debt is also varied: "General obligation" bonds (GOs) are backed by the full faith, credit, and taxing power of the governmental unit issuing

them; "revenue bonds," on the other hand, have a safety, or creditworthiness, that depends on the vitality and success of the particular entity (such as toll roads, hospitals, or water systems) within the municipal government issuing the bond.

The U.S. Treasury has the most voracious appetite for debt, but the bond market often receives calls from its agencies. Federal government agencies include federally related institutions and government-sponsored enterprises (GSEs).

It is important for the investor to realize that, by law or practice or both, these different borrowers have developed different ways of raising debt capital over the years. As a result, the distinctions among the various types of issuers correspond closely to differences among bonds in yield, denomination, safety of principal, maturity, tax status, and such important provisions as the call privilege, put features, and sinking fund. As we discuss the key features of fixed income securities, we will point out how the characteristics of the bonds vary with the obligor or issuing authority. A more extensive discussion is provided in later chapters in this book that explain the various instruments.

Maturity

A key feature of any bond is its *term-to-maturity,* the number of years during which the borrower has promised to meet the conditions of the debt (which are contained in the bond's indenture). A bond's term-to-maturity is the date on which the debt will cease and the borrower will redeem the issue by paying the face value, or principal. One indication of the importance of the maturity is that the code word or name for every bond contains its maturity (and coupon). Thus the title of the Anheuser Busch Company bond due, or maturing, in 2016 is given as "Anheuser Busch 8⁵/₈s of 2016." In practice, the words *maturity, term,* and *term-to-maturity* are used interchangeably to refer to the number of years remaining in the life of a bond. Technically, however, *maturity* denotes the date the bond will be redeemed, and either *term* or *term-to-maturity* denotes the remaining number of years until that date.

A bond's maturity is crucial for several reasons. First, maturity indicates the expected life of the instrument, or the number of periods during which the holder of the bond can expect to receive the coupon interest and the number of years before the principal will be paid. Second, the yield on a bond depends substantially on its maturity. More specifically, at any given point in time, the yield offered on a long-term bond may be greater than, less than, or equal to the yield offered on a short-term bond. As will be explained in Chapter 8, the effect of maturity on the yield depends on the *shape of the yield-curve*. Third, the volatility of a bond's price is closely associated with maturity: Changes in the market level of rates will wrest much larger changes in price from bonds of long maturity than from otherwise similar debt of shorter life.[1] Finally, as explained in Chapter 2, there are other risks associated with the maturity of a bond.

1. Chapter 7 discusses this point in detail.

When considering a bond's maturity, the investor should be aware of any provisions that modify, or permit the issuer to modify, the maturity of a bond. Although corporate bonds (referred to as "corporates") are typically *term bonds* (issues that have a single maturity), they often contain arrangements by which the issuing firm either can or must retire the debt early, in full or in part. Some corporates, for example, give the issuer a *call privilege,* which permits the issuing firm to redeem the bond before the scheduled maturity under certain conditions (these conditions are discussed below). Municipal bonds may have the same provision. The U.S. government no longer issues bonds that have a call privilege. The last callable bond was called in November 2009. Many industrials and some utilities have *sinking-fund provisions,* which mandate that the firm retire a substantial portion of the debt, according to a prearranged schedule, during its life and before the stated maturity. Municipal bonds may be *serial bonds* or, in essence, bundles of bonds with differing maturities. (Some corporates are of this type, too.)

Usually, the maturity of a corporate bond is between 1 and 30 years. This is not to say that there are not outliers. In fact, financially sound firms have begun to issue longer-term debt in order to lock in long-term attractive financing. For example, in the late 1990s, there were approximately 90 corporate bonds issued with maturities of 100 years.

Although classifying bonds as "short term," "intermediate term," and "long term" is not universally accepted, the following classification is typically used. Bonds with a maturity of 1 to 5 years are generally considered short term; bonds with a maturity between 5 and 12 years are viewed as intermediate term (and are often called *notes*). Long-term bonds are those with a maturity greater than 12 years.

Coupon and Principal

A bond's *coupon* is the periodic interest payment made to owners during the life of the bond. The coupon is always cited, along with maturity, in any quotation of a bond's price. Thus one might hear about the "IBM 6.5 due in 2028" or the "Campbell's Soup 8.875 due in 2021" in discussions of current bond trading. In these examples, the coupon cited is in fact the *coupon rate,* that is, the rate of interest that, when multiplied by the *principal, par value,* or *face value* of the bond, provides the dollar value of the coupon payment. Typically, but not universally, for bonds issued in the United States, the coupon payment is made in semiannual installments. An important exception is mortgage-backed and asset-backed securities that usually deliver monthly cash-flows. In contrast, for bonds issued in some European bond markets and all bonds issued in the *Eurobond market,* the coupon payment is made annually. Bonds may be *bearer bonds* or *registered bonds.* With bearer bonds, investors clip coupons and send them to the obligor for payment. In the case of registered issues, bond owners receive the payment automatically at the appropriate time. All new bond issues must be registered.

Zero-coupon bonds have been issued by corporations and municipalities since the early 1980s. For example, Barclay's Bank PLC has a zero-coupon bond outstanding due in August 2036 that was issued on August 15, 2006. Although the U.S. Treasury does not issue zero-coupon debt with a maturity greater than one year, such securities are created by government securities dealers. Merrill Lynch was the first to do this with its creation of Treasury Investment Growth Receipts (TIGRs) in August 1982. The most popular zero-coupon Treasury securities today are those created by government dealer firms under the Treasury's Separate Trading of Registered Interest and Principal Securities (STRIPS) Program. Just how these securities—commonly referred to as *Treasury strips*—are created will be explained in Chapter 9. The investor in a zero-coupon security typically receives interest by buying the security at a price below its principal, or maturity value, and holding it to the maturity date. The reason for the issuance of zero-coupon securities is explained in Chapter 9. However, some zeros are issued at par and accrue interest during the bond's life, with the accrued interest and principal payable at maturity.

Sovereign governments and corporations issue securities with a coupon rate tied to the rate of inflation. These debt instruments, referred to as *inflation-linked bonds,* or simply "linkers," have been issued since 1945. The earlier issuers of linkers were the governments of Argentina, Brazil, and Israel. The modern linker is attributed to the U.K. government's index-linked gilt issued in 1981 followed by Australia, Canada, and Sweden. The United States introduced an inflation-linked security in January 1997, calling those securities *Treasury Inflation Protected Securities*, or TIPS. These securities, which carry the full faith and credit of the U.S. government, comprised approximately 10% of the outstanding U.S. Treasury market as of mid-2009. Shortly after the introduction of TIPS in 1997, U.S. government-related entities such as the Federal Farm Credit, Federal Home Loan Bank, Fannie Mae, and the Tennessee Valley Authority began issuing linkers.

Different designs can be employed for linkers. The reference rate that is a proxy for the inflation rate is changes in the consumer price index (CPI). In the United Kingdom, for example, the index used is the Retail Prices Index (All Items), or RPI. In France, there are two linkers with two different indexes: the French CPI (excluding tobacco) and the Eurozone's Harmonised Index of Consumer Prices (HICP) (excluding tobacco). In the United States, the Consumer Price Index–Urban, Non-Seasonally Adjusted (denoted by CPI-U), is calculated by the U.S. Bureau of Labor Statistics.[2]

2. The CPI-U is the most widely followed and perhaps the most understood inflation index among alternative choices, such as the Gross Domestic Product (GDP) deflator and the Personal Consumption Expenditure (PCE) deflator. Monthly changes in the CPI-U represent the average changes in prices facing urban consumers with regard to a fixed basket of goods and services. This group of urban consumers represents about 87% of the total U.S. population. The Treasury reserves the right to substitute an alternative price index under the following circumstances: (1) the CPI-U is discontinued, (2) the CPI-U is altered materially to the detriment of the investor and/or the security, or (3) the CPI-U is altered by legislation or executive order in a manner harmful to the investor and/or the security.

There are securities that have a coupon rate that increases over time. These securities are called *step-up notes* because the coupon rate "steps up" over time. For example, a six-year step-up note might have a coupon rate that is 5% for the first two years, 5.8% for the next two years, and 6% for the last two years. Consider a *stairway note* issued by Barclays Bank PLC in July 2009. The initial coupon was 2.8% until January 2010 and thereafter the coupon rate reset every six months to the maximum of the previous coupon rate or six-month LIBOR.

In contrast to a coupon rate that is fixed for the bond's entire life, the term *floating-rate security* or *floater* encompasses several different types of securities with one common feature: The coupon rate will vary over the instrument's life. The coupon rate is reset at designated dates based on the value of some reference rate adjusted for a spread. For example, consider a floating-rate note issued in September 2007 by Bank of America that matured in September 2011. This floater delivered cash flows quarterly and had a coupon formula equal to three-month LIBOR plus 50 points.

Typically, floaters have coupon rates that reset more than once a year (e.g., semiannually, quarterly, or monthly). Conversely, the term *adjustable-rate* or *variable-rate security* refers to those issues whose coupon rates reset not more frequently than annually.

There are several features about floaters that deserve mention. First, a floater may have a restriction on the maximum (minimum) coupon rate that will be paid at any reset date called a *cap* (*floor*). Second, while the reference rate for most floaters is a benchmark interest rate or an interest rate index, a wide variety of reference rates appear in the coupon formulas. A floater's coupon could be indexed to movements in foreign exchange-rates, the price of a commodity (e.g., crude oil), movements in an equity index (e.g., the S&P 500), or movements in a bond index (e.g., the Merrill Lynch Corporate Bond Index). Third, while a floater's coupon rate normally moves in the same direction as the reference rate, there are floaters whose coupon rate moves in the opposite direction from the reference rate. These securities are called *inverse floaters* or *reverse floaters*. Consider a hypothetical inverse floater that makes coupon payments according to the following formula:

$$18\% - 2.5 \times (\text{three-month LIBOR})$$

This inverse floater had a floor of 3% and a cap of 15.5%. Finally, *range notes* are floaters whose coupon rate is equal to the reference rate (adjusted for a spread) as long as the reference rate is within a certain range on the reset date. If the reference rate is outside the range, the coupon rate is zero for that period. For instance, Barclay's Bank issued a range note in November 2006 (due in November 2016). This issue makes coupon payments quarterly. The investor earns three-month LIBOR + 113 basis points for every day during this quarter that three-month LIBOR is between 0% and 7.5%. Interest accrues at 0% for each day that three-month LIBOR is outside this range. As a result, this range note has a floor of 0%.

Structures in the *high-yield (junk bond) sector* of the corporate bond market have introduced variations in the way coupon payments are made. For example, in a leveraged buyout or recapitalization financed with high-yield bonds, the heavy interest payment burden the corporation must bear places severe cash-flow constraints on the firm. To reduce this burden, firms involved in leveraged buyouts (LBOs) and recapitalizations have issued deferred-coupon structures that permit the issuer to defer making cash interest payments for a period of three to seven years. There are three types of deferred-coupon structures: (1) deferred-interest bonds, (2) step-up bonds, and (3) payment-in-kind bonds. These structures are described in Chapter 12.

Another high-yield bond structure allows the issuer to reset the coupon rate so that the bond will trade at a predetermined price. The coupon rate may reset annually or reset only once over the life of the bond. Generally, the coupon rate will be the average of rates suggested by two investment banking firms. The new rate will then reflect the level of interest rates at the reset date and the credit-spread the market wants on the issue at the reset date. This structure is called an *extendible reset bond.* Notice the difference between this bond structure and the floating-rate issue described earlier. With a floating-rate issue, the coupon rate resets based on a fixed spread to some benchmark, where the spread is specified in the indenture and the amount of the spread reflects market conditions at the time the issue is first offered. In contrast, the coupon rate on an extendible reset bond is reset based on market conditions suggested by several investment banking firms at the time of the reset date. Moreover, the new coupon rate reflects the new level of interest rates and the new spread that investors seek.

One reason that debt financing is popular with corporations is that the interest payments are tax-deductible expenses. As a result, the true after-tax cost of debt to a profitable firm is usually much less than the stated coupon interest rate. The level of the coupon on any bond is typically close to the level of yields for issues of its class at the time the bond is first sold to the public. Some bonds are issued initially at a price substantially below par value (called *original-issue discount bonds,* or *OIDs*), and their coupon rate is deliberately set below the current market rate. However, firms usually try to set the coupon at a level that will make the market price close to par value. This goal can be accomplished by placing the coupon rate near the prevailing market rate.

To many investors, the coupon is simply the amount of interest they will receive each year. However, the coupon has another major impact on an investor's experience with a bond. The coupon's size influences the volatility of the bond's price: The larger the coupon, the less the price will change in response to a change in market interest rates. Thus the coupon and the maturity have opposite effects on the price volatility of a bond. This will be illustrated in Chapter 7.

The principal, par value, or face value of a bond is the amount to be repaid to the investor either at maturity or at those times when the bond is called or retired according to a repayment schedule or sinking-fund provisions. But the

principal plays another role, too: It is the basis on which the coupon or periodic interest rests. The coupon is the product of the principal and the coupon rate.

Participants in the bond market use several measures to describe the potential return from investing in a bond: current yield, yield-to-maturity, yield-to-call for a callable bond, and yield-to-put for a putable bond. A *yield-to-worst* is often quoted for bonds. This is the lowest yield of the following: yield-to-maturity, yields to all possible call dates, and yields to all put dates. The calculation and limitations of these yield measures are explained and illustrated in Chapter 6.

The prices of most bonds are quoted as percentages of par or face value. To convert the price quote into a dollar figure, one simply divides the price by 100 (converting it to decimal) and then multiplies by the par value. The following table illustrates this.

Par Value	Price Quote	Price as a Percentage of Par	Price in Dollars
$ 1,000	91 3/4	91.75	$ 917.50
5,000	102 1/2	102.5	5,125.00
10,000	87 1/4	87.25	8,725.00
25,000	100 3/4	100.875	25,218.75
100,000	71 9/32	71.28125	71,281.25
500,000	97 5/16	97.15625	485,781.25
1,000,000	88 111/256	88.43359375	884,335.94

There is a unique way of quoting pricing in the secondary market for Treasury bonds and notes. This convention is explained in Chapter 9.

Call and Refunding Provisions

If a bond's indenture contains a *call feature* or *call provision,* the issuer retains the right to retire the debt, fully or partially, before the scheduled maturity date. The chief benefit of such a feature is that it permits the borrower, should market rates fall, to replace the bond issue with a lower-interest-cost issue. The call feature has added value for corporations and municipalities. It may in the future help them to escape the restrictions that frequently characterize their bonds (about the disposition of assets or collateral). The call feature provides an additional benefit to corporations, which might want to use unexpectedly high levels of cash to retire outstanding bonds or might wish to restructure their balance sheets.

The call provision is detrimental to investors, who run the risk of losing a high-coupon bond when rates begin to decline. When the borrower calls the issue, the investor must find other outlets, which presumably would have lower yields than the bond just withdrawn through the call privilege. Another problem for the investor is that the prospect of a call limits the appreciation in a bond's price that could be expected when interest rates decline.

Because the call feature benefits the issuer and places the investor at a disadvantage, callable bonds carry higher yields than bonds that cannot be retired before maturity. This difference in yields is likely to grow when investors believe that market rates are about to fall and that the borrower may be tempted to replace a high-coupon debt with a new low-coupon bond. (Such a transaction is called *refunding.*) However, the higher yield alone is often not sufficient compensation to the investor for granting the call privilege to the issuer. Thus the price at which the bond may be called, termed the *call price,* is normally higher than the principal or face value of the issue. The difference between call price and principal is the *call premium,* whose value may be as much as one year's interest in the first few years of a bond's life and may decline systematically thereafter.

An important limitation on the borrower's right to call is the *period of call protection,* or *deferment period,* which is a specified number of years in the early life of the bond during which the issuer may not call the debt. Such protection is another concession to the investor, and it comes in two forms. Some bonds are *noncallable* (often abbreviated NC) for any reason during the deferment period; other bonds are *nonrefundable* (NF) for that time. The distinction lies in the fact that nonrefundable debt may be called if the funds used to retire the bond issue are obtained from internally generated funds, such as the cash-flow from operations or the sale of property or equipment, or from nondebt funding such as the sale of common stock. Thus, although the terminology is unfortunately confusing, a nonrefundable issue may be refunded under the circumstances just described and, as a result, offers less call protection than a noncallable bond, which cannot be called for any reason except to satisfy sinking-fund requirements, explained later. Beginning in early 1986, a number of corporations issued long-term debt with extended call protection, not refunding protection. A number are noncallable for the issue's life, such as Dow Chemical Company's $8^5/_8$s due in 2006. The issuer is expressly prohibited from redeeming the issue prior to maturity. These *noncallable-for-life issues* are referred to as *bullet bonds.* If a bond does not have any protection against an early call, then it is said to be *currently callable.*

Since the mid-1990s, an increasing number of public debt issues include a so-called *make-whole call provision.* Make-whole call provisions have appeared routinely in privately placed issues since the late 1980s. In contrast to the standard call feature that contains a call price fixed by a schedule, a make-whole call price varies inversely with the level of interest rates. A make-whole call price (i.e., redemption amount) is typically the sum of the present values of the remaining coupon payments and principal discounted at a yield on a Treasury security that matches the bond's remaining maturity plus a spread. For example, on January 22, 2008, an industrial firm issued $300 million in bonds with a make-whole call provision that mature on January 15, 2038. These bonds are redeemable at any time in whole or in part at the issuer's option. The redemption price is the greater of (1) 100% of the principal amount plus accrued interest or (2) the make-whole redemption amount plus accrued interest. In this case, the make-whole

redemption amount is equal to the sum of the present values of the remaining coupon and principal payments discounted at the Adjusted Treasury Rate plus 15 basis points.[3] The Adjusted Treasury Rate is the bond-equivalent yield on a U.S. Treasury security having a maturity comparable to the remaining maturity of the bonds to be redeemed. Each holder of the bonds will be notified at least 30 days but not more than 60 days prior to the redemption date. This issue is callable at any time, as are most issues with make-whole call provisions. Note that the make-whole call price increases as interest rates decrease, so if the issuer exercises the make-whole call provision when interest rates have decreased, the bondholder receives a higher call price. Make-whole call provisions thus provide investors with some protection against reinvestment rate risk.

A key question is, When will the firm find it profitable to refund an issue? It is important for investors to understand the process by which a firm decides whether to retire an old bond and issue a new one. A simple and brief example will illustrate that process and introduce the reader to the kinds of calculations a bondholder will make when trying to predict whether a bond will be refunded.

Suppose that a firm's outstanding debt consists of $300 million par value of a bond with a coupon of 10%, a maturity of 15 years, and a lapsed deferment period. The firm can now issue a bond with a similar maturity for an interest rate of 7.8%. Assume that the issuing expenses and legal fees amount to $2 million. The call price on the existing bond issue is $105 per $100 par value. The firm must pay, adjusted for taxes, the sum of call premium and expenses. To simplify the calculations, assume a 30% tax rate. This sum is then $11,190,000.[4] Such a transaction would save the firm a yearly sum of $4,620,000 in interest (which equals the interest of $30 million on the existing bond less the $23.4 million on the new, adjusted for taxes) for the next 15 years.[5] The rate of return on a payment of $11,900,000 now in exchange for a savings of $4,620,000 per year for 15 years is about 38%. This rate far exceeds the firm's after-tax cost of debt (now at 7.8% times 0.7, or 5.46%) and makes the refunding a profitable economic transaction.

In municipal securities, refunding often refers to something different, although the concept is the same. Municipal bonds can be *prerefunded* prior to maturity (usually on a call date). Here, instead of issuing new bonds to retire the debt, the municipality will issue bonds and use the proceeds to purchase enough risk-free securities to fund all the cash-flows on the existing bond issue.

3. A 30/360 day-count convention is employed in this present-value calculation.
4. Both expenses are tax deductible for the firm. The total expense is the call premium of $15 million plus the issuing expenses and legal fees of $2 million. The after-tax cost is equal to the before-tax cost times (1 − tax rate). Hence the after-tax cost is $17 million times (1 − 0.3), or $11,900,000.
5. The new interest expense would be $300 million times 0.078. The after-tax cost of the interest saving is $6.6 million times (1 − 0.3).

It places these in an irrevocable trust. Thus the municipality still has two issues outstanding, but the old bonds receive a new label—they are "prerefunded." If Treasury securities are used to prerefund the debt, the cash-flows on the bond are guaranteed by Treasury obligations in the trust. Thus they become AAA rated and trade at higher prices than previously. Municipalities often find this an effective means of lowering their cost of debt.

Sinking-Fund Provision

The *sinking-fund provision,* which is typical for publicly and privately issued industrial bonds and not uncommon among certain classes of utility debt, requires the obligor to retire a certain amount of the outstanding debt each year. Generally, the retirement occurs in one of two ways. The firm may purchase the amount of bonds to be retired in the open market if their price is below par, or the company may make payments to the trustee who is empowered to monitor the indenture and who will call a certain number of bonds chosen by lottery. In the latter case, the investor would receive the prearranged call price, which is usually par value. The schedule of retirements varies considerably from issue to issue. Some issuers, particularly in the private-placement market, retire most, if not all, of their debt before maturity. In the public market, some companies may retire as little as 20% to 30% of the outstanding par value before maturity. Further, the indenture of many issues includes a deferment period that permits the issuer to wait five years or more before beginning the process of sinking-fund retirements.

There are three advantages of a sinking-fund provision from the investor's perspective. The sinking-fund requirement ensures an orderly retirement of the debt so that the final payment, at maturity, will not be too large. Second, the provision enhances the liquidity of some debt, especially for smaller issues with thin secondary markets. Third, the prices of bonds with this requirement are presumably more stable because the issuer may become an active participant on the buy side when prices fall. For these reasons, the yields on bonds with sinking-fund provisions tend to be less than those on bonds without them.

The sinking fund, however, can work to the disadvantage of an investor. Suppose that an investor is holding one of the early bonds to be called for a sinking fund. All the time and effort put into analyzing the bond has now been wasted, and the investor will have to choose new instruments for purchase. Also, an investor holding a bond with a high coupon at the time rates begin to fall is still forced to relinquish the issue. For this reason, in times of high interest rates, one might find investors demanding higher yields from bonds with sinking funds than from other debt.

The sinking-fund provision also may harm the investor's position through the *optional acceleration feature,* a part of many corporate bond indentures. With this option, the corporation is free to retire more than the amount of debt the sinking fund requires (and often a multiple thereof) and to do it at the call price set for sinking-fund payments. Of course, the firm will exercise this option only if the price of the bond exceeds the sinking-fund price (usually near par), and this

happens when rates are relatively low. If, as is typically the case, the sinking-fund provision becomes operative before the lapse of the call-deferment period, the firm can retire much of its debt with the optional acceleration feature and can do so at a price far below that of the call price it would have to pay in the event of refunding. The impact of such activity on the investor's position is obvious: The firm can redeem at or near par many of the bonds that appear to be protected from call and that have a market value above the face value of the debt.

Put Provisions

A *putable bond* grants the investor the right to sell the issue back to the issuer at par value on designated dates. The advantage to the investor is that if interest rates rise after the issue date, thereby reducing the value of the bond, the investor can force the issuer to redeem the bond at par. Some issues with put provisions may restrict the amount that the bondholder may put back to the issuer on any one put date. Put options have been included in corporate bonds to deter unfriendly takeovers. Such put provisions are referred to as "poison puts."

Put options can be classified as *hard puts* and *soft puts.* A hard put is one in which the security must be redeemed by the issuer only for cash. In the case of a soft put, the issuer has the option to redeem the security for cash, common stock, another debt instrument, or a combination of the three. Soft puts are found in convertible debt, which we describe next.

Convertible or Exchangeable Debt

A *convertible bond* is one that can be exchanged for specified amounts of common stock in the issuing firm: The conversion cannot be reversed, and the terms of the conversion are set by the company in the bond's indenture. The most important terms are *conversion ratio* and *conversion price.* The conversion ratio indicates the number of shares of common stock to which the holder of the convertible has a claim. For example, Kaiser Aluminum issued $175 million in convertibles in April 2010 that mature in 2015. These convertibles carry a 4.5% coupon with a conversion ratio of 20.6949 shares for each bond. This translates to a conversion price of $48.32 per share ($1,000 par value divided by the conversion ratio 20.6949) at the time of issuance. The conversion price at issuance is also referred to as the *stated conversion price.*

The conversion privilege may be permitted for all or only some portion of the bond's life. The conversion ratio may decline over time. It is always adjusted proportionately for stock splits and stock dividends. Convertible bonds are typically callable by the issuer. This permits the issuer to force conversion of the issue. (Effectively, the issuer calls the bond, and the investor is forced to convert the bond or allow it to be called.) There are some convertible issues that have call protection. This protection can be in one of two forms: Either the issuer is not allowed to redeem the issue before a specified date, or the issuer is not permitted

to call the issue until the stock price has increased by a predetermined percentage price above the conversion price at issuance.

An *exchangeable bond* is an issue that can be exchanged for the common stock of a corporation other than the issuer of the bond. There are a handful of issues that are exchangeable into more than one security. One significant innovation in the convertible bond market was the "Liquid Yield Option Note" (LYON) developed by Merrill Lynch Capital Markets in 1985. A LYON is a zero-coupon, convertible, callable, and putable bond. Techniques for analyzing convertible and exchangeable bonds are described in Chapters 14 and 42.

Medium-Term Notes

Medium-term notes are highly flexible debt instruments that can be easily structured in response to changing market conditions and investor tastes. "Medium term" is a misnomer because these securities have ranged in maturity from nine months to 30 years and longer. Since the latter part of the 1980s, medium-term notes have become an increasingly important financing vehicle for corporations and federal agencies. Typically, medium-term notes are noncallable, unsecured, senior debt securities with fixed-coupon rates that carry an investment-grade credit rating. They generally differ from other bond offerings in their primary distribution process, as will be discussed in Chapter 12. *Structured medium-term notes,* or simply *structured notes,* are debt instruments linked to a derivative position and are discussed in Chapter 15. For example, structured notes are usually created with an underlying swap transaction. This "hedging swap" allows the issuer to create securities with interesting risk/return features demanded by bond investors.

Warrants

A *warrant* is an option a firm issues that permits the owner to buy from the firm a certain number of shares of common stock at a specified price. It is not uncommon for publicly held corporations to issue warrants with new bonds.

A valuable aspect of a warrant is its rather long life: Most warrants are in effect for at least two years from issuance, and some are perpetual.[6] Another key feature of the warrant is the *exercise price,* the price at which the warrant holder can buy stock from the corporation. This price is normally set at about 15% above the market price of common stock at the time the bond, and thus the warrant, is issued. Frequently, the exercise price will rise through time, according to the schedule in the bond's indenture. Another important characteristic of the warrant is its detachability. *Detachable warrants* are often actively traded on the American Stock Exchange. Other warrants can be exercised only by the bondholder, and

6. This long life contrasts sharply with the short life during which many exchange-traded call options on common stock, similar to warrants, are exercisable.

these are called *nondetachable warrants.* The chief benefit to the investor is the financial leverage the warrant provides.

PREFERRED STOCK

Preferred stock is a class of stock, not a debt instrument, but it shares characteristics of both common stock and debt. Like the holder of common stock, the preferred stockholder is entitled to dividends. Unlike those on common stock, however, preferred stock dividends are a specified percentage of par or face value.[7] The percentage is called the *dividend rate;* it need not be fixed but may float over the life of the issue.

Failure to make preferred stock dividend payments cannot force the issuer into bankruptcy. Should the issuer not make the preferred stock dividend payment, usually paid quarterly, one of two things can happen, depending on the terms of the issue. First, the dividend payment can accrue until it is fully paid. Preferred stock with this feature is called *cumulative preferred stock.* Second, if a dividend payment is missed and the security holder must forgo the payment, the preferred stock is said to be *noncumulative preferred stock.* Failure to make dividend payments may result in imposition of certain restrictions on management. For example, if dividend payments are in arrears, preferred stockholders might be granted voting rights.

Unlike debt, payments made to preferred stockholders are treated as a distribution of earnings. This means that they are not tax deductible to the corporation under the current tax code. (Interest payments, on the other hand, are tax deductible.) Although the after-tax cost of funds is higher if a corporation issues preferred stock rather than borrowing, there is a factor that reduces the cost differential: A provision in the tax code exempts 70% of qualified dividends from federal income taxation if the recipient is a qualified corporation. For example, if Corporation A owns the preferred stock of Corporation B, for each $100 of dividends received by A, only $30 will be taxed at A's marginal tax rate. The purpose of this provision is to mitigate the effect of double taxation of corporate earnings. There are two implications of this tax treatment of preferred stock dividends. First, the major buyers of preferred stock are corporations seeking tax-advantaged investments. Second, the cost of preferred stock issuance is lower than it would be in the absence of the tax provision because the tax benefits are passed through to the issuer by the willingness of buyers to accept a lower dividend rate.

Preferred stock has some important similarities with debt, particularly in the case of cumulative preferred stock: (1) The payments to preferred stockholders promised by the issuer are fixed, and (2) preferred stockholders have priority

7. Almost all preferred stock limits the security holder to the specified amount. Historically, there have been issues entitling the preferred stockholder to participate in earnings distribution beyond the specified amount (based on some formula). Preferred stock with this feature is referred to as *participating preferred stock.*

over common stockholders with respect to dividend payments and distribution of assets in the case of bankruptcy. (The position of noncumulative preferred stock is considerably weaker than cumulative preferred stock.) It is because of this second feature that preferred stock is called a *senior security.* It is senior to common stock. On a balance sheet, preferred stock is classified as equity.

Preferred stock may be issued without a maturity date. This is called *perpetual preferred stock.* Almost all preferred stock has a sinking-fund provision, and some preferred stock is convertible into common stock. A trademark product of Morgan Stanley is the Preferred Equity Redemption Cumulative Stock (PERCS). This is a preferred stock with a mandatory conversion at maturity.

RESIDENTIAL MORTGAGE-BACKED SECURITIES

A *residential mortgage-backed security* (RMBS) is an instrument whose cash-flow depends on the cash-flows of an underlying pool of mortgages. In the U.S. market, RMBS are classified into two groups: agency RMBS and nonagency RMBS.

An *agency RMBS,* the subject of Chapter 25, is one issued by the Government National Mortgage Association ("Ginnie Mae"), the Federal Home Loan Mortgage Corporation ("Freddie Mac"), or the Federal National Mortgage Association ("Fannie Mae"). Ginnie Mae is a federal government agency within the Department of Housing and Urban Development. The RMBS issued by this entity is guaranteed by the full faith and credit of the U.S. government. Freddie Mac and Fannie Mae are government-sponsored enterprises (GSEs). In September 2008, these two entities were placed into conservatorship run by the Federal Housing Finance Agency. The agency RMBS market is the largest sector of the U.S. bond market as of year-end 2010. In bond indexes such as the Barclays Capital U.S. Aggregate Bond Index, this sector is referred to as simply "mortgage-backed securities" or the "MBS" sector despite the fact that there are also nonagency RMBS.

Nonagency RMBS, the subject of Chapter 31, are issued by thrifts, commercial banks, or private conduits that are not backed by any government entity. These securities are structured so as to provide credit enhancement that support the credit ratings that they receive. At one time, the nonagency RMBS market was divided into two sectors: prime RMBS and subprime RMBS. The classification depended on the credit quality of the pool of borrowers and the type of lien on the properties that were mortgaged. The primary attribute used to categorize the borrower's credit quality has long been the borrower's Fair Isaacs or FICO credit score or any one of other related measures that are not discussed here (e.g., an income ratio indicating the borrower's ability to pay and the loan-to-value ratio measuring the borrower's equity in the property). Prime borrowers are generally those with FICO scores of 660 or higher. Subprime borrowers are those with impaired credit ratings, typically with FICO scores below 660. However, because of the difficulties faced in the RMBS subprime market that started in the summer of 2007, and the poor performance of the collateral underlying both prime and subprime RMBS, investors no longer draw a sharp distinction between these two

sectors of the nonagency RMBS market. Further, few experts believe that the subprime RMBS market will be revived in the future.

RMBS can take three forms: (1) mortgage pass-through securities, (2) collateralized mortgage obligations (CMOs), and (3) stripped mortgage-backed securities. Agency RMBS come in all three forms. Typically nonagency RMBS come only in the second form and, as a result, this sector of the market is referred to as the nonagency CMO market.

Agency RMBS expose an investor to *prepayment risk*. This is the risk that the borrowers in a mortgage pool will prepay their loans when interest rates decline. Prepayment risk is effectively the same as call risk faced by an investor in a callable corporate or municipal bond. Nonagency RMBS expose investors to both prepayment risk and credit risk, although the major concern by investors in this space is credit risk.

COMMERCIAL MORTGAGE-BACKED SECURITIES

Commercial mortgage-backed securities (CMBSs) are backed by a pool of commercial mortgage loans on income-producing property—multifamily properties (i.e., apartment buildings), office buildings, industrial properties (including warehouses), shopping centers, hotels, and health care facilities (i.e., senior housing care facilities). The basic building block of the CMBS transaction is a commercial loan that was originated either to finance a commercial purchase or to refinance a prior mortgage obligation. There are two major types of CMBS deal structures that have been of interest to bond investors, multiproperty single borrowers, and multiproperty conduits. The fastest-growing segment of the CMBS is conduit-originated transactions. *Conduits* are commercial-lending entities that are established for the sole purpose of generating collateral to securitize.

Unlike residential mortgage loans, where the lender relies on the ability of the borrower to repay and has recourse to the borrower if the payment terms are not satisfied, commercial mortgage loans are nonrecourse loans. This means that the lender can only look to the income-producing property backing the loan for interest and principal repayment. If there is a default, the lender looks to the proceeds from the sale of the property for repayment and has no recourse to the borrower for any unpaid balance. Basically, this means that the lender must view each property as a stand-alone business and evaluate each property using measures that have been found useful in assessing credit risk.

ASSET-BACKED SECURITIES

Asset-backed securities are securities collateralized by assets that are not mortgage loans. In structuring an asset-backed security, issuers have drawn from the structures used in the mortgage-backed securities market. Asset-backed securities have been structured as pass-throughs and as structures with multiple bond

classes called *pay-throughs,* which are similar to CMOs. Credit enhancement is provided by letters of credit, over-collateralization, or senior/subordination.

Three common types of asset-backed securities are those backed by credit card receivables, home equity loans, and automobile loans. Chapters 33 and 34 cover these securities. There are also asset-backed securities supported by a pool of manufactured homes, Small Business Administration (SBA) loans, student loans, boat loans, equipment leases, recreational vehicle loans, senior bank loans, and possibly, the future royalties of your favorite entertainer.

COVERED BONDS

In the wake of the financial crisis of 2008–2009, a bond structure very familiar to European investors—covered bonds—was touted as an alternative funding source for residential mortgage loans. Collateral in the typical European covered bond includes residential/commercial mortgages and public sector debt.

A *covered bond* is a debt instrument secured by a specific pool of collateralizing assets. Covered bonds, the subject of Chapter 22, differ from the typical mortgage-backed security issued in the United States on a number of dimensions. First, the cover pool remains on the issuer's balance sheet rather than being sold to a special-purpose entity. Second, the mortgages in the cover pool serve only as collateral for investors, whereas the covered bond's principal and interest are serviced by the issuer's cash-flows. Third, mortgage-backed securities are claims to static pools, whereas the cover pool is dynamic, and nonperforming mortgages must be replaced with performing ones. Fourth, unlike MBS, covered bonds are structured to prevent prepayments before maturity. Finally, investors in covered bonds retain an unsecured claim on the issuer for any shortfall due to them (i.e., unpaid principal and interest).

KEY POINTS

- Bonds differ on a number of dimensions, which include type of issuer, maturity, coupon, principal amount, method of redemption, and embedded options.
- Embedded options in a debt instrument are call and refunding provisions, prepayment provisions, optional accelerated provision, put provision, and conversion provision.
- Medium-term notes are highly flexible debt instruments that can be easily structured in response to changing market conditions and investor tastes.
- Structured notes are debt instruments that are linked to a derivative position and allow an issuer to create a customized debt instrument for an investor.

- Preferred stock is a security that shares characteristics of debt and equity.
- Residential RMBS are classified into agency and nonagency securities.
- There are three types of RMBS: (1) pass-throughs, (2) collateralized mortgage obligations, and (3) stripped mortgage-backed securities. Nonagency RMBS typically have the CMO structure.
- Asset-backed securities are collateralized by financial assets other than residential mortgages.
- A covered bond is a debt instrument secured by a specific pool of collateral called a collateral pool.

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CHAPTER
TWO

RISKS ASSOCIATED WITH INVESTING IN FIXED INCOME SECURITIES

Ravi F. Dattatreya, Ph.D.
Managing Director
Exellex Financial Engineering

Frank J. Fabozzi, Ph.D., CFA, CPA
Professor of Finance
EDHEC Business School

Sergio M. Focardi, Ph.D.
Professor of Finance
EDHEC Business School

The return obtained from a fixed income security from the day it is purchased to the day it is sold can be divided into two parts: (1) the market value of the security when it is eventually sold and (2) the cash-flows received from the security over the time period that it is held, plus any additional income from reinvestment of the cash-flow. Several environmental factors affect one or both of these two parts. We can define the risk associated with any security as a measure of the impact of these factors on the return characteristics of the security.

The different types of risk that an investor in individual fixed income securities is exposed to are as follows:

- Interest-rate risk
- Reinvestment risk
- Call/prepayment risk
- Credit risk
- Inflation, or purchasing-power, risk
- Liquidity risk
- Exchange-rate, or currency, risk

- Volatility risk
- Political or legal risk
- Event risk
- Sector risk

There are also risks associated with bond portfolio strategies. These include

- Statistical measures of portfolio risk
- Tracking error risk

Each risk is briefly described in this chapter. A more detailed description of these risks is provided in the chapters that follow.

To manage a bond portfolio, it important that a manager to be able to quantify these risks. In later chapters, multifactor risk models for building and controlling a portfolio's risk profile relative to a bond index or benchmark will be described. These models depend crucially on the ability to measure the primary risk factors. Although not all of the risks described in this chapter are quantifiable, the primary risk factors associated with any bond index and portfolio can be quantified. The key in active bond portfolio management in which the investor's benchmark is a bond index is to quantify the major risk factors so that a portfolio manager who seeks to take a view on some or all of the primary risk factors can do so by constructing a portfolio with a targeted risk profile relative to the benchmark. In the case of passive bond portfolio management, the portfolio manager seeks to match the risk profile of the benchmark.

INTEREST-RATE RISK

Interest-rate risk is the risk associated with an adverse change in interest rates. This risk includes two types of risk: level risk and yield-curve risk. In multifactor risk models described in later chapters, interest-rate risk is referred to as *curve risk* or *term structure risk*.

Level Risk

The price of a typical fixed income security moves in the opposite direction of the change in interest rates: As interest rates rise (fall), the price of a fixed income security will fall (rise).[1] This property is illustrated in Chapter 7. For an investor who plans to hold a fixed income security to maturity, the change in its price before maturity is not of concern; however, for an investor who may have to sell the fixed income security before the maturity date, an increase in interest rates will mean the

1. There are certain fixed income instruments whose price changes in the same direction as interest rates. Examples are put options and interest-only mortgage-backed securities.

realization of a capital loss. This risk is referred to as *interest-rate risk* which is one of the primary risks faced by an investor in the fixed income market.

It is customary to represent the market by the yield levels on Treasury securities. Most other yields are compared to the Treasury levels and are quoted as spreads off appropriate Treasury yields. To the extent that the yields of all fixed income securities are interrelated, their prices respond to changes in Treasury rates. As discussed in Chapter 7, the actual magnitude of the price response for any security depends on various characteristics of the security, such as coupon, maturity, and the options embedded in the security (e.g., call and put provisions).

To control interest-rate risk, it is necessary to quantify it. The most commonly used measure of interest-rate risk is *duration.* Duration is the approximate percentage change in the price of a bond or bond portfolio due to a 100 basis point change in yields. This measure and how it is computed is explained in Chapter 7.

Yield-Curve Risk

The yield-curve is the graphic depiction of the relationship between the yield on bonds of the same credit quality but different maturities. The yield-curve, and a related relationship called the *term structure of interest rates,* will be discussed in more detail in later chapters. A bond portfolio typically contains holdings with different maturities and each bond is subject to interest-rate risk. So, for example, consider two bond portfolios both consisting of three bonds: a 5-year bond, a 10-year bond, and a 20-year bond. The exposure of that portfolio depends on how interest rates change for each of the maturities. Suppose the first bond portfolio has 45% in both the 5-year and 20-year bonds and 10% in the 10-year bond. Suppose that the second bond portfolio has 5% in both the 5-year and 20-year bonds and 90% in the 10-year bond. It is not difficult to understand that the way in which interest rates change on the yield-curve can have a substantially different impact on the change in these two bond portfolios.

Yield-curve risk is the exposure of a portfolio to changes in the shape (i.e., movement) of the yield-curve. There are various measures that have been suggested for quantifying a portfolio's exposure to changes in the yield-curve. The most common measure used is *key rate duration.*

Yield-curve risk is an important risk in bond portfolio management, and with the exception of mortgage-backed securities, it is primarily a risk that must be dealt with at the portfolio level.

REINVESTMENT RISK

As explained in Chapter 6, the cash-flows received from a security are usually (or are assumed to be) reinvested. The additional income from such reinvestment, sometimes called *interest-on-interest,* depends on the prevailing interest-rate levels at the time of reinvestment, as well as on the reinvestment strategy.

The variability in the returns from reinvestment from a given strategy due to changes in market rates is called *reinvestment risk.* The risk here is that the interest rate at which interim cash-flows can be reinvested will fall. Reinvestment risk is greater for longer holding periods. It is also greater for securities with large, early cash-flows such as high-coupon bonds. This risk is analyzed in more detail in Chapter 6.

It should be noted that interest-rate risk and reinvestment risk oppose each other. For example, interest-rate risk is the risk that interest rates will rise, thereby reducing the price of a fixed income security. In contrast, reinvestment risk is the risk that interest rates will fall.

CALL/PREPAYMENT RISK

As explained in Chapter 1, bonds may contain a provision that allows the issuer to retire, or "call," all or part of the issue before the maturity date. By including this provision, the issuer retains the right to refinance the bond in the future if market interest rates decline below the coupon rate.

From the investor's perspective, there are three disadvantages of the call provision and hence faces *call risk*. First, the cash-flow pattern of a callable bond is not known with certainty. Second, because the issuer may call the bonds when interest rates have dropped, the investor is exposed to reinvestment risk. That is, the investor will have to reinvest the proceeds received when the bond is called at lower interest rates. Finally, the capital appreciation potential of a bond will be reduced because the price of a callable bond may not rise much above the price at which the issuer may call the bond. (We describe this property of a callable bond, referred to as *negative convexity*, in Chapter 7.)

Agency, corporate, and municipal bonds may have embedded in them the option on the part of the borrower to call, or terminate, the issue before the stated maturity date. All mortgage-backed securities have this option. Even though the investor is usually compensated for taking the risk of call by means of a lower price or a higher yield, it is not easy to determine if this compensation is sufficient. In any case, the returns from a bond with call risk can be dramatically different from those obtained from a noncallable bond. The magnitude of this risk depends on the various parameters of the call, as well as on market conditions.

In the case of mortgage-backed securities, the cash-flow depends on prepayments of principal made by the homeowners in the pool of mortgages that is the collateral for the security. Call risk in this case is called *prepayment risk.* It includes *contraction risk*—the risk that homeowners will prepay all or part of their mortgage when mortgage interest rates decline. The risk that prepayments will slow down when mortgage interest rates rise and force an investor who expected that the pool of mortgages would prepay at a faster rate is called *extension risk.*

CREDIT RISK

The *credit risk* of a bond includes

1. The risk that the issuer will default on its obligation (default risk).
2. The risk that the bond's value will decline and/or the bond's price performance will be worse than that of other bonds against which the investor is compared because either (a) the market requires a higher spread due to a perceived increase in the risk that the issuer will default or (b) companies that assign ratings to bonds will lower a bond's rating.

The first risk is referred to as *default risk*. The second risk is labeled based on the reason for the adverse or inferior performance. The risk attributable to an increase in the spread or, more specifically, the credit-spread demanded by the market, is referred to as *credit-spread risk*; the risk attributable to a lowering of the credit rating (i.e., a downgrading) is referred to as *downgrade risk*.

A *credit rating* is a formal opinion given by a specialized company of the default risk faced by investing in a particular issue of debt securities. The specialized companies that provide credit ratings are referred to as *rating agencies*. The three nationally recognized rating agencies in the United States are Moody's Investors Service, Standard & Poor's Corporation, and Fitch Ratings. The symbols used by these rating agencies and a summary description of each rating are given in Chapter 12.

Once a credit rating is assigned to a debt obligation, a rating agency monitors the credit quality of the issuer and can reassign a different credit rating to its bonds. An "upgrade" occurs when there is an improvement in the credit quality of an issue; a "downgrade" occurs when there is a deterioration in the credit quality of an issue. As noted earlier, downgrade risk is the risk that an issue will be downgraded.

Typically, before an issue's rating is changed, the rating agency will announce in advance that it is reviewing the issue with the potential for upgrade or downgrade. The issue in such cases is said to be on "rating watch" or "credit watch." In the announcement, the rating agency will state the direction of the potential change in rating—upgrade or downgrade. Typically, a decision will be made within three months.

In addition, rating agencies will issue rating outlooks. A *rating outlook* is a projection of whether an issue in the long term (from six months to two years) is likely to be upgraded, downgraded, or maintain its current rating. Rating agencies designate a rating outlook as either positive (i.e., likely to be upgraded), negative (i.e., likely to be downgraded), or stable (i.e., likely to be no change in the rating).

Gauging Default Risk and Downgrade Risk

The information available to investors from rating agencies about credit risk are (1) ratings, (2) rating watches or credit watches, and (3) rating outlooks. A study by Moody's found that for corporate bonds, its ratings combined with its rating watches

and rating outlook status provide a better gauge for default risk than using the ratings alone.[2] Moreover, periodic studies by the rating agencies provide information to investors about credit risk.

Below we describe how the information provided by rating agencies can be used to gauge two forms of credit risk: default risk and downgrade risk.

For long-term debt obligations, a credit rating is a forward-looking assessment of (1) the probability of default and (2) the relative magnitude of the loss should a default occur. For short-term debt obligations (i.e., obligations with initial maturities of one year or less), a credit rating is a forward-looking assessment of the probability of default. Consequently, credit ratings are the rating agencies' assessments of the default risk associated with a bond issue.

Periodic studies by rating agencies provide information about two aspects of default risk—default rates and default loss rates. First, rating agencies study and make available to investors the percentage of bonds of a given rating at the beginning of a period that have defaulted at the end of the period. This percentage is referred to as the *default rate*. A *default loss rate* is a measure of the magnitude of the potential of the loss should a default occur.

Rating transition tables published periodically by rating agencies also provide information. A rating transition table shows the percentage of issues of each rating at the beginning of a period that were downgraded or upgraded by the end of the time period. Consequently, by looking at the percentage of downgrades for a given rating, an estimate can be obtained of the probability of a downgrade, and this can serve as a measure of downgrade risk.

Credit Risk Models

Beyond credit ratings, portfolio managers are employing other methodologies for estimating the probability distribution of losses for a bond portfolio in order to compute loss measures such as value-at-risk (VaR) and conditional VaR (CVaR). For banks, there have been changes in the supervisory framework, as put forward in the Basel II Capital Accord, that require new tools and concepts for measuring credit risk and the development of an internal rating system (IRB), as well as the collection of detailed data on credit exposures and recovery rates. These new tools and concepts will aid banks in evaluating and managing their credit risk profile.

Models for credit risks have long existed in the actuarial and corporate finance literatures. The traditional models concentrate on default rates, credit ratings, and credit risk premiums and focus on diversification, making the assumption that default risks are idiosyncratic and hence can be diversified away in large portfolios. For single isolated credits, the models calculate risk premiums as markups onto the risk-free rate. Since the mid 1990s, however, there have been

2. David T. Hamilton and Richard Cantor, "Rating Transitions and Defaults Conditional on Watchlist, Outlook and Rating History," Moody's Investors Service, February 2004.

major advances in modeling credit risk for estimating the probability distribution of losses for a bond portfolio. The models are divided into three categories: structural models, reduced-form models, and incomplete-information models. Each of these models is described in Chapter 45.

INFLATION, OR PURCHASING-POWER, RISK

Inflation risk, or *purchasing-power risk,* arises because of the variation in the value of cash-flows from a security due to inflation, as measured in terms of purchasing-power. For example, if an investor purchases a five-year bond in which he or she can realize a coupon rate of 7%, but the rate of inflation is 8%, then the purchasing-power of the cash-flow has declined. For all but inflation-linked securities (sometime referred to as "linkers"), an investor is exposed to inflation risk because the interest rate the issuer promises to make is fixed for the life of the security. To the extent that interest rates reflect the expected inflation rate, floating-rate bonds have a lower level of inflation risk than fixed-rate bonds.

LIQUIDITY RISK

Liquidity risk is the risk that the investor will have to sell a bond below its true value where the true value is indicated by a recent transaction. The primary measure of liquidity is the size of the spread between the bid price and the ask price quoted by a dealer. The wider the bid/ask spread, the greater is the liquidity risk.

A liquid market generally can be defined by "small bid/ask spreads which do not materially increase for large transactions."[3] How to define the bid/ask spread in a multiple-dealer market is subject to interpretation. For example, consider the bid/ask spread for four dealers. Each quote is for 92 plus the number of 32nds shown:

	Dealer			
	1	**2**	**3**	**4**
Bid price	1	1	2	2
Ask price	4	3	4	5

The bid/ask spread for each dealer (in 32nds) is

	Dealer			
	1	**2**	**3**	**4**
Bid/ask spread	3	2	2	3

3. Robert I. Gerber, "A User's Guide to Buy-Side Bond Trading," Chapter 16 in Frank J. Fabozzi (ed.), *Managing Fixed Income Portfolios* (New Hope, PA: Frank J. Fabozzi, 1997), p. 278.

The bid/ask spread as computed above is measured relative to a dealer. The best bid/ask spread is two 32nds for Dealers 2 and 3.

From the perspective of the *market overall,* the bid/ask spread can be computed by looking at the best bid price (high price at which one of the dealers is willing to buy the security) and the lowest ask price (lowest offer price at which one of the dealers is willing to sell the security). This liquidity measure is called the *market bid/ask spread.* For the four dealers, the highest bid price is 92 plus two 32nds and the lowest ask price is 92 plus three 32nds. Thus the market bid/ask spread is one 32nd.

For investors who plan to hold a bond until maturity and need not mark a position to market, liquidity risk is not a major concern. An institutional investor who plans to hold an issue to maturity but is periodically marked to market is concerned with liquidity risk. By marking a position to market, it is meant that the security is revalued in the portfolio based on its current market price. For example, mutual funds are required to mark to market at the end of each day the holdings that are in their portfolio in order to compute the net asset value (NAV). While other institutional investors may not mark to market as frequently as mutual funds, they are marked to market when reports are periodically sent to clients or the board of directors or trustees.

Where are the prices obtained to mark a position to market? Typically, a portfolio manager will solicit indicative bids from several dealers and then use some process to determine the bid price used to mark the position. The less liquid the issue, the greater the variation there will be in the bid prices obtained from dealers. With an issue that has little liquidity, the price may have to be determined by a pricing service rather than by dealers. Moreover, lack of dealer indicative bids and concern with models used by pricing services may lead the manager to occasionally override a bid (subject to internal approval beyond the control of the manager).

EXCHANGE-RATE, OR CURRENCY, RISK

A non-dollar-denominated bond (i.e., a bond whose payments occur in a foreign currency) has unknown U.S. dollar cash-flows. The dollar cash-flows are dependent on the foreign-exchange-rate at the time the payments are received. For example, suppose that an investor purchases a bond whose payments are in Japanese yen. If the yen depreciates relative to the U.S. dollar, then fewer dollars will be received. The risk of this occurring is referred to as *exchange-rate risk,* or *currency risk.* Of course, should the yen appreciate relative to the U.S. dollar, the investor will benefit by receiving more dollars.

In addition to the change in the exchange-rate, an investor is exposed to the interest-rate, or market, risk in the local market. For example, if a U.S. investor purchases German government bonds denominated in euros, the proceeds received from the sale of that bond prior to maturity will depend on the level of interest rates in the German bond market, in addition to the exchange-rate.

VOLATILITY RISK

As will be explained in later chapters, the price of a bond with an embedded option depends on the level of interest rates and factors that influence the value of the embedded option. One of the factors is the expected volatility of interest rates. Specifically, the value of an option rises when expected interest-rate volatility increases. In the case of a callable bond or mortgage-backed security, because the investor has granted an option to the borrower, the price of the security falls because the investor has given away a more valuable option. The risk that a change in volatility will adversely affect the price of a security is called *volatility risk.*

Multifactor risk models often refer to volatility risk as *vega*. This is because in option theory, there are measures of the exposure of an option to changes in the factors that affect an option's value. One of the factors is volatility, and vega is the term used to measure the sensitivity of an option's price to a change in volatility. Hence, the sensitivity of bonds with embedded options and a bond portfolio containing bonds with embedded options to changes in volatility is given the same name.

POLITICAL OR LEGAL RISK

Sometimes the government can declare withholding or other additional taxes on a bond or declare a tax-exempt bond taxable. In addition, a regulatory authority can conclude that a given security is unsuitable for investment entities that it regulates. These actions can adversely affect the value of the security. Similarly, it is also possible that a legal or regulatory action affects the value of a security positively. The possibility of any political or legal actions adversely affecting the value of a security is known as *political* or *legal risk.*

To illustrate political or legal risk, consider investors who purchase tax-exempt municipal securities. They are exposed to two types of political risk that can be more appropriately called *tax risk.* The first type of tax risk is that the federal income tax rate will be reduced. The higher the marginal tax rate, the greater is the value of the tax-exempt nature of a municipal security. As the marginal tax rates decline, the price of a tax-exempt municipal security will decline. For example, proposals for a flat tax with a low tax rate significantly reduced the potential tax advantage of owning municipal bonds. As a result, tax-exempt municipal bonds began trading at lower prices. The second type of tax risk is that a municipal bond issued as tax exempt eventually will be declared taxable by the Internal Revenue Service (IRS). This may occur because many municipal (revenue) bonds have elaborate security structures that could be subject to future adverse congressional actions and IRS interpretations. As a result of the loss of the tax exemption, the municipal bond will decline in value in order to provide a yield comparable to similar taxable bonds.

EVENT RISK

Occasionally, the ability of an issuer to make interest and principal payments is seriously and unexpectedly changed by (1) a natural or industrial accident or (2) a takeover or corporate restructuring. These risks are referred to as *event risk.* The cancellation of plans to build a nuclear power plant illustrates the first type of event in relation to the utility industry.

An example of the second type of event risk is the takeover in 1988 of RJR Nabisco for $25 billion via a financing technique known as a *leveraged buyout* (LBO). In such a transaction, the new company incurred a substantial amount of debt to finance the acquisition of the firm. Because the corporation was required to service a substantially larger amount of debt, its quality rating was reduced to non-investment-grade quality. As a result, the change in yield spread to a benchmark Treasury, demanded by investors because of the LBO announcement, increased from about 100 to 350 basis points.

There are also spillover effects of event risk on other firms. For example, if there is a nuclear accident, this will affect all utilities producing nuclear power.

SECTOR RISK

Bonds in different sectors of the market respond differently to environmental changes because of a combination of some or all of the preceding risks, as well as others. Examples include discount versus premium coupon bonds, industrial versus utility bonds, and corporate versus mortgage-backed bonds. The possibility of adverse differential movement of specific sectors of the market is called *sector risk.*

OTHER RISKS

The various risks of investing in the fixed income markets reviewed in this chapter do not represent the entire range of risks. In the marketplace, it is customary to combine almost all risks other than market risk (interest-rate risk) and refer to it as *basis risk.*

STATISTICAL MEASURES OF PORTFOLIO RISK: STANDARD DEVIATION, SKEWNESS, AND KURTOSIS

In the development of portfolio theory as formulated by Harry Markowitz (also known as mean-variance analysis), a portfolio's risk is measured by the *standard deviation* of historical portfolio returns.[4] This statistical measure provides a range around the average return of a portfolio within which the actual return over a period

4. Harry M. Markowitz, "Portfolio Selection," *Journal of Finance* 7, 1 (1952), pp. 77–91.

is likely to fall with some specific probability. In evaluating actual and potential performance relative to a benchmark that is a bond index, the mean return and standard deviation of returns of the bond index and the portfolio are compared.

Extensions of portfolio risk to take into account other statistical measures of a return distribution are being used in practice.[5] Two statistical measures most commonly used are skewness and kurtosis. A return distribution is said to be symmetric based on the probability distribution around the mean or expected value. If the return distribution is the same above and below the mean value, then the distribution is said to be symmetric. If a return distribution does not exhibit this property, it is said to be *asymmetric*. *Skewness* is a measure of the symmetry of a return distribution. Actually, it is more meaningful to say that skewness is a measure of the lack of symmetry of the return distribution. The normal distribution is a symmetric distribution. Consequently, when the return distribution is assumed to be normally distributed, skewness is not a concern.

Kurtosis is a statistical measure of whether a return distribution is peaked or flat relative to a normal distribution. That is, a return distribution with high kurtosis tends to have a distinct peak near the mean value, decline rather rapidly, and has fat (or heavy) tails. This property for a return distribution occurs when in addition to many modest-sized deviations from the mean value there are also infrequent extreme deviations from the mean value. Return distributions that exhibit low kurtosis tend to have a flat top near the mean value rather than a sharp peak.

TRACKING ERROR RISK

A bond portfolio's standard deviation and a designated benchmark's standard deviation are absolute numbers. A portfolio manager can compare the mean values and standard deviations to try to get a feel for the risk profile of the portfolio relative to the benchmark. If skewness and kurtosis are also considered, this would provide an expanded profile of the relative risks of the bond portfolio and the bond index.

A portfolio manager or client can also assess what the variation in the portfolio's return is relative to a benchmark (such as a bond index) by looking at the deviations of the periodic (weekly or monthly) portfolio return from that of the benchmark. The difference between the two is called the *active return*. That is

Active return = Portfolio's actual return – Benchmark's actual return

From the active returns, a portfolio's risk relative to the benchmark can be calculated by the standard deviation of the active returns. This standard deviation is referred to as *tracking error risk* or *tracking error volatility*, or simply *tracking error*.

5. Svetlozar T. Rachev, Christian Menn, and Frank J. Fabozzi, *Fat-Tailed and Skewed Asset Return Distributions: Implications for Risk Management, Portfolio Selection, and Option Pricing* (New York: John Wiley & Sons, 2005).

The larger a portfolio's tracking error, the more its risk profile deviates from that of the benchmark. In fact, when bond portfolio strategies are discussed in later chapters, we will see that there are active and passive strategies. The latter strategies involve little tracking error. For example, a portfolio constructed to match the performance of a bond index will have a tracking error close to zero. Active strategies will have higher tracking error, how much higher depending on the degree of risk the portfolio manager or client is willing to accept.

There are two types of tracking error. Tracking error calculated from a portfolio's historical active returns is called *backward-looking tracking error*. It is also called *historical tracking error* and *ex-post tracking error*. The limitation of backward-looking tracking error is that it fails to take into account the effect of current decisions by the portfolio manager on the future active returns and therefore may have little predictive value and can be misleading regarding the portfolio risks going forward. The other type of tracking error is *forward-looking tracking error*—also called *predicted tracking error* and *ex-ante tracking error*. This form of tracking error seeks to accurately reflect the portfolio's risk going forward. In practice, forward-looking tracking error is estimated using a multi-factor risk model as described in Chapters 46 and 47.

KEY POINTS

- The risks associated with investing in individual fixed income securities are interest-rate risk, reinvestment risk, call/prepayment risk, credit risk, inflation (or purchasing-power) risk, liquidity risk, exchange-rate (or currency) risk, volatility risk, political or legal risk, event risk, and sector risk.
- Interest-rate risk is the risk associated with an adverse change in interest rates and includes level risk and yield-curve risk. The most popular measure of level risk is duration; key rate duration is the most popular measure of yield-curve risk.
- Credit risk includes default risk, credit-spread risk, and downgrade risk. Credit risk models seek to estimate the probability distribution of losses for a bond portfolio.
- Portfolio risk measures include statistical measures of return and tracking error risk.
- Statistical measures of portfolio and benchmark risk include the standard deviation, skewness, and kurtosis.
- Tracking error risk is the standard deviation of the active return of a portfolio (i.e., the difference between the portfolio's return and the benchmark's return). Backward-looking tracking error is used to assess a portfolio's performance relative to a benchmark. Forward-looking tracking error is used to predict future performance relative to a benchmark.

CHAPTER
THREE

BOND MARKET INDEXES

FRANK K. REILLY, PH.D., CFA
Bernard J. Hank Professor of Finance
University of Notre Dame

DAVID J. WRIGHT, PH.D.
Professor of Finance
University of Wisconsin–Parkside

The value of nonmunicipal bonds outstanding in the United States at over $8 trillion is fairly close to the combined value of equity in the United States, and a similar comparison holds for world capital markets, where the value of fixed income securities is typically similar to the total value of equity. The only instance where this capital comparison does not hold is in some emerging-market countries, where the bond markets have not yet developed. Given the economic importance of fixed income markets, it is difficult to understand why there has not been greater concern and analysis of bond market indexes. Part of the reason for this lack of analysis of bond market indexes is the relatively short history of these indexes. Specifically, in contrast to stock market indexes that have been in existence for over 100 years, total rate-of-return bond indexes were not developed until the 1970s, and those created in the 1970s were limited to U.S. investment-grade bonds. For example, indexes for U.S. high-yield bonds, where the market has grown to over $1 trillion, were not established until the mid-1980s, which is also when international government bond indexes were created.

There are four parts to this chapter. The first section considers the major uses for bond market indexes. The second section is concerned with the difficulty of building and maintaining a bond market index compared with the requirements for a stock market index. The third section contains a description of the indexes available in three major categories. Finally, we present the risk/return characteristics of the alternative bond market sectors and examine the correlations among the alternative indexes.

USES OF BOND INDEXES

An analysis of bond market indexes is important and timely for several reasons. First, the bond portfolios of both pension funds and individuals have grown substantially in recent years; sales of fixed income mutual funds have exceeded

equity mutual fund sales in a number of years. With the increase in the number and size of bond portfolios, investors and portfolio managers increasingly have come to rely on bond indexes *as benchmarks for measuring performance* and, in the case of those managing portfolios on a performance-fee basis, for determining compensation. There are numerous indexes of differing construction that purport to measure the aggregate bond market and the major sectors of the market (government, corporate, and mortgages). An obvious concern is the choice of an appropriate index that will provide an accurate benchmark of bond market behavior.

Second, benchmarks for *bond index funds* have become increasingly popular because those who monitor the performance of bond portfolios have discovered that, similar to equity managers, most bond portfolio managers have not been able to outperform the aggregate bond market. The amount of money invested in bond index funds grew from $3 billion in 1984 to over $400 billion in 2010. Given the total size and growth of the bond market, it is estimated that bond index funds could grow to over $600 billion during the second decade of the twenty-first century.

The behavior of a particular bond index is critical to fixed income managers who attempt to replicate its performance in an index fund. Clearly, if all indexes move together, one would be indifferent to the choice of a particular index. We examine the return correlations between the various indexes and their risk/return characteristics. The analysis of long-term risk/return and correlations is important because index numbers may differ markedly over short periods of time and yet still exhibit similar long-run movements.

Portfolio managers of a bond index fund need to rebalance their assets to replicate the composition, maturity, and duration of the bond market. As shown in Reilly, Kao, and Wright,[1] the composition of the bond market changed dramatically during the 1980s, and there have been continuing changes during the 1990s and early 2000s. It is possible to use the indexes to document the intertemporal changes in the makeup, maturity, and duration of the bond market that have influenced its risk and return characteristics.

Third, because of the size and importance of the bond market, there has been and will continue to be substantial fixed income research; the bond market indexes can provide accurate and timely measurement of the risk/return characteristics of these assets and the characteristics of the market, as noted earlier. For example, the time-series properties of equity index returns have been examined extensively, but these same tests were not applied to bond market returns. Our investigation indicated significant autocorrelation in bond market index returns, which were explained by examining the intertemporal behavior of U.S. Treasury securities with different maturities.[2]

1. Frank K. Reilly, Wenchi Kao, and David J. Wright, "Alternative Bond Market Indexes," *Financial Analysts Journal* 48, no. 3 (May–June 1992), pp. 44–58.
2. *Ibid.*

BUILDING AND MAINTAINING A BOND INDEX

To construct a *stock market index,* you have to select a sample of stocks, decide how to weight each component, and select a computational method. Once you have done this, adjustment for stock splits typically is automatic, and the pricing of the securities is fairly easy because most of the sample stocks are listed on a major stock exchange or actively traded in the over-the-counter (OTC) market. Mergers or significant changes in the performance of the firms in an index may necessitate a change in the index components. Other than such events, a stock could continue in an index for decades. (On average, the Dow Jones Industrial Average has about one change per year.)

In contrast, the creation, computation, and maintenance of a bond market index is more difficult for several reasons. First, *the universe of bonds is broader and more diverse than that of stocks*. It includes U.S. Treasury issues, agency series, municipal bonds, and a wide variety of corporate bonds spanning several segments (industrials, utilities, financials) and ranging from high-quality, AAA-rated bonds to bonds in default. Furthermore, within each group, issues differ by coupon and maturity, as well as by sinking funds and call features. As a result of this diversity, an aggregate bond market series can be subdivided into numerous subindexes; the Bank of America Merrill Lynch series (B of A-ML), for example, contains over 150 subindexes.

Second, *the universe of bonds changes constantly*. A firm typically will have one common stock issue outstanding, which may vary in size over time as the result of additional share sales or repurchases. In contrast, a major corporation will have several bond issues outstanding at any point in time, and the characteristics of the issues will change constantly because of maturities, sinking funds, and call features. This constant fluctuation in the universe of bonds outstanding also makes it more difficult to determine the market value of bonds outstanding, which is a necessary input when computing market-value-weighted rates of return.

Third, *the volatility of bond prices varies across issues and over time*. As indicated in Chapter 7, bond price volatility is influenced by the *duration* and *convexity* of the bond. These factors change constantly because they are affected by the maturity, coupon, market yield, and call features of the bond. Also, market yields have become more volatile, which, in turn, has an effect on the value of embedded call options and makes it more difficult to estimate the duration, convexity, and implied volatility of an individual bond issue or an aggregate bond series.

Finally, *there can be significant problems in the pricing of individual bond issues*. Individual bond issues generally are not as liquid as stocks. While most stock issues are listed on exchanges or traded on an active OTC market with an electronic quotation system (NASDAQ), most bonds (especially corporates) have historically been traded on a fragmented OTC market. Notably, this problem will be alleviated in the future with expanded trading on electronic platforms.[3]

3. Electronic bond trading and trading platforms are discussed in Chapter 4.

DESCRIPTION OF ALTERNATIVE BOND INDEXES

This section contains three subsections to reflect three major sectors of the global bond market: (1) U.S. investment-grade bonds (including Treasury bonds), (2) U.S. high-yield bonds, and (3) international government bonds. We examine the overall constraints and computational procedures employed for the indexes in these three sectors.

Several characteristics are critical in judging or comparing bond indexes. First is the *sample of securities,* including the number of bonds as well as specific requirements for including the bonds in the sample, such as maturity and size of issue. It is also important to know what issues have been excluded from the index. Second is the *weighting of returns* for individual issues. Specifically, are the returns market-value weighted or equally weighted? Third, users of indexes need to consider the *quality of the price data* used in the computation. Are the bond prices used to compute rates of return based on actual market transactions, as they almost always are for stock indexes? Alternatively, are the prices provided by bond traders based on recent actual transactions or are they the traders' current "best estimate"? Finally, are they based on *matrix pricing,* which involves a computer model that estimates a price using current and historical relationships? Fourth, what *reinvestment assumption* does the rate of return calculation use for interim cash-flows?

U.S. Investment-Grade Bond Indexes

Four firms publish ongoing rate-of-return investment-grade bond market indexes. Three of them publish a comprehensive set of indexes that span the universe of U.S. bonds: Barclays Capital (BC) (formerly Lehman Brothers), Bank of America-Merrill Lynch (B of A-ML), and Morgan Stanley Smith Barney (MSSB). The fourth firm, Ryan Labs (RL), concentrates on a long series for the Treasury bond sector.

Exhibit 3–1 summarizes the major characteristics of the indexes created and maintained by these firms. Three of the four firms (BC, B of A-ML, and MSSB) include numerous bonds (over 5,000), and there is substantial diversity in a sample that can include Treasuries, corporates (credits), mortgage-backed, and asset-backed securities. In contrast, the RL series is limited to Treasury bonds and has a sample size that has varied over time based on the Treasury issues outstanding (i.e., from 26 to 118 issues). All the indexes require bonds to have maturities of at least one year. The required minimum size of an issue varies from $50 million (MSSB) to $200 million (BC), whereas the Treasury issues used by RL are substantially larger. All the series include only investment-grade bonds (rated BBB or better) and exclude convertible bonds and floating-rate bonds. The three broad-based indexes by BC, B of A-ML, and MSSB also exclude government flower bonds, whereas RL has included these bonds in its index because flower bonds were a significant factor in the government bond market during the 1950s.

The two major alternatives for weighting are *relative market value* of the issues outstanding and *equal weighting* (also referred to as *unweighted*). The justification for market-value weighting is that it reflects the relative economic

EXHIBIT 3–1

Summary of Bond Market Indexes

Name of Index	Number of Issues	Maturity	Size of Issues	Weighting	Pricing	Reinvestment Assumption	Subindexes Available
U.S. Investment-Grade Bond Indexes							
Barclay Capital Aggregate	8,000+	Over 1 year	Over $250 million	Market value	Trader priced	No	Government, gov./credit, corporate, mortgage-backed, asset-backed
Bank of America-Merrill Lynch Composite	6,000+	Over 1 year	Over $150 million	Market value	Trader priced (externally)	At one-month LIBID rate	Government, gov./corp., corporate mortgage pass-through
Ryan Treasury Composite	118	Over 1 year	All Treasury	Market value and equal	Market priced	In specific bonds	Treasury
Morgan Stanley Smith Barney	5,000+	Over 1 year	Over $50 million	Market value	Trader priced	In one-month T-bill	Broad inv. grade, Treas.-agency, corporate, mortgage
U.S. High-Yield Bond Indexes							
Credit Suisse First Boston	500+	All maturities	Over $100 million	Market value	Trader priced	Yes	Composite and by rating
Barclays Capital	1,800+	Over 1 year	Over $150 million	Market value	Trader priced	No	Composite and by rating
Bank of America-Merrill Lynch	2,000+	Over 1 year	Over $100 million	Market value	Trader priced (externally)	At one-month LIBID rate	Composite and by rating
Morgan Stanley Smith Barney	300+	Over 7 years	Over $50 million	Market value	Trader priced	Yes	Composite and by rating
Global Government Bond Indexes							
Barclays Capital	1,200+	Over 1 year	Over $300 million	Market value	Trader priced	No	Composite and 23 countries, local and U.S. dollars
Bank of America-Merrill Lynch	800+	Over 1 year	Approx. $1 billion U.S.	Market value	Trader priced	Yes	Composite and 20 countries, local and U.S. dollars
J. P. Morgan	700+	Over 1 year	Over $200 million	Market value	Trader priced	In index	Composite and 13 countries, local and U.S. dollars
Morgan Stanley Smith Barney	525	Over 1 year	Over $250 million	Market value	Trader priced	Yes at local short-term rate	Composite and 14 countries, local and U.S. dollars

Sources: Updated from Frank K. Reilly, Wenchi Kao, and David J. Wright, "Alternative Bond Market Indexes," *Financial Analysts Journal* 48, no. 3 (May–June 1992); Frank K. Reilly and David J. Wright, "An Analysis of High-Yield Bond Benchmarks," *Journal of Fixed Income* 3, no. 4 (March 1994); and Frank K. Reilly and David J. Wright, "Global Bond Markets: An Analysis of Performance and Benchmarks," mimeo (March 1994).

importance of the issue and is a logical weighting for an investor with no preferences regarding asset allocation. Although this theoretical argument is reasonable, it is important to recognize that in the real world it is difficult to keep track of the outstanding bonds, given the possibility of calls, sinking funds, and redemptions. The alternative of equal weighting is reasonable for an investor who has no prior assumptions regarding the relative importance of individual issues. Also, equal weighting is consistent if one is assuming the random selection of issues. Finally, an equally weighted index is easier to compute, and the results are unambiguous because it is not necessary to worry about outstanding market value owing to calls and so on. The three large-sample indexes are value-weighted, whereas RL has created both a value-weighted and an equal-weighted series (for comparability, we use the value-weighted series).

As noted, one of the major problems with computing returns for a bond index is that continuous transaction prices are not available for most bonds. RL can get recent transaction prices for its Treasury issues, whereas MSSB gets all prices from its traders. As noted, these trader prices may be based on a recent actual transaction, the trader's current bid price, or what the trader would bid if he made a market in the bond. Both BC and B of A-ML use a combination of trader pricing (B of A-ML from an external source) and matrix prices based on a computer model. Because most of the individual issues are priced by traders, the majority of each index is based on trader prices.

The indexes also treat interim cash-flows differently. RL assumes that cash-flows are immediately reinvested in the bonds that generated the cash-flows, MSSB assumes that flows are reinvested at the one-month T-bill rate, B of A-ML assumes reinvestment at the one-month London interbank bid (LIBID) rate, whereas BC does not assume any reinvestment of funds. Obviously, immediate reinvestment in the same bond is the most aggressive assumption, whereas no reinvestment is the most conservative.

U.S. High-Yield Bond Indexes

There are two notable points about high-yield (HY) bond indexes. First, they have a shorter history than the investment-grade bond indexes. This is not surprising because, as shown in several studies, this market only became a recognizable factor in 1977, and its major growth began in about 1982.[4] Therefore, the fact that HY bond indexes began in about 1984 is reasonable.

4. Edward I. Altman, "Revisiting the High-Yield Bond Market: Mature but Never Dull," *Journal of Applied Corporate Finance* 13, no. 1 (Spring 2000), pp. 64–74; Rayner Cheung, Joseph C. Bencivenga, and Frank J. Fabozzi, "Original-Issue High-Yield Bonds: Historical Return and Default Experiences 1977–1989," *Journal of Fixed Income* 2, no. 2 (September 1992), pp. 58–76; Martin S. Fridson, "The State of the High-Yield Bond Market: Overshooting or Return to Normalcy?" *Journal of Applied Corporate Finance* 7, no. 1 (Spring 1994), pp. 85–97; Frank K. Reilly, David J. Wright, and James A. Gentry, "Historic Changes in the High-Yield Bond Market," *Journal of Applied Corporate Finance* 21, no. 3 (Summer, 2009), pp. 65–79.

Second, earlier we noted the general difficulty of creating and maintaining bond indexes because of the constant changes in the size and characteristics of the sample and the significant pricing problems. The fact is that these difficulties are magnified when dealing with the HY bond market because it experiences more extensive sample changes owing to defaults and more frequent redemptions. In addition, the illiquidity and bond pricing problems in the HY bond market are a quantum leap above those faced in the government and investment-grade corporate bond markets.

As shown in Exhibit 3–1, four investment firms have created HY bond indexes Credit Suisse First Boston (CSFB), Barclays Capital (BC), Bank of America-Merrill Lynch (B of A-ML), and Morgan Stanley Smith Barney (MSSB). The investment firms also have created indexes for rating categories within the HY bond universe: BB, B, and CCC bonds.

The summary of characteristics in Exhibit 3–1 indicates that there are substantial differences among the HY bond indexes. This contrasts with relatively small differences in the characteristics of investment-grade bond indexes. The number of issues in the alternative HY bond indexes varies from about 300 HY bonds in the MSSB series to 1,900 bonds in the B of A-ML series. Some of the differences in sample size can be traced to the maturity constraints of the particular index. The large number of bonds in the B of A-ML series can be explained in part by its maturity guideline, which includes all HY bonds with a maturity over one year compared with a seven-year maturity requirement for the MSSB series.

The minimum issue size is also important because MSSB has a minimum issue size requirement of $50 million compared with $100 million (CSFB and B of A-ML) and $150 million (BC).

Notably, there are significant differences in how the alternative indexes handle defaulted issues. The treatment varies, from dropping issues the day they default (B of A-ML) to retaining them for an unlimited period subject to size and other constraints (CSFB and BC). In contrast, there is no difference in return weighting; that is, all the indexes use market-value weighting.

All the bonds in the HY bond indexes are trader priced except for B of A-ML, which uses matrix pricing for a few of its illiquid issues. The difficulty with trader pricing is that when bond issues do not trade, the price provided is a trader's best estimate of what the price "should be." Matrix pricing is likewise a problem because each issue has unique characteristics that may not be considered by the computer program. Therefore, it is possible to get significantly different prices from alternative traders or matrix pricing programs.

All the indexes except BC assume the reinvestment of interim cash-flows, but at different rates—that is, the individual bond rate, the one-month LIBID rate, or a T-bill rate. Finally, the average maturity and the duration for the indexes are consistent with the constraints on the index: CSFB, BC, and B of A-ML have one-year minimums and lower durations, whereas MSSB with a seven-year minimum is at the high end.

In summary, there are significant differences in the characteristics of the alternative HY bond indexes in terms of the samples and pricing. One would expect these differences to have a significant impact on the risk/return performance and the correlations among indexes.[5]

Global Government Bond Market Indexes

Similar to the HY bond indexes, these global-based indexes are relatively new (beginning in 1985) because there was limited interest in these markets prior to the 1980s. The summary description in Exhibit 3–1 indicates numerous similarities among the indexes by the four investment firms (J. P. Morgan [JPM], Barclays Capital [BC], Bank of America-Merrill Lynch [B of A-ML], and Morgan Stanley Smith Barney [MSSB]). An exception is the minimum size, which varies from $200 million (JPM) to $1 billion (B of A-ML). In turn, this issue-size constraint has an impact on the sample sizes, which ranges from JPM at 500 to BC with over 800 bonds. The indexes are the same regarding market value weighting and trader pricing. All of them except BC assume the reinvestment of cash-flows with small differences in the reinvested security. The final difference is the number of countries included, which varies from 13 (JPM) to 23 (BC).

RISK/RETURN CHARACTERISTICS

The presentation of the risk/return results is divided into two subsections. The first subsection presents and discusses the results for the U.S. indexes, including government and investment-grade bonds, as well as HY bonds. The second subsection provides a similar presentation for global bond indexes, including both domestic and U.S. dollar returns.

U.S. Investment-Grade and HY Bonds

The arithmetic and geometric average annual rates of return and risk measures are contained in Exhibit 3–2 for the period beginning in 1986, when the data are available for almost all the series except the Altman defaulted bond series, which began in 1987. We show the BC index for U.S. investment-grade bonds because it has been shown that all the investment-grade bond series are very highly correlated.[6]

When viewing the results in Exhibit 3–2 and Exhibit 3–3, one is struck by two factors. The first is the generally high level of mean returns over this 25-year period, wherein the investment-grade bonds experienced average annual returns of between 7% and 8% and the HY bonds attained returns between 7% and almost 10%.

5. For a detailed analysis of the alternative HY bond indexes, see Frank K. Reilly and David J. Wright, "An Analysis of High-Yield Bond Benchmarks," *Journal of Fixed Income* 3, no. 4 (March 1994), pp. 6–25.
6. Reilly, Kao, and Wright, *op cit*.

EXHIBIT 3–2

Rates of Return, Risk, and Annual Range for U.S. and Global Bond Indexes (1986–2010)

	Geometric Mean Annual Return	Arithmetic Mean Annual Return	Standard Deviation of Monthly Returns	Coefficient of Variation*	Minimum Annual Return	Maximum Annual Return
U.S. Bond Indexes						
Barclays Capital Govt/Credit	7.42	7.56	5.45	0.72	–3.51	19.24
Barclays Capital Government	7.20	7.36	5.86	0.80	–3.37	18.34
Barclays Capital Credit	7.94	8.13	6.49	0.80	–3.93	22.25
Barclays Capital U.S. MBS	7.56	7.65	4.46	0.58	–1.61	16.80
Barclays Capital Aggregate	7.46	7.58	5.09	0.67	–2.92	18.47
Barclays Capital Composite High-Yield	8.96	10.14	16.87	1.66	–26.16	58.21
Barclays Capital High-Yield Ba Grade	9.66	10.26	11.89	1.16	–17.53	46.09
Barclays Capital High-Yield B Grade	8.26	9.25	15.01	1.62	–26.65	44.73
Barclays Capital High-Yield Caa Grade	7.19	10.80	30.28	2.80	–44.35	90.65
Altman Default Index (1987-2010)	7.15	12.23	34.11	2.79	–55.09	96.42
Bank of America-Merrill Lynch Global Government Bond Indexes in Local Currency						
B of A-ML Canada	8.40	8.57	6.14	0.72	–4.33	21.28
B of A-ML France	7.79	7.96	6.10	0.77	–4.37	20.21
B of A-ML Germany	6.26	6.36	4.74	0.75	–2.10	16.03
B of A-ML Japan	4.34	4.44	4.69	1.06	–2.92	13.45
B of A-ML U.K.	8.74	8.96	7.02	0.78	–5.65	21.20
B of A-ML U.S. Treasury	7.20	7.37	6.09	0.83	–3.72	18.45

*Coefficient of Variation = Standard Deviation of Annual Returns/Arithmetic Mean Annual Return

(Continued)

EXHIBIT 3–2

Rates of Return, Risk, and Annual Range for U.S. and Global Bond Indexes (1986–2010) *(Continued)*

	Geometric Mean Annual Return	Arithmetic Mean Annual Return	Standard Deviation of Monthly Returns	Coefficient of Variation*	Minimum Annual Return	Maximum Annual Return
Bank of America-Merrill Lynch Global Government Bond Indexes in $U.S.						
B of A-ML Global with U.S.	8.17	8.43	7.74	0.92	–6.48	22.96
B of A-ML Global without U.S.	8.92	9.48	11.41	1.20	–9.12	35.88
B of A-ML Canada	9.89	10.32	9.77	0.95	–10.52	29.17
B of A-ML France	9.65	10.39	12.86	1.24	–17.17	33.83
B of A-ML Germany	8.48	9.28	13.49	1.45	–16.48	37.52
B of A-ML Japan	8.20	9.14	14.75	1.61	–14.21	40.05
B of A-ML U.K.	9.09	9.84	13.28	1.35	–18.35	46.31
B of A-ML U.S. Treasury	7.20	7.37	6.09	0.83	–3.72	18.45

*Coefficient of Variation = Standard Deviation of Annual Returns/Arithmetic Mean Annual Return

EXHIBIT 3–3

Geometric Mean Return versus the Standard Deviation of U.S. Bond Index Returns (1986–2010)

The second observation is that the relationship between return and risk (measured as the standard deviation of annual returns) generally was consistent with expectations. The investment-grade bond indexes typically had lower returns and risk, whereas the HY bond indexes had higher returns and risk measures. The major deviations were the high-risk segments (Caa-rated bonds and defaulted bonds), which experienced returns clearly below HY debt but risk substantially above all other assets.[7] The Ba-rated bonds experienced abnormally positive results because they experienced returns clearly above other HY bonds but experienced the lowest risk among any other HY bond sector.

Global Government Bonds

These results will be considered in two parts, involving results in local currency and in U.S. dollars. The results in Exhibits 3–2 and 3–4 show significant consistency between the risk and returns in local currency. Within Europe, Germany experienced the lowest return (6.26%), while the United Kingdom had the highest return (8.74%) but also experienced the highest risk (over 7% for the United Kingdom

7. For a detailed analysis of defaulted-debt securities, see Frank K. Reilly, David J. Wright, and Edward I. Altman, "Including Defaulted Debt in the Capital Markets Asset Spectrum," *Journal of Fixed Income* 8, no. 3 (December 1998), pp. 33–48.

EXHIBIT 3–4

Geometric Mean Return versus the Standard Deviation of Country Government Bond Index Returns in Local Currency (1986–2010)

versus less than 5% for Germany). The only country that deviated from the main security market line was Japan, which experienced low risk but very low return (about 4.3%).

The return/risk results in U.S. dollars are shown in Exhibits 3–2 and 3–5. The graph in Exhibit 3–5 makes it clear that the results change substantially with

EXHIBIT 3–5

Geometric Mean Return versus the Standard Deviation of Global and Country Government Bond Index Returns in U.S. Dollars (1986–2010)

the conversion to U.S. dollars. Specifically, the United States is clearly the low risk/return market, in contrast to Canada that had the highest return and the lowest risk except for the United States. France, the United Kingdom, and Germany had similar risk but France experienced the highest return followed by the UK and then Germany. Japan was below the consensus line with the highest risk and returns below all countries but the United States.

In addition to the individual countries, there is a global index with and without the United States. Both these indexes were consistent with overall results.

CORRELATION RELATIONSHIPS

The correlations likewise are presented in two parts: U.S. bond market results and global bond market results.

U.S. Investment-Grade and HY Bonds

The correlation results in Exhibit 3–6 confirm some expectations about relationships among sectors of the bond market but also provide some unique results. The expected relationships are those among the five investment-grade bond indexes. Because all these are investment grade, there is a small probability of default, so the major factor influencing returns is aggregate interest-rate changes based on the Treasury yield-curve. Therefore, since these index returns have a common determinant (Treasury bond rate changes), they are very highly correlated. Specifically, the correlations among the BC investment grade indexes range from about 0.79 to 0.99, with the results for the mortgage bond sector at the low end because of the impact of embedded call options on mortgage bonds.

The HY bond results show two distinct patterns. First, the correlations among the HY indexes are quite high, ranging from 0.72 to 0.96. In contrast, the correlations among investment-grade bonds and HY bonds have a greater range and are significantly lower, generally ranging from about 0.00 to 0.56. Not surprisingly, the highest correlations are between Ba-rated bonds and investment-grade bonds, whereas the lowest correlations (typically insignificant) are between investment-grade bonds and Caa-rated bonds.

The correlations of defaulted debt with other segments were diverse but not unexpected. The correlations between defaulted debt and investment-grade debt generally were negative and sometimes significant. In contrast, the correlations among defaulted debt and various HY bonds were relatively large positive values, and all were significant.

Global Government Bond Correlations

Again the discussion is in two parts, wherein we consider the local currency results and then U.S. dollar results. Exhibit 3–7 contains correlations among

EXHIBIT 3–6

Correlation Coefficients of the U.S. Bond Index Monthly Returns (1986–2010)

	BC Govt./Credit	BC Govt.	BC Credit	BC MBS	BC Aggr.	BC HY-Comp	BC HY-Ba	BC HY-B	BC HY-Caa	Altman Default
BC Govt./Credit	1.000									
BC Govt.	0.965*	1.000								
BC Credit	0.931*	0.805*	1.000							
BC MBS	0.874*	0.870*	0.788*	1.000						
BC Aggr.	0.990*	0.960*	0.919*	0.925*	1.000					
BC HY-Comp	0.233*	0.038	0.483*	0.171*	0.249*	1.000				
BC HY-Ba	0.354*	0.158*	0.590*	0.286*	0.369*	0.931*	1.000			
BC HY-B	0.204*	0.015	0.448*	0.149*	0.220*	0.983*	0.893*	1.000		
BC HY-Caa	0.076	–0.094	0.310*	0.045	0.092	0.910*	0.781*	0.876*	1.000	
Altman Default ('87–'10)	–0.084	–0.241*	0.142*	–0.132*	–0.080	0.670*	0.563*	0.659*	0.694*	1.000

*Significant at the 5% level.

EXHIBIT 3–7

Correlation Coefficients among Monthly Global Government Bond Index Returns in Local Currency (1986–2010)

	B of A-ML U.S.	B of A-ML Canada	B of A-ML France	B of A-ML Germany	B of A-ML Japan	B of A-ML U.K.	B of A-ML Global w/o U.S.	B of A-ML Global with U.S.
B of A-ML U.S.	1.000							
B of A-ML Canada	0.745	1.000						
B of A-ML France	0.606	0.512	1.000					
B of A-ML Germany	0.633	0.532	0.851	1.000				
B of A-ML Japan	0.338	0.334	0.312	0.372	1.000			
B of A-ML U.K.	0.587	0.587	0.645	0.678	0.356	1.000		
B of A-ML w/o U.S.	0.410	0.339	0.279	0.348	0.423	0.373	1.000	
B of A-ML with U.S.	0.620	0.489	0.388	0.445	0.430	0.460	0.960	1.000

All of the correlation coefficients are significant at the 5% level. The B of A-ML Global returns are expressed in U.S. dollars.

returns in local currencies. The correlations of Canada with all European countries indicate a similar relationship (about 0.50), with Japan at 0.33, and the U.S.–Canada correlation was about 0.75. In turn, France had a strong correlation with Germany (0.85)—its major trading partner in Europe—and 0.68 with the United Kingdom. Japan had correlations with the European countries between 0.31 and 0.37 and a correlation with the United States of only 0.34, even though Japan and the United States conduct significant trade.

Exhibit 3–8 contains correlations among returns in U.S. dollars. The results differ from local currency results and normal expectations. Typically, correlations decline when one goes from local currency to U.S. currency because of the effect of random exchange-rate changes, which reduce the relationships. As expected, this decline in correlations occurred among all these countries and the United States, and it also happened for all correlations with Canada. In contrast, the correlations among the European countries and for these countries with Japan consistently experienced large *increases* when returns were in U.S. dollars, and all the correlations with the global indexes increased substantially. For example, the correlations between France and Germany went from about 0.85 to 0.97. This implies that during this period, the exchange-rate correlations were quite high and became a cause for stronger return correlations. In addition, the European Union currency was initiated on January 1, 1999, which had an impact on the recent results.

KEY POINTS

- Bond market indexes are important for those who analyze bonds or manage bond portfolios because they have several significant uses, including acting as performance benchmarks, a benchmark for investors who want to invest through index funds, and a means to determine fixed income asset risk/return characteristics and correlations as inputs into the asset allocation decision.
- A brief analysis of the risk/return characteristics of alternative bond series indicates that most of the series had results in line with expectations. The outliers are the very risky securities (Caa bonds and defaulted bonds), which underperformed, while low-risk high-yield bonds (Ba rated), outperformed. The global bond results are heavily affected by the currency effect. Local currency results are consistent, except for Japan, which was below the market line. The U.S. dollar results were quite consistent in terms of risk and return, with most countries showing benefits from the weak dollar. The global index results were in line with most country results.
- The analysis of correlations for U.S. bond indexes indicates that there are very high correlations among bond series within either the investment-grade or the high-yield bond sector (typically between 0.79 and 0.99).

EXHIBIT 3–8

Correlation Coefficients among Monthly Global Government Bond Index Returns in U.S. Dollars (1986–2010)

	B of A-ML U.S.	B of A-ML Canada	B of A-ML France	B of A-ML Germany	B of A-ML Japan	B of A-ML U.K.	B of A-ML Global w/o U.S.	B of A-ML Global with U.S.
B of A-ML U.S.	1.000							
B of A-ML Canada	0.397	1.000						
B of A-ML France	0.411	0.349	1.000					
B of A-ML Germany	0.382	0.327	0.971	1.000				
B of A-ML Japan	0.270	0.108	0.513	0.538	1.000			
B of A-ML U.K.	0.358	0.341	0.663	0.661	0.431	1.000		
B of A-ML w/o U.S.	0.410	0.352	0.872	0.880	0.826	0.738	1.000	
B of A-ML with U.S.	0.620	0.433	0.865	0.859	0.761	0.706	0.960	1.000

All of the correlation coefficients are significant at the 5% level, except Japan versus Canada, which is significant at the 10% level.

In contrast, there are significantly lower correlations between investment-grade and high-yield bonds (with correlations typically between 0.20 and 0.40.) Defaulted debt had no correlation with investment-grade debt but fairly significant correlation with high-yield debt.

- The correlations among the global indexes in local currencies typically show fairly low relationships with other countries (about 0.50), except United States–Canada and France–Germany (between 0.75 and 0.85). The correlations changed when we considered returns in U.S. dollars. Specifically, all the correlations with the United States declined, whereas many of the correlations among non-U.S. countries increased owing to the weak U.S. dollar during this period, which affected these countries simultaneously—and the introduction of European Union currency.
- The significance of many of the empirical results of risk/return and correlations is limited because of the relatively short 25-year time period. Although these results do not have the long history one would want, the important point is that it is currently possible to do serious analysis of the bond market because there are a number of very well-constructed and diverse bond indexes available, as described herein. Such an analysis of the bond market and its components is critical for investors and portfolio managers making asset allocation and portfolio-performance decisions.

CHAPTER
FOUR

ELECTRONIC TRADING FOR FIXED INCOME MARKETS

MARSHALL NICHOLSON
Managing Director
Knight BondPoint

In a short time, technology has revolutionized trading in the fixed income industry, just as it has in other securities markets such as equities, options, and foreign exchange. We're only at the beginning of sweeping changes expected to touch every participant, from the back office to the trader, from the money manager to the investment advisor, from the regulator to the retail investor.

OVERALL BOND MARKET GROWTH

To appreciate how electronic trading fits into the fixed income markets, it's important to start with the whole of the U.S. bond market, a market that has doubled in size since 2000. By the close of 2010, there was more than $35 trillion in outstanding debt, according to the Securities Industry and Financial Markets Association (SIFMA). Treasury and mortgage-related debt accounted for approximately one-fourth of all U.S bond market debt through the close of 2010, followed closely by corporate debt, around 21% of the market. Municipal, agency, money market, and asset-backed debt each represents less than 10% of the aggregate amount outstanding. The entire U.S. equity market capitalization is quite small by comparison, approximately $22 trillion at the end of 2010, according to the World Federation of Exchanges (WFE).

Fixed income trading volumes have also increased. Average daily volume for the U.S. bond categories mentioned was more than $1 trillion in December 2010, with a daily average of approximately $950 billion for the full year, according to SIFMA. That's up more than 50% from an average of almost $630 billion in 2002, the first year SIFMA included corporate debt in its calculations. Debt once again trumped equities, where average daily exchange-traded U.S. equity volume was $99.3 billion in 2010, calculates SIFMA.

Broken down by SIFMA, trading volumes in U.S. Treasuries accounted for more than half of the 2010 average daily volume, and agency mortgage-backed securities (MBS) accounted for more than $300 billion. Less-liquid corporate and municipal bonds experienced daily trading volumes of $16.5 billion and $13.3 billion, respectively. A number of factors have contributed to an increase both in the overall size of the bond market, and the volume of daily fixed income trading. Some growth is related to cyclical factors, such as interest rates and the relative weaker performance of equities post-financial crisis in 2008, or driven by one-time events, such as the May 6, 2010 "flash crash" and resulting uncertainty in the equities markets.

But long-term demographic and structural shifts have and will continue to sustain the expansion of fixed income. Quite simply, fixed income is in increasing demand as the U.S. population ages. By 2030, there will be approximately 72.1 million people age 65 and older, more than twice their number in 2000, according to the Administration on Aging, and they will account for 19% of the population by then. Baby Boomers are reallocating from capital appreciation type securities like equities into bonds for income distribution and wealth preservation.

Fixed income market participants in the United States are divided into three groups. Issuers include governments, corporations, banks, and municipalities, and their primary function includes issuing debt to finance various activities and needs of the entity. That debt is underwritten, distributed, and traded in the secondary markets by intermediaries, including investment banks, commercial banks, and interdealer brokers. The investors who buy fixed income include governments, mutual funds, insurance companies, commercial banks, corporations, and retail investors. Of this last group, retail is a growing presence owing in great part to easier access to individual fixed income securities through advances in technology.

THE RISE OF ELECTRONIC TRADING

Since the 1960s, fixed income has been traded predominantly in the secondary over-the-counter (OTC) markets in the United States. Until approximately 2000, most trading took place over telephone, fax, and electronic mail and messaging services across disparate parties, with no exchange or way to link up market participants in a central location. Additionally, the fixed income market consists of numerous individual issues, some three million today, versus approximately 20,000 different equity securities, making the establishment of a central fixed income liquidity hub and/or connectivity that much more difficult.

The New York Stock Exchange (NYSE) stepped into the void and in the 1920s and 1930s operated an exchange for corporate, government, and municipal

bonds trading. In 2006, NYSE launched the NYSE Bonds platform to replace the NYSE Automated Bond System in hopes of building an electronic trading venue in which buyers and sellers could trade corporate bonds. However, with the lack of a central place for liquidity to congregate and the OTC nature of the fixed income market, electronic trading was much slower to develop than equities.

The typical workflow of a fixed income trade would consist of a number of telephone exchanges between buyers and sellers and intermediaries such as brokers' brokers or fixed income dealers. Imagine the inefficiencies and errors as the manual nature of finding, pricing, and executing fixed income securities created manual and duplicate workflow activities, with a higher likelihood of data entry errors.

Once technology evolved to make it more cost-effective and efficient to link buyers, and sellers, the fixed income industry was able to move forward. Trade executions moved from the telephone to transactions via fax, then on to e-mails and instant messaging, until the establishment of electronic communications networks (ECNs).

However, fixed income trading has stayed primarily over the counter. The large number of outstanding fixed income issues lack uniformity in the secondary marketplace and are thinly traded when compared with other financial securities traded daily on U.S. exchanges. This fragmented, heterogeneous, less-liquid nature of the fixed income markets has been yet another obstacle in establishing electronic trading.

Despite this backdrop, electronic trading in fixed income securities gained significant traction in the late 1990s and early 2000s. Opportunities arose out of the Internet revolution and emerging Web technologies, and they were supported by the increasing ability for those with foresight to raise capital for businesses pursuing such technologies. At their core, these technologies allowed for a low-cost infrastructure and a faster, more efficient deployment model from which a number of electronic trading venues arose, from bona fide exchanges and multi-dealer electronic communications networks to single-dealer trading systems. By 2001, some 90 electronic trading systems for fixed income securities were operational, up from only 11 in 1997, according to The Bond Market Association's annual survey.[1]

From 2001 to 2005, many of these early entrants into electronic fixed-income trading closed, were consolidated or transformed their business models to new fixed income–related initiatives. Over-investment in the space drove the emergence of too many venues, resulting in excess capacity given the demand for electronic fixed income trading at the time. The survivors were typically well capitalized and often formed as broker-dealer consortiums whose owners were natural users, and/or focused on more standardized and

1. The Bond Market Association is now part of SIFMA.

liquid fixed income products such as government and agency bonds and high-grade corporate debt.

It was not until the second half of the decade, post-consolidation, that growth in electronic fixed income trading was fueled finally by growing industry acceptance and the wider adoption of electronic access. Two primary drivers of continued adoption came via the introduction of value-added by various electronic trading venues, as well as more rigorous regulatory oversight of fixed income markets. The ability to perform transactions electronically was an important advance, but the tipping point for adoption was the introduction of more pre- and post-trade services which eliminated redundant workflow processes.

Indeed, pre- and post-trade services further automated aspects of the fixed income trade life cycle beyond the execution itself. This automation of the trade life cycle is often known as Straight Through Processing (STP), which essentially allows for information that has been electronically entered to be transferred from one party to another in the clearance and settlement process without manually reentering the same pieces of information repeatedly over the entire sequence of events. Examples of STP services offered by electronic trading venues include the delivery of confirms and account allocations to portfolio management systems, as well as the delivery of trade execution messages to back office and clearing for post-trade processing. Other types of ancillary services offered by providers of fixed income trading systems include compliance modules to assist in the capture and documentation of regulatory and compliance requirements, as well as risk management and monitoring. These additional services can enhance the operational efficiency of firms engaged in fixed income trading by eliminating and automating duplicative workflow. This automation, in turn, reduces the number of trade errors that must be researched and resolved when compared with the largely manual processes used throughout fixed income trading's history.

The equities markets adopted the Financial Information eXchange (FIX) as a messaging standard in the early 1990s, to great success. FIX, a technology in the public domain, facilitates real-time electronic exchange of securities transactions. The later adoption of FIX as a protocol for fixed income transactions was one of the primary technological developments in this space over the last decade. Before FIX, efforts to connect and link various fixed income systems without a messaging standard were resource intensive. FIX enabled electronic trading venues to offer post-trade messaging services in support of their STP initiatives. Today FIX handles a variety of messages necessary to conduct fixed income transactions, including transmission of orders and confirmation of trade executions, as well as allows dealers to supply bid or offer information for fixed income securities (Exhibit 4–1). For fixed income dealers and investors, FIX brought efficiency by eliminating duplicative activities and supporting regulatory responsibilities. In essence, FIX enabled electronic trading venues to build a "network effect" of dealers and investors quickly and cost effectively. Once established, these network effects allow electronic venues to create barriers to entry for new competitors.

EXHIBIT 4–1

Diagram of FIX Connectivity between Fixed Income Market Participants

THE IMPACT OF REGULATORY REQUIREMENTS

One regulatory effort in particular had a significant impact in driving increased electronic trading in fixed income. In 2001, the U.S. Securities & Exchange Commission (SEC) approved rules that required broker-dealers who were members of the National Association of Securities Dealers (NASD, which is now the Financial Industry Regulatory Authority, or FINRA) to report secondary market transactions in certain corporate fixed income securities. These rules were developed to bring greater price transparency to the corporate bond markets by collecting and disseminating fixed income transaction data from and back into the marketplace. Greater transparency, it was perceived by regulators, would reduce bid/ask spreads and subsequently lower investor trading costs associated with purchases and sales of corporate bonds.

This system, managed by FINRA for reporting and disseminating corporate bond trade information, became known as the Trade Reporting and Compliance Engine, or TRACE. TRACE required that eligible transactions in corporate bonds be reported by dealers within 15 minutes of trade completion. TRACE ultimately was expanded in 2010 to cover certain federal government agency debt as well as primary market transactions in eligible corporate bonds.

Additionally, in 2004, the SEC approved proposed rule changes relating to the Municipal Securities Rule Board's (MSRB) implementation of real-time transaction reporting and price dissemination, detailed in MSRB Release 34-50294. According to the MSRB, the purpose of this rule change—in which eligible transactions were required to be reported to the MSRB's Real-Time Transaction Reporting System or RTRS facility—was to increase price transparency in municipal securities and enhance surveillance database and audit trails used by enforcement agencies. Similar to TRACE reporting requirements, the MSRB's rule change shortened reporting requirements from end of day to within 15 minutes of time of trade, in accordance with MSRB Notice 2004-29.

TRACE was successful in lowering trade execution costs for TRACE-eligible securities by 50% and increasing competition in the corporate bond markets, based on a 2005 study by Bessembinder, Maxwel, and Venekatraman.[2] In fact, TRACE helped increase market share for smaller dealers while eliminating cost advantages for larger dealers. The industry now had appropriate incentives to enhance operational efficiency via continued adoption and support of fixed income electronic trading: a reduction of bid/ask spreads, lower transaction costs, greater regulatory emphasis on fixed income transactions, and easier access to technology. Electronic trading systems, in turn, were given the opportunity to help users fulfill regulatory obligations by offering services such as TRACE reporting and STP initiatives that could link electronic trading systems to proprietary or third-party systems for message automation.

SHIFT TO A FEE-BASED BROKER-DEALER REVENUE MODEL

The retail brokerage industry shift to fee-based from commission revenue models played a role in driving the adoption of electronic trading in the retail fixed income markets.

Historically, broker-dealers with large retail sales forces held a substantial inventory and conducted predominantly principal trading of fixed income securities with retail accounts via financial advisors. However, over the last decade, many broker-dealers introduced fee-based platforms. Under a fee-based model, accounts were charged a fee based on assets under management at the broker-dealer rather than commissions on individual transactions. For these fee-based accounts, the SEC limited broker-dealers to acting in a principal capacity when effecting trades on their clients' behalf.

As a result of these limitations in servicing fee-based accounts, broker-dealers sought solutions that enabled fixed income product access and agency

2. Hendrik Bessembinder, William F. Maxwell, and Kumar Venkataraman, "Market Transparency, Liquidity Externalities, and Institutional Trading Costs in Corporate Bonds." Presented at the 2006 American Finance Association Meeting Available at SSRN: http://ssrn.com/abstract=644624 or doi:10.2139/ssrn.644624.

execution solutions. Electronic retail platforms such as Knight BondPoint and BondDesk arose to provide these solutions through Web-based financial advisor portals and access to alternative trading system (ATS) multi-dealer platforms. With the loss of principal trading opportunities in a growing number of retail accounts, many broker-dealers looked to broaden their retail distribution beyond their own retail sales force. These retail-centric electronic trading platforms provided that opportunity as well

As of early 2011, there are no formal measurement levels of daily fixed income transactions executed electronically. While TRACE and MSRB reporting requirements dictate that participants report transactions in eligible securities, reporting firms are not required to provide whether the transaction was executed electronically, much less the system or venue upon which the transaction may have taken place. Furthermore, many systems and venues do not publish volume statistics directly to the marketplace, and those that do use a variety of different methodologies for counting and reporting volumes, making comparisons less than scientific.

However, in April 2008, Celent, a division of Oliver Wyman, estimated that 57% of average daily volume of U.S. fixed income products was executed electronically and predicted that adoption would drive the percentage of executions taking place electronically to 62% by 2010. According to Celent, electronic trading has had greater penetration in more-liquid securities, including U.S. Treasuries, with an estimated 80% of daily average trading volume executed electronically at the time of the study. Meanwhile, electronic transactions in agency MBS accounted for 32% of average daily volume.[3] Celent went on to estimate that electronic trading was not as well adopted in less-liquid securities such as municipal bonds, corporate bonds and federal agency securities. In fact, only 15% of federal agency security volume, 10% of corporate bond volume, and 8% of municipal bond volume were traded electronically in 2006. Celent predicted that adoption in these securities would be slow, with estimated percentages of daily volumes executed electronically in 2010 of 16% of federal agency securities, 12% of corporate bonds, and 10% of municipal bonds.

UNIVERSE OF ELECTRONIC TRADING PLATFORMS

In this section, we briefly describe the types of trading platforms and types of trading models.

Types of Trading Platforms

While the financial services industry lacks formal definitions to describe various types of electronic fixed income trading platforms, most are grouped by the participants and the type of trading methodology deployed upon these systems.

3. David Easthope, "Electronic Trading: Reaching The Tipping Point," Report by Celente, April 14, 2008 (http://reports.celent.com/PressReleases/200804142/ebond.asp).

Interdealer Systems

Allowing fixed income dealers to execute trades electronically and anonymously with each other, interdealer systems utilize an interdealer broker (IDB) as intermediary. Interdealer platforms are most prevalent in Treasury and government agency trading. Typical IDBs provided both electronic and voice capabilities for their clients. Many of these platforms now allow nondealers, such as institutional customers, access to these platforms. Examples of Interdealer Systems include eSpeed, and BrokerTec.

Single-Dealer Client Systems

Owned and operated by major fixed income dealers, these single-dealer client systems typically allow institutional clients to trade a variety of fixed income products electronically directly with the dealer sponsor of the system. Fixed income dealers operating these single-dealer systems act in a principal capacity. Examples include Deutsche Bank's Autobahn and J.P. Morgan's JPeX.

Multi-Dealer Client Systems

These systems enable institutional clients to access price quotes from and execute with multiple dealers, and they typically offer pre- and post-trade services as an additional benefit for institutional clients and dealers utilizing the system. Many of the multi-dealer systems in existence today were started as consortiums founded by fixed income dealers. Examples include Tradeweb and MarketAxess.

Exchanges

Offering a system model for fixed income securities in which buyers and sellers match trades, exchanges create liquidity, rather than relying on fixed income market makers to provide price quotes. Transactions are conducted anonymously. An example would be NYSE Bonds.

Odd-Lot Trading Systems

Odd lots are defined by trades under $1 million in par value, and these systems are used by firms buying and selling fixed income securities on behalf of direct retail investors. As a result, most support trading in a variety of bond types. Most odd-lot systems are multi-dealer, but some dealers who specialize in odd lots also have single-dealer systems over which their clients can execute. In addition, odd-lot trading systems are used by institutional customers to facilitate trading in odd-lot positions they may need to buy or sell. Examples include Knight BondPoint, BondDesk, and TMC.

Types of Trading Models

While there are a variety of trading models deployed in order to facilitate electronic trading in fixed income securities, the three most prevalent today are

request for quote, order-driven, and auction models. Many electronic platforms now support multiple trading models, depending largely on the need of a user at a given time.

Request for Quote

Typically deployed by multi-dealer client systems and used by institutional customers to execute trades, the request for quote (RFQ) model enables the client to request pricing on a bond or bonds from one or more dealers participating on the multi-dealer platform. Upon receipt of the request, dealers can respond with price quotes. Quotes can then be acted upon and an execution occurs if a bid is hit or an offer is lifted.

Order-Driven

The order-driven model enables participants to place orders against price quotes provided by other participants that are called price makers, liquidity providers, or market makers. Executions occur when orders submitted are matched against price quotes from liquidity providers. Upon a matched order, an execution message is generated for both liquidity provider and liquidity taker. Most of the odd-lot trading systems are order-driven based systems.

Auction Systems

Most often auction systems are used in new issue or book-building activities. Typically these systems allow an issuer or manager of an issue to post details of the offering, such as security, size, and rules of the auction. Subsequently, indications of interest are placed and order are allocated up on close of the auction.

CURRENT TECHNOLOGIES

The evolution of technology in fixed income trading has been consistent with the patterns seen in other asset classes, such as equities, options, and foreign exchange. One of the most significant observations is the diminishing importance of unique graphical user interface (GUI) applications for trading fixed income electronically. A growing percentage of activity taking place on electronic fixed income venues is now originated via an application program interface (API), which has enabled programmatic aggregation of information from multiple and competing electronic platforms.

GUI versus API

The equity markets have certainly led the others in adopting automation. More than 90% of inbound prices and orders in the equity markets arrive at their destination, such as an ECN or exchange, via a FIX API. The percentage of API-delivered prices and orders in the foreign exchange market is not quite that high,

but likely represents the vast majority of the volume. In both cases, the ATSs and ECNs in these markets began with GUIs to gain initial adoption and eventually evolved to primarily API-based activity.

Trading in fixed income markets also is following these natural evolutionary steps from single- and multi-dealer systems with proprietary GUIs to the current set of mature fixed income ECNs. The early versions of the electronic trading platforms in this asset class generated most of their price-making and price-taking activity via GUI and usually focused on one or more specific sectors. As a result, many participants on both sides of the market had to manage market activity on multiple GUIs, which introduced inefficiencies and risk, particularly for firms engaged in market making.

In response to requests from the market, ECNs began offering API alternatives. The institution-focused ECNs led the way in this maturation process, and the odd-lot or retail ECNs eventually followed. Initial API integration was seen as costly and time-consuming due to the lack of integration tools as well as to nonstandard proprietary communication protocols used differently at each ECN. However, as ECNs matured, more and more adopted FIX, which allowed easier integration for many firms. Generally, on odd-lot, retail-focused ECNs, the vast majority of quotes are delivered in real-time via API, and less than half of the price taking activity is conducted by API. In the institutional markets the percentages of volume represented by APIs is somewhat higher due to the earlier start and ongoing demand. For example, given the availability of APIs, price makers can now enter prices from one system connected to all the ECNs (or as many as they require).

The Bloomberg Trade Order Management System (TOMS) has been the single-entry system of choice for fixed income dealers participating in the retail market because it combines inventory management with the Bloomberg security master and offers other value-added features. Alternatively, some dealers use proprietary systems to manage their price models and deliver prices to distinct APIs. In most cases, the price models are managed by manual adjustments of spreads to benchmarks, but more automated methods are used for selected instruments, such as the on-the-runs and other highly liquid U.S. Treasuries.

Meanwhile, the buy side has preferred to manage activity from buy-side-oriented order management systems (OMSs), such as Bloomberg's AIM, Charles River, and Latent Zero. The availability of APIs from all ECNs eliminates the need to monitor and manage extra screens and ensures a smooth integration with post-trade processes. In most cases, the decision point for price taking is still human-based, but it is indicated in the GUI of an OMS as opposed to one from the ECN. The capability exists to accept orders from sophisticated models. Therefore, some larger institutions have employed rules-based or algorithmic trading for a completely automated execution process, but the demand has not yet reached the levels seen in equities and foreign exchange.

In the early history of fixed income ECNs, well-designed GUIs were considered to be a distinctive competitive advantage. In the present era, due to the growing volume of API-based platforms, GUIs are considered by some participants to be a commodity. As of the beginning of 2011, both of the institutional fixed income ECNs in the U.S.—MarketAxess and Tradeweb Markets—offered both GUI and API access for price making and price taking. In addition, the same choice is available at all four of the retail ECNs: BondDesk, Knight BondPoint, TMC, and Tradeweb Retail.

In most cases, the API access uses the FIX protocol, which is consistent with other markets. There remains some distinction based on sector coverage, such as TMC's focus on municipal bonds, or MarketAxess's focus on credit, but otherwise the competitive gap related to the participants, inventory, and bond prices has become very small. While the differences among the ECNs have shrunk, the overall demand for access has increased. In fact, the availability of API access was considered a significant contributor to a record year in electronic trading in 2009 and is expected to play an increasing role in the future.

MARKET DATA AND THE AGGREGATION OF FIXED INCOME ECNs

The introduction of market data to the existing API capabilities offered by fixed income ECNs has enabled the next evolutionary phase of electronic trading—aggregation and automation. This follows trading models now commonly used within other asset types, as the availability of market depth across liquidity pools and automated price making are being widely used in equities and foreign exchange. Wider availability of market data from these ECNs also has allowed aggregation tools to become available to the sell and buy side, offering both many advantages.

On the sell side, dealers can use aggregation tools for real-time management of their positions and risks associated with submitting prices that may be inconsistent with the market levels at any moment. A good aggregation application can allow them to compare their current prices with those from many ECN sources to make sure they are not contributing to an inverted market or are otherwise outside of a normal range. More and more dealers who have adopted these technologies are now implementing automated trading models to establish advantages over competitors.

On the buy side, there are decision-making and compliance-based advantages to an aggregated view. A well-developed aggregation platform can show depth of market across all ECNs, providing a level of transparency that has never before been possible. Institutions with a relatively large position of a single bond can now better assess how much appetite exists for that bond, and

whether the current best price could be applied to the whole position or, if not, what prices and sizes are available beyond the best price.

On the compliance side, regulatory authorities now require documentation of best execution within an ECN, for example, a printout or electronic record showing that the executed price was within an accepted range of price for that size of trade at the moment of the trade. However, some internal compliance departments require a stricter standard and expect their traders and portfolio managers to document best execution across the entire market (i.e., all ECNs). A commercially available aggregation product can provide this capability without any development, allowing a firm to quickly ramp up to this higher standard. Some experts believe that regulatory authorities are considering requiring this level of compliance market wide in the future.

RETAIL-FIXED INCOME MARKET PARTICIPATION

Retail fixed income investors can gain access to fixed income markets utilizing a variety of available investment vehicles, including mutual funds, closed-end funds, unit investment trusts (where a professional money manager is utilized to select and manage a portfolio of fixed income securities), and fixed income–oriented exchange-traded funds, or ETFs. Retail investors can also manage a portfolio of fixed income securities through direct ownership in a brokerage account. As of 2009, retail investors held some $2.2 trillion in fixed income mutual funds, according to the Investment Company Institute's Investment Company Fact Book. Another $107 billion in bonds were owned through ETFs in 2009. While comprehensive data on individual bond ownership by retail investors are somewhat limited, we do know that retail investors are significant participants in the municipal and Treasury markets. According to SIFMA, individuals owned $1.06 trillion in municipal bonds through the third quarter of 2010, more than one-third of total ownership including funds, banks, and insurers. Retail accounts for a smaller percentage of Treasuries owned compared with institutions, but nonetheless held $1.08 trillion in Treasuries through the third quarter of 2010.

Regulatory efforts targeting transparency have helped provide the industry with good insight into retail participation in corporate, agency, and municipal securities through the collection and dissemination of trade data. Data published by FINRA indicate that retail transaction volumes have grown substantially since 2007. In addition, retail has accounted for a larger percentage of overall transactions. For example, TRACE data indicate the following:

- Average daily secondary investment grade market trades = 28,349; 79% of those transactions were for under $100,000 in par value (typical of retail) in Q3 2010, up from 71% in 2007.
- Average daily high-yield transaction = 8,307; 63% under $100,000 in par value in Q3 2010, up from 53% in 2007.

In a pattern similar to investment-grade corporate transactions, data provided by the MSRB also highlight that retail investors are increasingly active participants.

- In Q4 2010, 75% of municipal transactions were for under $100,000 in par value.

RETAIL ACCESS TO INDIVIDUAL BONDS

Retail investors have traditionally bought and sold individual fixed income securities through a financial intermediary affiliated with a broker-dealer. A decade ago, the process would entail a number of emails, phone calls, and/or faxes between the retail investor and financial advisor, and then the financial advisor and fixed income trader or sales liaison. Additional emails, phone calls, and faxes could take place with the fixed income trader or sales liaison and other traders within the firm, and between traders and sales people at other firms. Then, upon the retail account selecting a bond or bonds to purchase, it was likely that the bond or some of the bonds may no longer be available, or available only in a different quantity or price than originally indicated. Hence, more phone calls, faxes, and emails would take place among the retail account, financial advisor, and trade desk in order to complete the transaction.

This inefficient process was first addressed with the growth of Web technologies in the mid-to-late 1990s, via simple Web applications that enabled fixed income professionals to search a list of offerings consolidated in a single database. At that time, fixed income dealers would fax or email a list of inventory to the operators of these systems, and data entry personnel would manually enter the bond inventories received into the centralized database. These systems were often described as an "Electronic Blue List," in reference to the daily digest and advertisement of fixed income offerings for municipal and corporate securities created and distributed by Standard & Poor's on blue newspaper. Users of these Web systems could search a database of offerings by various bond-related criteria, including maturities, ratings, and yields. Dealer contact information was identified on each offering and users of the system would place phone calls to negotiate trades.

These Web-based systems were augmented in the early 2000s with advanced functionality to include the ability to route orders electronically to dealers offering bonds through the system, as well as additional capabilities for dealers to send inventory to the system via API. In addition, versions of these systems were developed for use by financial advisors and for direct use by retail accounts with the inclusion of order entry and order routing capabilities to an internal trading desk.

These enhanced capabilities offered by various providers of electronic trading systems coincided with many online brokerages' strategic plans to expand

their product offerings beyond equities, options, and mutual funds to include access to individual bonds. Hence, through collaboration between online brokerages and providers of electronic trading systems, the retail investor was able to search and transact individual fixed income securities electronically via Web-based applications that were tightly integrated into online brokerage technology. Today, these fixed income portals allow retail investors to search a large number of both primary and secondary offerings, conduct price discovery, build portfolios and bond ladders consisting of individual securities, and execute transactions electronically.

Exhibits 4–2 through 4–5 are examples of Web-based applications and searches for municipal bonds (Exhibits 4–2 and 4–3) and corporate bonds (Exhibits 4–4 and 4–5) as provided by Knight BondPoint.

EXHIBIT 4–2

Multi-Variable Municipal Bond Screener

EXHIBIT 4–3

Municipal Bond Screener Results

Knight

TRADING OFFERING TOOLS/NEWS BID WANTED INSTANT NOTIFICATION LOGOUT

Knight BondPoint

Municipal Bond Search Results <<Back to Search

For more details or to place an order, click on the CUSIP number. 1 - 25 of 77

Qty / Min / Incr/MBR	Ratings / Insurer / Underlying Ratings	Description / CUSIP	State	Coupon / Maturity	Gross Yld / Conc	Price / Offer/Bid	YTM / YTW / Execution	Buy
5 / 5 / 5/	Aa2/AA/AA / Not Ins. / Aa2/---/AA	NEW YORK N Y GO BDS 64966QQ88 G.O.	NY	4.000 / 02/01/2013	NET	105.444 / Offer	1.250 / 1.250 / Electronic	BUY
10 / 5 / 5/5	Aaa/BBB/--- / MBIA / Aaa/---/---	NEW YORK N Y CITY TRANSITIONAL 64971M3F7 Insured, REV, Pre-refunded to 02/01/2013	NY	5.250 / 02/01/2021	NET	108.459 / Offer	0.991 / 0.991 / Electronic	BUY
345 / 5 / 5/25	Aa3/---/--- / Unknown / A2/---/---	WHEATFIELD N Y PUB IMPT BDS 962557EY6 Insured, G.O., BQ	NY	3.000 / 02/01/2013	NET	103.363 / Offer	1.300 / 1.300 / Electronic	BUY
180 / 10 / 10/10	Aa3/A+/A+ / AMBAC / Aa3/A+/A+	NEW YORK N Y CITY HEALTH & HOS 649674FC7 Insured, REV	NY	4.000 / 02/15/2013	NET	104.375 / Offer	1.816 / 1.816 / Electronic	BUY
10 / 5 / 5/5	Aa3/A+/A+ / Not Ins. / Aa3/---/---	NEW YORK N Y CITY HEALTH & HOS 649674FZ6 REV	NY	4.000 / 02/15/2013	NET	105.339 / Offer	1.350 / 1.350 / Electronic	BUY
50 / 50 / 5/	Aa2/AA/AA / Not Ins. / Aa2/---/AA	NEW YORK ST GO BDS 649787T88 G.O.	NY	3.000 / 02/15/2013	NET	103.840 / Offer	1.100 / 1.100 / Electronic	BUY
15 / 15 / 5/	Aa3/AA-/--- / Not Ins. / Aa3/---/---	NEW YORK ST DORM AUTH REVS REV 6498375A5 REV, ETM, Cont Callable, Extra Redemp, OID: 98.969	NY	5.200 / 02/15/2013	NET	106.916 / Offer	1.750 / -79.737 / Electronic	BUY
20 / 5 / 5/5	Aa2/AA/AA / Not Ins. / Aa2/---/AA	NEW YORK N Y GO BDS 64966CCW9 G.O., Pre-refunded to 03/01/2013, OID: 99.696	NY	4.800 / 03/01/2017	NET	107.680 / Offer	.081 / 1.081 / Electronic	BUY
25 / 5 / 5/5	Aa2/---/AA / Not Ins. / Aa2/---/AA	NEW YORK N Y GO BDS 64966H2Q9 G.O., Pre-refunded to 03/01/2013, OID: 99.031	NY	5.000 / 03/01/2022	NET	108.269 / Offer	1.000 / 1.000 / Electronic	BUY

EXHIBIT 4–4

Corporate Bond Screener Results

Knight BondPoint

Corporate Bond Search Results <<Back to Search

For more details or to place an order, click on the CUSIP number. 1 - 5 of 5

Qty / Min / Incr/MBR	Ratings / Execution	Description / CUSIP	Coupon / Maturity / Industry	Spread	Price / Bid/Offer	YTM / YTW	Buy
500/510 / 1 / 1/1	Ba1/BBB/BBB- / Electronic	LIFE TECHNOLOGIES CORP 53217VAD1 Make Whole, Spec Redemp, Non-callable	3.500 / 01/15/2016 / Industrial		99.936 / 100.635 / Offer	3.360 / 3.360	BUY SELL
500/500 / 200 / 1/200	Ba1/BBB/BBB- / Electronic	LIFE TECHNOLOGIES CORP 53217VAD1 Make Whole, Spec Redemp, Non-callable	3.500 / 01/15/2016 / Industrial		98.183 / 101.818 / Offer	3.103 / 3.103	BUY SELL
100/0 / 1 / /	Baa1/BBB+/A- / Electronic	RYDER SYS MTN BE 78355HJP5 NYBE Make Whole, Spec Redemp, Non-callable	3.600 / 03/01/2016 / Industrial		100.169 / 0.000 / Bid	3.563 / 3.563	SELL
90/0 / 1 / /	Baa1/BBB+/A- / Electronic	RYDER SYS MTN BE 78355HJP5 NYBE Make Whole, Spec Redemp, Non-callable	3.600 / 03/01/2016 / Industrial		100.916 / 0.000 / Bid	3.403 / 3.403	SELL
89 / 10 / 1/10	Aa2/AA+/--- / Electronic	GE CAPITAL INTERNOTES 36966R6C5 Survivor's Option	3.650 / 04/15/2016 / Financial		102.250 / Offer	3.180 / 3.180	BUY

BUY OFFER ADD SELECTED BONDS TO THIS PORTFOLIO New Portfolio RESET

To view the offering dealer information drag the mouse over "Offer" in the "Offer/Bid" column.
NC - Next Call MBR - Minimum Balance Remaining

EXHIBIT 4–5

Live Executable Quotes from Multiple Dealers

Knight BondPoint

Corporate Bond Detail <<Back to Search Results

Issuer: CISCO SYS INC Coupon: 5.250 Maturity: 02/22/2011
Make Whole

Description

CUSIP:	17275RAB8	Bond Form:	Book Entry	Call Schedule:	N/A
Industry:	Industrial	Dated Date:	02/22/2006	Sinking Fund:	N/A
Ratings:	A1/A+/---	First Coupon:	08/22/2006	Put Schedule:	N/A
Exchange:	None	Pay Frequency:	Semi-Annual	Step Schedule:	N/A
Payment Months:	Feb			Put Features:	N/A

FIND SIMILAR BONDS ADD BOND TO THIS PORTFOLIO: New Portfolio

Current Orders and Offers Hide

Sel.	Type	Execution Type	Qty	Min	Incr	MBR	Price	Yield to Worst	YTM	Spread To Benchmark	Settlement	Buy/Sell
☐	OFFER	Electronic	20	1	1	1	100.449	0.343 to 02/22/2011	0.343		01/19/2011	BUY
	BID	Electronic	100	1			100.357	1.322 to 02/22/2011	1.322			SELL
☐	OFFER	Electronic	180	1	1	1	100.454	0.290 to 02/22/2011	0.290		01/19/2011	BUY
☐	OFFER	Electronic	137	5	1	5	100.465	0.173 to 02/22/2011	0.173		01/19/2011	BUY
	BID	Electronic	1000	5			100.421	0.641 to 02/22/2011	0.641			SELL
☐	OFFER	Electronic	100	20	1	20	100.473	0.088 to 02/22/2011	0.088		01/19/2011	BUY

Re-Offer Trading Calculator Hide

Trader		Commissions		Customer		Net Money	
Trade Qty:	1	◉ BID	○ OFFER	Price:	100.500	Settlement:	1/19/2011
Spread:	0.000	GTC Points:	0.000 ☑	YTM:	-0.199	Trader:	
Benchmark[1]:		GTC Dollars:	0.00	YTW:	-0.199	Principal:	1,000.00
Treasury Yld:	0.000	GTC Price:	100.000	Call Date:	02/22/2011	Accrued:	21.44
Offer Yield:	5.140	GSC Points:	0.500 ☑	Tax %:	0.00	Total:	1,021.44
Priced To:	Maturity	GSC Dollars:	5.00	Tax Free Yld:	-0.199	Customer:	
Offer Price:	100.000 ☑	Total Markup:	0.500%	Current Yld:	5.224	Principal:	1,005.00
				Convexity:	0.000	Accrued:	21.44
				Duration:	0.092	Fee:	0.00
						Total:	1,026.44

FIXED INCOME PRICING

When transacting in secondary fixed income markets, broker-dealers typically act in one of three possible capacities when dealing with retail investors.

Broker-dealers acting in a principal capacity buy or sell bonds to retail investors for their own account, profiting from this activity by collecting the bid/ask spread on the transaction(s). For example, an investor may wish to sell a bond from his portfolio, the broker-dealer serving as intermediary on the transaction may take the bond into its own inventory in hopes of selling to another investor or broker-dealer at a higher price in the future.

Broker-dealers acting in a riskless-principal transaction facilitate retail transactions by finding a buyer or seller of a fixed income instrument prior to execution, profiting from the transaction by applying a markup or markdown to the price of the bond for the retail investor. For example, an investor may wish to sell a bond from his portfolio and so sends the request to the broker-dealer for pricing. Upon the receipt, the broker-dealer may send the request to other broker-dealers and, upon receiving prices for the instrument from interested parties, may provide a slightly lower price than received from other broker-dealers as a price at which the retail investor can sell the instrument. Factors affecting the amount

of markup or markdown on secondary transactions include the size of the transaction and/or the maturity of the instrument.

When acting in agency capacity, broker-dealers charge retail investors commissions on secondary market transactions. As in a riskless-principal transaction, the broker-dealer serving as intermediary offers the retail investor the best price available for the instrument. However, rather than marking up or down, the broker-dealer adds a commission to the transaction. These commissions are typically set in schedules that are made available to retail investors and, while they reflect the different business models of competing broker-dealers, follow a general pattern. Retail customers typically pay a price per trade or execution, additional costs per security either included or per unit, with minimum and maximum charges. These costs to the retail investor have dropped over time as it has become more efficient for broker-dealers to offer fixed income trading products and services to their customers. Some broker-dealers do not charge any commissions for certain transactions such as secondary treasuries and offer commissions on other products that are not too different than equity commissions.

KEY POINTS

- Long-term demographic and structural shifts have and will continue to sustain the expansion of the fixed income market and trading volumes.
- Retail investors are a growing presence due in great part to easier access to individual fixed income securities through advances in technology.
- The structure of the fixed income market slowed the adoption of electronic trading compared with other asset classes such as equities and foreign exchange.
- The introduction of Web-based technologies and access to capital helped fuel the expansion of numerous electronic trading venues in the 1990s and early 2000s, followed by a period of consolidation.
- Key technology advancements included automation through Straight Through Processing, electronic connectivity through FIX, access through APIs, and the integration of market data onto trading platforms.
- Regulatory requirements including real-time transaction reporting, price dissemination, and best execution documentation further spurred the move toward electronic trading.
- As the retail brokerage industry shifted to a fee-based model and looked to broaden their distribution, demand for electronic retail platforms increased.
- Greater efficiencies in fixed income market access and trading have pushed commissions down, helping to attract an even greater retail investor presence.

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CHAPTER
FIVE

MACRO-ECONOMIC DYNAMICS AND THE CORPORATE BOND MARKET

STEVEN I. DYM, PH.D.
President
Mariner Capital Partners

Perhaps more than any other sector in the capital markets, corporate bonds are profoundly affected by the dynamics of the macro-economy. Movements in interest rates, inflation, yield-curve shape and corporate earnings are all driven in large part by the business cycle. These variables, and their volatilities, all play a role in the determination of corporate bond yields and prices, and their derivatives. This chapter explains these various roles and their interactions. It begins with a short synopsis of practical macro-economics.[1]

THE MACRO-ECONOMY

Real Gross Domestic Product, or GDP, represents the total value of goods and services produced in a country over a given time period, usually one quarter. It is typically presented as a rate of change from the previous quarter—a growth rate—and annualized. This is convenient, as interest rates and inflation are typically expressed on an annual percentage basis as well. It is "real" in that the inflation rate is subtracted from the raw estimate.

The amount of GDP that the economy is capable of producing is known as *potential GDP*, or *potential output*. It is a theoretical measure because, by definition, it is not observed. Yet, it is extremely important, and here's why. A country's potential GDP is determined by its resources—labor, physical capital, and natural. If actual GDP is below potential then some of these resources are not being fully utilized. Rather, they are underemployed (or unemployed, if a person is not working at all, yet willing), a deadweight loss to society. The difference between actual and potential GDP is the *GDP gap*.

1. For a fuller treatment, directed specifically to fixed income market participants, see Chapters 5 and 6 in Steven Dym, *The Complete Practitioner's Guide to the Bond Market* (New York: McGraw-Hill, 2010).

Why do investors, particularly those involved with corporate bonds, care about real GDP, potential GDP, and the GDP gap? A few good reasons are:

- Movements in GDP are highly correlated with corporate revenues. Indeed, it is almost definitional—output must be produced, and companies do the producing.[2] More revenue implies an enhanced ability for firms to service their debt, hence reduce the risk of default (and, resultantly, lower risk premia on corporate bonds, to be discussed later). A caveat, however, is in order. Debt service is met from *net*, not gross, revenue. A firm's revenue may be consumed by production costs (e.g., labor) and fixed (e.g., rent) costs. This makes the correlation imperfect.
- Interest rates are determined by the supply and demand for credit. In turn, the supply of credit—via household savings, the ultimate (domestic) supplier of credit—and demand for credit—by corporations (and governments)—are both profoundly influenced by the level of GDP and GDP growth (plus expectations for such).
- At least in the short run (say, over a business cycle), the rate of inflation is an outgrowth of the size of the GDP gap. Demand for input (labor, materials and capital goods) is determined to a great extent by actual GDP, while input supply reflects the economy's potential. The nexus of this supply and demand goes a long way in explaining inflationary pressure or its absence.
- The central bank's insertion and removal of liquidity is largely a function of the GDP gap. Directly, the central bank is concerned with under (or over) utilization of the country's resources, particularly labor, as measured by the GDP gap. Indirectly, the bank seeks to prevent inflationary (or deflationary) pressure, likely a result of the gap. And since the central bank's policy tools work through the financial markets, corporate bond investors take notice of and, indeed, try to anticipate the bank's actions.

Clearly, then, corporate bond investors are profoundly interested in what makes GDP, hence the GDP gap, tick. Unfortunately, we're not quite sure. We have a decent understanding of relationships among macro-economic variables, but no one is totally confident about the drivers of macro-economic activity. So, let's just review what we know, and point out the major differences of opinion. Clarity about what is not known is as important to an investor as confidence in what is known.

The "product" in GDP is sold to demanders of that product. We divide all the demanders, or purchasers, into what is referred to as *aggregate demand sectors*:

- *Households*. Also known as consumers, households purchase the majority of produced goods and services. It would be hard to experience any significant GDP expansion or contraction without concomitant movements

2. This is not exactly right because households, governments, and unincorporated businesses can produce product as well.

in consumer spending. Part of consumption adds to potential GDP even as it adds to actual GDP. Spending on education is an example since, at least theoretically, it contributes to the person's productive capabilities. Consumer spending on discretionary items is sensitive to the business cycle, hence volatile, unlike spending on necessities. A relatively small, but very volatile part of household expenditures is for homes—not the furnishings or appliances, but the house itself. The percentage of household disposable income not spent on goods and services is defined as the (personal) savings rate, where disposable income is measured as household income less taxes.

- *Businesses.* Purchases by companies of materials, payments of wages and benefits to workers, rent to building owners or interest to lenders are not counted in GDP; these are already represented in the prices of goods and services paid by the ultimate user. Rather, included are capital expenditures, such as on plant, equipment, and software. Importantly, these expenditures, referred to as *Capex,* add to the economy's potential GDP as well as to actual, because they enhance each worker's ability to produce output. Another way to say this is that Capex adds to GDP and simultaneously improves the country's "productivity," typically defined as the ratio of aggregate output to labor input. Separately, a pile up of inventories, due either to disappointing sales or intended stock accumulation, increases GDP—after all, the goods have been produced. A subsequent drawdown of stocks will reduce GDP. Capital expenditures and inventories account for a relatively small portion of the level of actual GDP. But because of their sensitivity to the economy's fluctuations, they (and housing) tend to account for a disproportionately high fraction of *changes* in GDP.
- *Governments.* Spending by state and local governments is about twice as large as that of the federal government. Both units tax and spend for current consumption as well as capital projects (e.g., schools, bridges), the latter contributing to the country's potential GDP. When the federal government increases spending (or reduces taxes) specifically to raise aggregate demand and, hopefully, stimulate the economy, it is termed *fiscal policy*. Note that some government programs (unemployment insurance is the most well known) kick in without new legislation when the economy is weak. These are known as *automatic stabilizers*. It is crucial not to confuse the central government's spending on goods and services with the central bank's "spending" on financial instruments (monetary policy)—the former enters the "real" economy, the latter winds its way through the financial markets. We'll get to this crucial distinction soon.
- *Foreigners.* Any portion of the above spending that is purchased from foreigners—that is, imports—results in a reduction in aggregate demand, hence lower GDP. Any purchases by foreigners of U.S. produced goods

> and services add to aggregate demand. For a given level of GDP, an excess of businesses capital expenditures over household savings must be matched by an excess of government receipts (mainly taxes) over government spending. If the former is larger than the latter, a trade deficit (more imports than exports) must result. All the more so if government spending exceeds receipts. Conversely, if household savings exceeds capital expenditures, and the difference is less than the difference between government spending and taxes, a trade surplus is the result.[3]

Here's the bottom line. An increase in demand from any of the sectors elicits production of goods and service. GDP increases. Producers use materials, purchasing them from other firms, which in turn produce more. Firms hire labor, who spend their earnings. Physical capital is more heavily utilized, prompting additions to the capital stock. In short, a positive dynamic is introduced into the economy. The GDP gap narrows, as resources are more fully employed. Depending on the degree of GDP growth or, equivalently, the extent of the GDP gap narrowing, inflation may be sparked. Material supplies become tighter and the labor market strengthens, both putting upward pressure on production costs.

It's a nice, straightforward story. However, be aware that there is no general agreement among economists, or among market participants, that the story is true. The theoretical underpinnings of the disagreement are complex. Nevertheless, corporate bond investors need some appreciation of the issues.

Briefly, this is a "demand driven" view of the macro-economy. Economic activity is driven—that is, determined—by aggregate demand, or the sum of spending by the above sectors. If demand is weak, economic slack—the GDP gap—results. If spending strengthens, resources are required, hence purchased and employed; the GDP gap narrows. Aggregate production thus, *responds* to demand. Others would argue that this analysis ignores a basic principal of economics—the price mechanism as the equilibrator of supply and demand for goods and services. Similarly, the price of labor (wages plus benefits) should adjust until labor supply meets demand for workers by firms based on their productivity. (Further, interest rates equilibrate supply and demand for capital.) Now, this may not hold instantaneously but, the argument goes, macro-economic variables approach these equilibrium values over time. The upshot of the alternative argument is this: As long as fundamental economic measures—such as the household savings rate, labor market realities including productivity and unemployment insurance benefits—are unchanged, real GDP and, hence, the GDP gap will not exhibit lasting change. In particular, an increase in government spending will not have long-term effects, as households will reduce their spending in recognition that they will ultimately be taxed. Government demand "crowds out" private sector demand.

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3. This is only true if the GDP "pie" is fixed. Theoretically, should an increase in government spending, not matched by an increase in household savings, stimulate additional GDP growth, it is possible for Capex to increase without a concomitant increase in the foreign trade deficit.

Regardless of whether aggregate demand determines macro-economic activity or, in the alternative view, is in some fashion (jointly) determined by it, it is certainly an indicator of actual GDP. If there is no spending, there is obviously no production. Hence, understanding the dynamics of and predicting aggregate demand does the same for GDP. That explains the strong interest of corporate bond investors in the demand sectors enumerated above.

CORPORATE PROFITS

It would be too easy to say that corporate profits, in the aggregate, rise and fall with macro-economic activity. Rather, corporate *revenue* follows the macro-economy's path. Indeed, this is almost an identity, since GDP measures the output of goods and services, and corporations produce that output. Corporate bonds, however, are serviced from profits,[4] not revenue, so that is our interest here.

Clearly, more GDP means more sales or revenue. If the company is producing at a profit, the higher level of sales translates into greater profit. Interest and other debt service are more easily covered, bondholders feel more comfortable, and credit-spreads narrow (more on this later). All good for corporate profits, but note the following possibility. The greater level of economic activity, however, pushes the economy closer to its potential. As explained above, this may well raise production costs. At some point, inflation is precipitated. If material and labor costs rise faster than output prices, corporate profit margins are eaten into (in the extreme they turn negative), reducing debt coverage. Investors then fear a greater probability of default, and corporate bond credit-spreads widen.

INTEREST RATES

What we've discussed until now is known as the *real* side of the economy. We need an understanding of this for its own sake, as a determinant of corporate revenue and profits. But, in addition, macro-economic activity is intimately related to the financial side, which directly impacts corporate bond investors.

What determines interest rates? Fundamentally, supply of and demand for credit. From a macro-economic perspective, credit is made available by households consuming less than they produce. You can think of this in two ways, one the obverse of the other. Goods and services are produced by households (who are the ultimate owners of their own labor and the economy's physical capital and natural resources). The portion which they do not consume is made available to others (businesses, governments, foreigners) to consume. But they must pay it back, with interest. Alternatively, households receive income for their productive efforts, in the form of wages, profits, and rent. Rather than spending it all, they lend a portion to borrowers (who purchase the "left over" goods and service

4. Actually, payments to bondholders are made from earnings before (deductions for) interest and taxes (EBIT), which is not exactly the same as profits, but close enough for our purposes.

produced by households), and expect to be repaid, with interest. The more credit households make available to borrowers, that is, the more they save, the lower the interest rate borrowers must pay. The more credit borrowers require, the higher the interest rate necessary to elicit more savings from households.

THE CENTRAL BANK

What we've drawn now is the big picture. There are lots of details, only some of which are relevant to corporate bonds. A major one is the role of the central bank. Where does it fit in?

The central bank has a monopoly on liquidity creation, at least in the short run. Liquidity, in this context, refers to the means of effecting transactions. Every economy requires liquidity. Indeed, the greater the pace of economic activity, the more liquidity required.[5] This monopoly is what gives the central bank the ability to set (short-term) interest rates. Here's how it works, in a nutshell. Let's focus on the central bank in the United States, the Federal Reserve (the Fed). Central banks in other (industrialized) countries operate similarly.

Suppose the Fed observes real GDP growing substantially below its potential. Unemployment is uncomfortably high (and inflation not an issue). The central bank enters the market to purchase government securities from bond dealers. The Fed pays for the bonds with its own IOUs, called dollars. Liquidity has thus entered the financial markets. The dealer will either buy another bond with these dollars, or deposit them in its bank. Either way, some bank ends up with more dollars at the end of the day. Unless that bank decides to hoard the cash, the dollars will find their way into the interbank market. Hence, the interbank rate, known in the U.S. as the *federal funds rate*, declines. In short, purchases of bonds by a central bank add liquidity—dollars, in the case of the Fed—to the financial system.[6] Indeed, this would result from any asset purchase (including the making of a loan) by the central bank. The bank's balance sheet is expanded: bonds or loans on the asset side; dollars, or whatever the country's currency is, on the liability side.

The intention of the Fed with its liquidity injection as narrated above was to lower interest rates, hence borrowing costs, for households and businesses, thereby inducing them to increase expenditures, hence GDP. Lower interbank rates, by themselves, don't do the trick. The Fed hopes that the decline in the federal funds rate will filter through the financial markets, ultimately causing longer-term interest rates—upon which borrowing and spending decisions are based—to drop as well. How so? The lower federal funds rate prods banks to be less aggressive in

5. Interestingly, in the very long run, the more advanced an economy, the more efficient it tends to become at using liquidity, and the more substitutes it invents. Think of credit cards and electronic payments (even though ultimately, behind these payment transfers, lie dollars).

6. This is known as an "open market" operation. Not all operations are in the open market. For example, the Fed also makes direct ("discount window") loans to banks. In 2008, the Fed was granted a host of new open market and direct means of adding liquidity to the U.S. economy.

issuing deposits, such as certificates of deposits (CDs). Their rates drop, bringing down other money market interest rates which compete with CDs and other bank deposits. Investors, now searching for higher rates, extend along the yield-curve. This pushes longer-term rates lower. Furthermore, with interest rates having fallen, investors may be more willing to accept credit risk as they seek to replace yield in their portfolios. Risk spreads on corporate bonds narrow. More on these last two points—the yield-curve and corporate credit-spreads—later.

We can go through the reverse scenario quickly. Suppose the economy has been growing above its potential rate, so that the central bank fears inflation. To clamp down on aggregate demand the Fed wants interest rates to rise. It sells assets from its portfolio. The financial system is left with less cash, or liquidity, causing the interbank rate to be bid up. In turn, and subject to the caveats to be discussed below, money market and then long-term rates rise, dampening spending by those sectors sensitive to interest rates.[7]

It is important to note that the federal funds rate can rise or fall without any action on the part of the Fed. Indeed, this happens *because* of inaction on the part of the Fed. Suppose GDP rises. A greater level of economic activity requires more liquidity. If the central bank is not forthcoming with the additional liquidity via asset purchases, some banks will be searching for it in the interbank market. The federal funds rate will rise, with the ensuing repercussions as described above. If the Fed does supply the necessary dollars, it is said to have "validated" the demand for liquidity. How does the increase in the federal funds rate restore equilibrium if the Fed decides not to validate (perhaps because the economy is deemed strong enough)? Some banks may be sitting on excess liquidity, or reserves, which they may decide to lend now that the return on lending has risen. Or, some banks may approach the Fed for a loan, which is equivalent to the Fed purchasing additional assets.

IMPORTANT CONSIDERATIONS

While correct as far as it goes, this analysis is too simplistic, and corporate bond investors need to understand why. The key is the yield-curve, the relationship among interest rates over different maturities. The central bank's monopoly over liquidity creation allows it to set overnight rates, but what about rates for longer maturities (which influence aggregate demand)? As we will elaborate upon shortly, expectations about future interest rates, in turn driven by the business cycle, inflation outlook, savings rates, and government deficits, determine longer-term rates relative to shorter-term rates. And these fundamental factors are in large part *outside* the realm of the Fed.

Wait a second! If the Fed can control short-term interest rates, and longer-term interest rates reflect expectations of these very same short-term rates

7. We'll leave the less frequent central bank tools—reserve requirements and discount window lending—for a macro-economics textbook.

controlled by the Fed, then the Fed is responsible for all rates—either directly through their actions or via expectations of such! On the surface it does seem so. Further inspection shows otherwise.

The crucial point to recognize is that interest rates have been around a lot longer than central banks. Clearly, therefore, central banks cannot be the sole determinant of interest rates. Rather, at any point in time there is an "equilibrium" rate of interest for any given maturity. This rate reflects the confluence of fundamental factors, all finding expression in the supply of and demand for credit (as opposed to liquidity). Savers—mostly households—supply credit. Firms and governments (unless budgets are in surplus) demand credit. The equilibrium interest rate clears supply and demand. On top of this "real" rate is added a premium for expected inflation for that particular maturity. Where does the central bank fit into this framework? Through its monopoly on liquidity creation, the central bank, in the manner described earlier, can force the actual interest rate to diverge from the equilibrium rate. Indeed, this is what central bank monetary policy is all about. When the economy is weak (in our framework, a wide GDP gap) the equilibrium interest rate will fall on its own. Households tend to save a greater portion of their income in bad economic times, and firms have less of an incentive to borrow for capital expenditures.[8] The now lower interest rates should, theoretically, induce households and businesses to spend more. Practically, though, they may not (in reaction to the macro-economic weakness). And even if they do, it may happen too slowly to satisfy the central bank. In that case, the central bank will add liquidity to push short-term interest rates below their equilibrium levels, hopefully forcing long-term rates down as well, in order to spur aggregate demand. Conversely, a strong economy (a narrow, even negative, GDP gap) raises the equilibrium real interest rate, reflecting reduced households savings rates and healthy demand for capital by firms. The central bank may fear an inflationary outcome if the situation is permitted to proceed on its own. It will then remove liquidity in order to raise short-term rates above the equilibrium rate, hoping long-term rates will follow, which will discourage spending and cool off the economy.

So, what's wrong with this version of the macro-economic story? Can we not conclude that the central bank "fine-tunes" interest rates in order to achieve macro-economic stability? It's wrong because it suggests that the central bank has complete control—not over the economy, of course, but over interest rates. It doesn't. Suppose the bank holds rates too low, that is, compared with the equilibrium rate that would otherwise equate supply and demand for credit. The bank must continually pump liquidity into the financial system. The result is inflation.[9] At worst it occurs very soon, at best it becomes expected and built into financial contracts. In any case, the currency loses its value. In the extreme, people refuse to hold it, which erases the central bank's power entirely, as it resides in its monopoly over a

8. Government finances are more likely to be in deficit during these periods, but this typically is not enough to prevent a decline in the equilibrium interest rate.

9. In other words, in the long run, inflation is a monetary phenomenon (as opposed to being a function of the gap, or the shorter-term, cyclical relationship alluded to earlier).

commodity that nobody wants. Conversely, should the bank keep interest rates above the equilibrium rate for too long a period, individuals and institutions will adapt. With the cost of liquidity high, they will economize on cash and develop means of transacting that bypass the now expensive central bank liability. Again, the bank's capabilities are compromised.[10] In short, the central bank can only force interest rates away from their equilibrium values temporarily.

But how long is temporary? No one knows, not even the central bank. What we can say for sure is that the longer interest rates are maintained away from their equilibrium values, and the further the distance, the greater the probability of the currency losing its status as the ultimate source of liquidity, and with it the central bank's monopoly over liquidity. Central bankers understand this.

What does this imply for corporate bonds? A lot. Along with sector (e.g., government vs. corporate bonds) choice and issuer selection, investors must make a maturity decision. This involves, among other parameters, expectations about where interest rates (and credit-spreads) will be in the future. Building these expectations, we can now conclude, involves analyzing the likely course of the economy and attendant supply and demand for credit (more than liquidity). Such an analysis follows.

THE YIELD CURVE

With this fundamental background in mind, let's think about the yield-curve and, crucially for corporate bonds, the *spread curve*. The yield-curve represents the relationship, at any particular point in time, between yields on bonds and their remaining maturities. Yield-curves are typically presented for benchmark government bonds, so that the curve reflects "pure" interest rate factors and is not confused with credit risk, liquidity, and other factors.[11] Fundamentally, the shape of the yield-curve is determined by:

- Expectations on the part of market participants as to future (short-term) interest rates
- Expectations as to inflation over the period covered by the bond
- Interactions between supply and demand factors pertaining to particular points (maturities) on the curve plus risk aversion
- Interest rate volatility and bond convexity[12]

10. The introduction of money market mutual funds with check writing privileges in response to inflation and double digit interest rates in the 1970s serves as a great example.
11. To be totally correct, the yield-curve should really represent yields on "zero coupon" government bonds, the purest of all interest rates (technically referred to as "spot" rates).We make the jump, as most yield-curve pictures do, from zero coupon to coupon-bearing bonds (that is, from spot rates to yields) in our analysis.
12. A fuller treatment, one that space does not allow for here, of how these factors determine the shape of the yield-curve can be found in Steven Dym, *The Complete Practitioner's Guide to the Bond Market*.

EXHIBIT 5–1

Components of Corporate Bond Yields for 10-Year Yield-Curve

Year	Yield	Forward Rate	Expected Real Interest Rate	Expected Inflation Rate	Credit-Spread	Corporate Yield
1	2	2	1	1	3.6	5.6
2	3	4	3	1	3.25	6.25
3	3.5	4.5	3.5	1	3	6.5
4	4	5.5	4	1.5	2.95	6.95
5	4.4	6	4.5	1.5	3.08	7.48
6	4.75	6.5	5	1.5	3.25	8
7	5.07	7	5	2	3.43	8.5
8	5.34	7.25	4.75	2.5	3.61	8.95
9	5.56	7.25	4.5	2.75	3.74	9.3
10	5.68	6.75	4.25	2.5	3.97	9.65

The first two factors can be said to be primary, as they explain, in a quantitative sense, the bulk of the yield-curve; the last two factors are secondary. The state of the macro-economy, its point of cyclicality, and expectations thereof, find expression in the primary factors. This is where the above analysis will suit us perfectly. So, let's examine the stylized yield-curve contained in Exhibit 5–1. It is upward sloping, a curve shape typical of an economy in the early days of economic expansion. The "yield" column contains long-term interest rates, the focus of yield-curves. Each yield equals the average of the "forward" rates up until that year, contained in the second column.[13] Forward rates may be thought of as market participants' expectations for the one-year interest rates to obtain during that future year. Bond yields are "nominal," in that they equal the sum of the real interest rate and the market's view of inflation over the term of the bond. Hence, the next two columns present these ingredients for each future year. Each pair represents the market's expectation for the real interest rate and inflation rate, respectively, for that particular year, and sum to the forward rate for that year.[14]

13. Again, to be perfectly correct, the averages should be geometric, whereas in Exhibit 5–1 they are arithmetic.

14. For example, the exhibit assumes that market participants expect the one-year real interest rate two years from today to equal 3.5% and the inflation rate for that year to be 1%.This is not to be confused with the three-year real rate prevailing today and the expectation for inflation over the next three years.

Let's examine the entries of Exhibit 5–1, and the resultant yield-curve, in the context of macro-economic dynamics. Keep in mind that the interest rates in the columns under discussion thus far are for Treasury securities, i.e., they are (default) risk-free rates. The exhibit paints a stylized picture of a weak economy, but one expected to begin its rebound within a year. Consider the (nominal) forward rate column, which equals the sum of the next two columns, as just stated. In the current year (year 1), with economic activity restrained, labor and commodity markets have a great deal of slack, hence inflation is quite tame at 1%. The central bank has added liquidity, pushing the nominal one-year rate down to 2%. Taken together, this means that the real interest rate is 1%. The Fed's hope is that the low rates will make borrowing and spending more attractive. Market participants, in this scenario, believe that the policy will work. When economic activity picks up next year, if expectations are borne out, liquidity demands will rise concomitantly, the central bank will be less accommodating, and short-term real rates will increase as shown in Exhibit 5–1, from 1% to 3%.

Take particular notice of the expected inflation rate column in the exhibit. Even though a pickup in the economy is expected for next year, inflation is not expected to accelerate. True, there is an empirical regularity of inflation rising and falling, more or less, together with aggregate economic activity. But it is also generally true that this relationship is lagged. That is, price pressures tend to mount only after the economy has strengthened for a while, not concurrently with the start of the strengthening. Our stylized scenario assumes that market participants expect inflation to accelerate three years from now. Thus, even though real rates are anticipated to rise only moderately then—by a half percent in year 4—as the economy continues its expansion, the higher expected inflation term interacts with the real forward rate to produce a more sizable 1% jump in the nominal forward rate.

For the subsequent few years, expectations are that both real interest rates and inflation will increase. Real interest rates will rise because the expanding economy becomes more credit demanding; inflation will increase because resources are being used more intensively, thus forcing up their prices. For year 8, market participants foresee a decline in real rates, reflecting their view of the expansion coming to an end. Yet they believe that inflation will continue to accelerate, again reflecting its lagged response to the economy's dynamics. This prevents the forward rate from declining. It is not until year 10 that inflation, with a couple of years of economic weakness behind it, is expected to turn. The forward rate then falls. The yield-curve's shape, though, remains upward sloping throughout.[15]

15. This is because forward, or expected future, rates lie above yields throughout the period covered in the exhibit. See Chapter 8 in Steven Dym, *The Complete Practitioner's Guide to the Bond Market*. The analysis here is restricted to macro-economic factors in the yield-curve. Micro-economic factors, such as interest rate risk, volatility and bond convexity are omitted. For a fuller treatment, see Dym, ibid.

THE SPREAD CURVE

The sixth column contains the credit-spread for the relevant future year. Credit-spreads are the investor's compensation for risk of default, hence are added to the risk-free government bond rate to produce corporate bond yields.[16] The greater the risk of default, the wider the spread. Which corporate bonds? As this is a stylized analysis, we'll assume it refers to an average of various grade credits for each maturity. When analyzing credit-spreads over maturities, two factors come into play.

1. *Cyclical nature of corporate profits*. As explained at the outset, expanding economic activity is usually associated with increasing corporate profits, and narrowing spreads. The expectations set underlying the yield-curve in Exhibit 5–1 is one of a rebounding and then accelerating economy. Hence, along with expectations of rising risk-free interest rates, due to increasing credit demand, come expectations of narrowing corporate credit-spreads, reflecting ever greater ability of firms to service their debt. With inflation expected to gather steam in later years, however, the worry is that wages and material costs start to accelerate, perhaps faster than output prices, hurting corporate profitability and widening spreads for further-out years.
2. *Time factor in credit risk*. All else the same, the longer the maturity of a corporate bond, the greater the likelihood of default. Why? The longer the time frame, the more chances of negative events occurring, which reduce profits and, as the events compound, lead to default. True, the chances of positive events increase as well. But remember, bondholders do not gain from positive shocks to corporate earnings (as equity owners do). They stand only to lose from negative events. Hence, the longer the maturity, the greater the default risk, and the wider the credit-spread.

In short, during expansionary periods, or expectations of such, these two factors are typically counteractive elements in the corporate yield-spread curve—adding years to the (noninflationary) expansion narrows credit-spreads, while lengthening maturities widens them. The corporate yield-curve presented in Exhibit 5–1 assumes the cyclical factor dominates in the near years. For later years, the combination of the time factor plus expectations of wage and materials price inflation does the reverse. If, instead, the economy were in the throes of a contraction, the factors would typically be re-enforcing. Corporate credit-spreads would widen substantially with maturity, even for the early years. Indeed, a result is that in some situations the government bond yield-curve may be downward

16. Technically, the credit-spread should be added to each year's forward rate, and the corporate bond yield for that year calculated as a cumulative (geometric) average of the sums up to that year. The exhibit simplifies by adding the spread to the government bond yield.

sloping, reflective of overall macro-economic weakness and expectations of such, yet the corporate curve slopes upward.

CYCLICALITY OF CREDIT SPREADS

In the previous section we examined a stylized picture of yields and credit-spreads over a range of maturities for a particular point in time (i.e., a corporate bond yield-curve). Here we'll look at how corporate yields and spreads tend to behave dynamically over the business cycle. We consider both high-grade and high-yield corporates.

The discussion revolves around the information in Exhibit 5–2, which contains long-term, stylized averages of bond yields. The first column describes the state of macro-economic activity relative to the country's potential, as explained above. Let's begin with Treasuries, the yields of which anchor the rest. Recall that government bond interest rates, lacking a credit risk factor, contain only two components: a base interest rate, known as the real rate, plus a premium for the inflation rate expected over the life of the bond. The line labeled "potential" in Exhibit 5–2 refers to an economy operating with a GDP gap just above zero, a sort of neutral situation. In such an environment, we can assume a ballpark average real rate of 3%. A midpoint 3% rate for inflation is reasonable as well, since we need to look at time periods longer than just recent experience. Hence, the Treasury (nominal) yield is 6%.[17] The "weak" line denotes the economy operating substantially below its potential. This is not necessarily a recession (a contracting economy), but recessionary periods are included in the average here. Real interest rates are lower in this stage of the business cycle, reflecting both weak credit demand and ample liquidity supplied by the central bank. Inflation tends to be more volatile than real interest rates. Hence this entry assumes a real rate of

EXHIBIT 5–2

Yields over Various Stages of the Business Cycle

Business Cycle Stage	Treasury Yield	Investment Grade Corporate Yield	Speculative Grade Corporate Yield
weak	3%	5.5%	17%
potential	6%	7.5%	11%
strong	9%	10.0%	13%
stagflation	8%	12.0%	20%

17. Recognize that we're being somewhat loose with the numbers because our focus is not so much the *level* of rates in each table entry, but their co-movements (or lack thereof) across the business cycle.

2% and inflation of 1%, or a Treasury yield of 3%. Conversely, the economy operating above potential—the line labeled "strong"—results in higher inflation, say 5%. Credit demand is more robust, which, together with the Federal Reserve holding back on liquidity growth to prevent further inflation, pushes the real rate up to 4%, for a total of 9%. We'll get to the last line later.

The entries in the investment grade corporate bond column equal the Treasury yield (real interest rate plus inflation) plus a spread for credit risk. That spread, in turn, reflects a host of fundamental factors including the makeup of the firm's balance sheet, characteristics of the particular industry, company and management history, and from the investors' side, their degree of risk aversion. In terms of our macro-economic focus, most important is the firm's expected earnings. Each individual firm's sensitivity to the stage of the business cycle is unique. However, considering the high-grade sector overall, corporate profits, as we saw above, are certainly positively related to macro-economic activity. Let's begin with the middle line again. A midrange figure for credit-spreads, associated with the economy operating near its potential, is 1.5%, hence the 7.5% entry. Weak economic activity reduces average corporate profits, raising default risk and with it default spreads, from 1.5% to 2.5%, producing the 5.5% figure. At the other end, with macro-economic activity above the country's potential, spreads tighten to 1%, reflecting outsized corporate profits, which adds up to 10%. Credit-spreads, in other words, are counter-cyclical—they contract during an economic expansion, and expand during an economic contraction. This is a very important conclusion because, as explained just above, Treasury interest rates are *pro*-cyclical. Thus, the two components of corporate bond yields—Treasury rates and credit-spreads—offset each other over the course of the business cycle. Another way to say this is that corporate bond yields exhibit less volatility—on an absolute or a relative basis—than Treasury yields, as is clear from the first three lines of the table. Nevertheless, their correlation is positive. Notice further that weaker than average corporate earnings add a full percent to average credit-spreads (compared to the potential line), whereas stronger than average earnings subtracts only half a percent. Why the lack of symmetry? Simple: the most spreads can fall to is zero, while upside is limited only by actual default. To summarize:

- The yields on high-grade corporate and government bonds exhibit positive correlation over stages of the business cycle.
- High-grade corporate bond yields are less volatile than their Treasury counterparts.

Turn now to the final column. Credit-spreads for high-yield bonds preserve the cyclical pattern found in the high-grade column—widening during recessions, tightening in expansions. But the degree of cyclical sensitivity is so high for the speculative bond sector that it perverts the overall relationship with Treasuries. Consider: the "high-yield" in speculative grade bonds is due, of course, to their very wide credit-spreads over credit-riskless government bonds. The wide spreads, in turn, reflect substantial risk of default, largely the result of greater leverage in

the firms' balance sheets and, compared to the high-grade sector, more volatile industries (e.g., manufacturing as opposed to utilities). The sector's earnings, therefore, are acutely susceptible to movements in aggregate demand in the macro-economy. The effect of this earnings cyclicality on credit-spreads is augmented by the dynamics of investors' risk appetites. Risk aversion tends to decrease during expansions, increase in recessions, reflecting the natural correlation between income/wealth and willingness to take risk. Together, these factors tend to make spreads on high-yield bonds sharply sensitive to the business cycle. This combination of high-yield and greater sensitivity to the business cycle has two major implications for investment portfolios. Compare high-yield spreads (column 4 less column 2) with high-grade spreads (column 3 less column 2).The former exhibits much greater volatility. Here lies the perverse relationship. Both spreads are counter-cyclical, as is clear from Exhibit 5–2. But the proportion of a high-yield bond's interest rate due to the credit-spread component is of an order of magnitude greater than it is for high-grade interest rates. For example, in line 2, the high-grade spread accounts for one fifth (1.5/7.5) of the total rate, whereas the high-yield spread accounts for nearly one half (5/11). Hence, any movement in Treasury rates over the business cycle is swamped by movements in the high-yield spread. This negates the correlation between Treasury bond and high-yield bond interest rates. We can conclude:

- Not only do speculative grade bonds present higher yields than investment grade, their credit-spreads are more volatile over the economy's business cycle.[18]
- Whereas investment grade bond yields exhibit positive correlation with those of Treasury bonds, the larger role of credit-spreads in speculative grade bonds erases any meaningful correlation with Treasury yields.[19]

STAGFLATION

There have been few episodes of stagflation in the modern U.S. economy, but they are not forgotten. *Stagflation* denotes a period of macro-economic stagnation accompanied by inflation. Stagnation describes an economy operating well below its potential, hence with substantial unemployment. It does not necessarily

18. There's a bit of "sleight of hand" here. High-grade bonds exhibit less yield volatility than those of high-yield bonds only as long as the bonds remain high-grade. If a firm's credit worthiness deteriorates dramatically, possibly due to business cycle factors, it enters the speculative-grade region, and becomes high-yield. Its resultant yield volatility won't show up in the statistic covering high-grade volatility, yet it should.
19. A further implication of this conclusion concerns hedging. Hedging involves the "short" sale of a security (or derivative) to protect against a possible decline in price of a security owned in the portfolio. A hedge is successful to the extent the instrument used as the hedge is correlated with the security being hedged against. This way a price decline in one is offset by that of the other. Our analysis tells us that Treasury bonds may be useful for hedging high-grade corporate bonds, but are a poor hedge for high-yield corporates.

qualify as a recession, as economic activity is not contracting further, though it may likely follow a period of contraction. Yet, despite the macro-economic weakness, inflation is relatively high. A situation of stagflation can be the result of a period of rising commodity (typically oil) prices, and/or inflation expectations which have become embedded in the economy. Stagflation is devastating for corporate bonds.[20] Profits are down, due to weak economic activity. Firms are not adding to their capacity, as inflation creates uncertainty regarding future product demand. This combination of inflation, uncertainty, and economic lethargy causes risk premiums on corporate debt to widen dramatically, as shown in the last line of Exhibit 5–2. A sharp eye will notice the qualitative difference between the stagflation line and the others in the exhibit. Using the potential line as the benchmark, observe, as we have before, that in both the weak and strong periods, the Treasury rate and the risk premia (for both high-grade and high-yield corporate) move in opposite directions. The dynamics are starkly different under a regime of stagflation. Treasury rates increase, due to their inflation component. Yet, at the same time, spreads widen considerably. In short, credit-spread widening exacerbates corporate yield increases during periods of stagflation.

CORRELATION AND CAPITAL STRUCTURE

Our final topic relates not to the impact of macro-economic shifts on corporate bonds as a whole (or on corporate bond sectors). Rather, we examine the differential effects of macro dynamics on corporate bonds situated at different points on the issuer's capital structure. Some bonds are secured by collateral (effectively making them more senior in the firm's capital structure), while others are uncollateralized (known as debentures, hence are subordinated, or junior). The role of collateral in reducing the credit risk of corporate bonds is intimately wrapped up with the concept of correlation. This is not a well understood concept. But it is crucial in correctly analyzing the relative values of collateralized vs. uncollateralized bonds, particularly in a macro-economic context.[21]

Suppose a retail chain has issued bonds, half of them senior, half subordinated. The company owns a major building within which lies its flagship store. The building serves as collateral for the senior debt, hence that debt is secured. In the event of default, the keys to the building are handed over to the bondholders. The junior, or subordinated, debt is uncollateralized.[22] Exhibit 5–3 examines the four possible scenarios facing the firm, and their implications for the two classes of bondholders.

20. It is actually devastating for all corporate securities, including equities.
21. This is an especially important concept with regard to those credit derivatives whose value is attached to more than one security or company.
22. In the event of default, if the value of the building exceeds the claim of the senior debt holders, the excess is normally used to partially pay off the subordinated claims. For simplicity, our example assumes that the building will not be worth more than the face amount of the senior debt. Hence, the subordinated holders do not "look to" the real estate for payment, as the senior holders do.

EXHIBIT 5–3

Possible Scenarios for Retail Chain Bond Issuer (√:survival; ×:default)

Scenario	Retail Business	Real Estate
I	√	√
II	×	√
III	√	×
IV	×	×

A"√" mark denotes survival of the particular entity or asset (at least until the bonds mature); an "×" represents lack of survival. Clearly, the four scenarios exhaust all possibilities. We will make the simple assumption that the functioning retail business on its own can pay off both classes of bondholders, and the real estate, if necessary, can be sold to pay off the senior debt. For our purposes no probabilities need be associated with the possible outcomes. Still, from a macro-economic perspective, Scenario I is the most likely. If the firm's retail business survives, both the senior and junior debt will be paid in full. The fact that the building has retained its value is certainly a good thing for the firm, but in this situation presents no additional benefit to any of the bondholders.

If the firm's core retail business falters, and the firm defaults on its debt, the senior secured debt holders will look to the collateral (assuming the firm's other assets have already been deployed to pay off other creditors standing in line before bondholders, such as the government looking to collect any back taxes) for repayment. In Scenario II, the building has held up, so the senior debt is paid in full, which was the point of the collateral in the first place. The subordinated claimants go home empty handed (the building's market value is only enough to pay of the senior debt).

Scenario III represents the reverse, and less common, situation—the firm's business is doing fine, at least enough to cover its obligations to both bondholders, but the building has lost value. The decline in real estate, in this case, is effectively irrelevant to the bond positions.

Finally, Scenario IV has the retail business failing and the real estate depreciating to the point where the senior debt holders cannot be repaid in full. Not very likely, but quite possible (the recent recession serving as a dramatic example).

Let's step back and take a closer look at the senior, secured bondholders' position. They will only lose under Scenario IV, as they draw their payment from either the retail business or the real estate. Looked at another way, they will only lose if both businesses, or assets, fail to cover their claim. Now think about an extreme case. What if the real estate and retail business are perfectly negatively correlated? In that case Scenario IV could never unfold. The senior debt holders

could never lose! Said differently, their only possibility of loss reflects the extent that the building and the firm's business show any degree of positive correlation, making Scenario IV at least possible. Indeed, the more highly correlated, the more risky their position, as this would increase the chances of Scenario IV unfolding.[23]

Before we consider the other theoretical extreme—the retail business and the real estate are perfectly positively correlated—let's look at risk from the subordinated bondholders' perspective. If the company defaults, due to the retail business's deterioration, the junior bondholders will not be looking to the real estate for payment; the building secures the senior debt holders, and that's it. Both scenarios II and IV are what these lenders worry about. In other words, the second column in Exhibit 5–3 is irrelevant to them. If the two businesses are perfectly negatively correlated, they still lose in Scenario II; in contrast to the senior, the junior bond holders do not benefit from the negative correlation.[24]

Now consider the opposite extreme—the firm's retail selling business is perfectly *positively* correlated with the value of the building serving as collateral. In this case, only Scenarios I and IV can occur. In I, both classes of bondholders are paid; in IV, neither. Under perfectly positive correlation, therefore, there is no added benefit to being senior/secured. Another way to say the same thing is, the more positively correlated the collateral is to the core business of the bond issuer, the less valuable the collateral as an enhancement to being senior in the company's capital structure. And the less valuable, the less it should cost to be senior; that is, the less they should give up in yield. In bond terminology, the greater the correlation, the narrower the difference in interest rates, or spread, between the senior and junior debt holders.

Here, then, is the straightforward macro-economic implication. Business cycles are characterized by their breadth as well as depth. A downturn can be quite severe, but it may bypass some sectors of the economy. Real estate, for example, may hold up as aggregate demand falters, i.e., it exhibits weak correlation with the rest of the economy. In that case, collateralization is useful, and secured bonds are not as negatively impacted (their credit-spreads widen modestly). The 2008–2009 downturn was different. It was not only sharp, but broad. Indeed, real estate suffered relatively more than the economy as a whole. Collateralization proved less beneficial, which was reflected in dramatic corporate bond spread widening across all classes.[25]

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23. The secured debt holders, therefore, can be said to be subject only to *correlation risk.*
24. They are, therefore, exposed to outright risk, not to correlation risk.
25. Let's alter the structure just a bit. Assume the retail business can only cover the senior debt. The firm's balance sheet is simple: the sum of the two bonds' face value equal the sum of the values of the core business and real estate (i.e., in default scenarios the equity cushion vanishes). Again, the senior/secured bondholders only lose in Scenario IV. But now the subordinated bondholders will lose in every situation but the first. Hence the punch line: if the two assets are perfectly negatively correlated, the subordinated debt holders always lose! Said another way, the more negatively correlated, the greater is the risk, a key notion in structured credit products such as collateralized debt obligations.

KEY POINTS

- The ability of firms to service their debt is, in the aggregate, dependent upon the level of macro-economic activity. Generally, higher GDP levels are associated with greater income and profits. Conversely, recessionary GDP levels reduce the ability of firms to service debt, hence increase the risk of default. Understanding the drivers of the economy, therefore, are crucial to investing in corporate bonds.
- Corporate bond yields are the sum of the Treasury rate plus a default risk premium. In turn, the former includes a real interest rate and a premium for expected inflation. The Treasury yield-curve reflects, fundamentally, investors' expectations regarding the course of the business cycle and its interactions with inflation. Inflation in the short run is a function of the GDP "gap;" in the long run it is a monetary phenomenon. The monetary authority can "control" short-term (interbank) rates through its near monopoly on liquidity creation, but in the long run it cannot deviate significantly from the economy's equilibrium interest rate.
- Spreads on corporate debt are determined by overall economic dynamics, sector sensitivity to the business cycle and firm-specific factors such as leverage. Investor risk appetites play an important role as well, especially in the high-yield sector. The "spread curve" reflects two, sometimes competing, factors. The longer the maturity, the greater the chance of a negative event. At the beginning of a macro-economic rebound, the longer the time frame, the greater the chance of the economy, hence companies, gaining earnings momentum.
- High-grade corporate bond yields are less volatile than Treasury yields over a complete business cycle because credit-spreads are counter-cyclical, whereas the risk-free rate tends to be cyclical. Still, investment grade bond yields show positive correlation with Treasury rates. High-yield bonds may show greater volatility, depending on the sharpness of the cycle, and by nature present little correlation with Treasuries.
- Corporate bonds of the same issuer can react differently to macro-economic dynamics, depending on their positions in the firm's capital structure. Senior bonds, particularly those secured with real estate, are hurt only if both the firm's business (producing the cash-flow) and the collateral are insufficient to pay off the debt. Hence, the more negatively correlated the two, the less risk faced by the senior debt holders (and the narrower their required credit-spread). Subordinated, uncollateralized bond holders gain little from negative correlation, as they do not look to the collateral for payment.

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CHAPTER
SIX

BOND PRICING, YIELD MEASURES, AND TOTAL RETURN

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

In this chapter the pricing of fixed income securities and the various measures of computing return (or yield) from holding a fixed income security will be explained and illustrated. The chapter is organized as follows: In the first section, we apply the present-value analysis to explain how a bond's price is determined. Then we turn to yield measures, first focusing on conventional yield measures for a fixed-rate bond (yield-to-maturity and yield-to-call in the case of a callable bond) and a floating-rate bond. After highlighting the deficiencies of the conventional yield measures, a better measure of return—total return—is then presented.

BOND PRICING

The price of any financial instrument is equal to the present value of the expected cash-flow. The interest rate or discount rate used to compute the present value depends on the yield offered on comparable securities in the market. In this chapter we shall explain how to compute the price of an option-free bond (i.e, a bond that is not callable, putable, or convertible). The pricing of bonds with embedded options is explained in Chapter 40.

Determining the Cash-Flow

The first step in determining the price of a bond is to determine its cash-flow. The cash-flow of an option-free bond consists of (1) periodic coupon interest payments to the maturity date and (2) the par (or maturity) value at maturity. Although the periodic coupon payments can be made over any time interval (weekly, monthly, quarterly, semiannually, or annually), most bonds issued in the United States pay coupon interest semiannually. In our illustrations, we shall assume that the coupon interest is paid semiannually. Also, to simplify the analysis, we shall assume that

the next coupon payment for the bond will be made exactly six months from now. Later in this section we explain how to price a bond when the next coupon payment is less than six months from now.

In practice, determining the cash-flow of a bond is not simple, even if we ignore the possibility of default. The only case in which the cash-flow is known with certainty is for fixed-rate, option-free bonds. For callable bonds, the cash-flow depends on whether the issuer elects to call the issue. In the case of a putable bond, it depends on whether the bondholder elects to put the issue. In either case, the date that the option will be exercised is not known. Thus the cash-flow is uncertain. For mortgage-backed and asset-backed securities, the cash-flow depends on prepayments. The amount and timing of future prepayments are not known, and therefore, the cash-flow is uncertain. When the coupon rate is floating rather than fixed, the cash-flow depends on the future value of the reference rate. The techniques discussed in Part 5 have been developed to cope with the uncertainty of cash-flows. In this chapter, the basic elements of bond pricing where the cash-flow is assumed to be known are presented.

The cash-flow for an option-free bond consists of an annuity (i.e., the fixed coupon interest paid every 6 months) and the par or maturity value. For example, a 20-year bond with a 9% (4.5% per 6 months) coupon rate and a par or maturity value of $1,000 has the following cash-flows:

$$\begin{aligned} \text{Semiannual coupon interest} &= \$1{,}000 \times 0.045 \\ &= \$45 \\ \text{Maturity value} &= \$1{,}000 \end{aligned}$$

Therefore, there are 40 semiannual cash-flows of $45, and a $1,000 cash-flow 40 six-month periods from now.

Notice the treatment of the par value. It is *not* treated as if it will be received 20 years from now. Instead, it is treated on a consistent basis with the coupon payments, which are semiannual.

Determining the Required Yield

The interest rate that an investor wants from investing in a bond is called the *required yield.* The required yield is determined by investigating the yields offered on comparable bonds in the market. By comparable, we mean option-free bonds of the same credit quality and the same maturity.[1]

The required yield typically is specified as an annual interest rate. When the cash-flows are semiannual, the convention is to use one-half the annual interest rate as the periodic interest rate with which to discount the cash-flows. A periodic interest

1. In Chapter 7, we introduce a measure of interest-rate risk known as *duration*. Instead of talking in terms of a bond with the same maturity as being comparable, we can recast the analysis in terms of the same duration.

rate that is one-half the annual yield will produce an effective annual yield that is greater than the annual interest rate.

Although one yield is used to calculate the present value of all cash-flows, there are theoretical arguments for using a different yield to discount the cash-flow for each period. Essentially, the theoretical argument is that each cash-flow can be viewed as a zero-coupon bond, and therefore, the cash-flow of a bond can be viewed as a package of zero-coupon bonds. The appropriate yield for each cash-flow then would be based on the theoretical rate on a zero-coupon bond with a maturity equal to the time that the cash-flow will be received. For purposes of this chapter, however, we shall use only one yield to discount all cash-flows. In later chapters, this issue is reexamined.

Determining the Price

Given the cash-flows of a bond and the required yield, we have all the necessary data to price the bond. The price of a bond is equal to the present value of the cash-flows, and it can be determined by adding (1) the present value of the semiannual coupon payments and (2) the present value of the par or maturity value.

Because the semiannual coupon payments are equivalent to an ordinary annuity, the present value of the coupon payments and maturity value can be calculated from the following formula:[2]

$$c\left[\frac{1-\left\{\frac{1}{(1+i)^n}\right\}}{i}\right]+\frac{M}{(1+i)^n}$$

where

c = semiannual coupon payment ($)
n = number of periods (number of years times 2)
i = periodic interest rate (required yield divided by 2) (in decimal)
M = maturity value

Illustration 1. Compute the price of a 9% coupon bond with 20 years to maturity and a par value of $1,000 if the required yield is 12%.

The cash-flows for this bond are as follows: (1) 40 semiannual coupon payments of $45 and (2) $1,000 40 six-month periods from now. The semiannual or periodic interest rate is 6%.

2. The first term in the formula is the same as the formula for the present value of an ordinary annuity for n periods.

The present value of the 40 semiannual coupon payments of \$45 discounted at 6% is \$677.08, as shown below:

$$c = \$45$$
$$n = 40$$
$$i = 0.06$$
$$\$45\left[\frac{1-\left\{\frac{1}{(1.06)^{40}}\right\}}{0.06}\right]$$
$$= \$45\left[\frac{1-\left\{\frac{1}{10.28572}\right\}}{0.06}\right]$$
$$= \$45\left[\frac{1-0.097222}{0.06}\right]$$
$$= \$45(15.04630)$$
$$= \$677.08$$

The present value of the par or maturity value *40 six-month periods* from now discounted at 6% is \$97.22, as shown below:

$$M = \$1,000$$
$$n = 0.40$$
$$i = 0.06$$
$$\$1,000\left[\frac{1}{(1.06)^{40}}\right]$$
$$= \$1,000\left[\frac{1}{10.28572}\right]$$
$$= \$1,000(0.097222)$$
$$= \$97.22$$

The price of the bond is then equal to the sum of the two present values:

Present value of coupon payments	\$677.08
Present value of par (maturity) value	97.22
Price	\$774.30

Illustration 2. Compute the price of the bond in Illustration 1 assuming that the required yield is 7%.

The cash-flows are unchanged, but the periodic interest rate is now 3.5% (7%/2).

The present value of the 40 semiannual coupon payments of $45 discounted at 3.5% is $960.98, as shown below:

$$
\begin{aligned}
c &= \$45 \\
n &= 40 \\
i &= 0.035 \\
&\$45\left[\frac{1-\left\{\frac{1}{(1.035)^{40}}\right\}}{0.035}\right] \\
&= \$45\left[\frac{1-\left\{\frac{1}{3.95926}\right\}}{0.035}\right] \\
&= \$45\left[\frac{1-0.252572}{0.035}\right] \\
&= \$45(21.35509) \\
&= \$960.98
\end{aligned}
$$

The present value of the par or maturity value of $1,000 *40 six-month periods from now* discounted at 3.5% is $252.57, as shown below:

$$
\begin{aligned}
M &= \$1,000 \\
n &= 40 \\
&= 0.035 \\
&\$1,000\left[\frac{1}{(1.035)^{40}}\right] \\
&= \$1,000\left[\frac{1}{3.95926}\right] \\
&= \$1,000(0.252572) \\
&= \$252.57
\end{aligned}
$$

The price of the bond is then equal to the sum of the two present values:

Present value of coupon payments	$960.98
Present value of par (maturity) value	252.57
Price	$1,213.55

EXHIBIT 6–1

Price/Yield Relationship for a 20-Year, 9% Coupon Bond

Required Yield	Price of Bond
5%	$1,502.05
6	1,346.72
7	1,213.55
8	1,098.96
9	1,000.00
10	914.21
11	839.54
12	774.30
13	717.09
14	666.71

Relationship between Required Yield and Price at a Given Time

The price of an option-free bond changes in the direction opposite to the change in the required yield. The reason is that the price of the bond is the present value of the cash-flows. As the required yield increases, the present value of the cash-flows decreases; hence the price decreases. The opposite is true when the required yield decreases: The present value of the cash-flows increases, and therefore, the price of the bond increases.

We can see this by comparing the price of the 20-year, 9% coupon bond that we priced in Illustrations 1 and 2. When the required yield is 12%, the price of the bond is $774.30. If, instead, the required yield is 7%, the price of the bond is $1,213.55. Exhibit 6–1 shows the price of the 20-year, 9% coupon bond for required yields from 5% to 14%.

If we graphed the price/yield relationship for any option-free bond, we would find that it has the "bowed" shape shown in Exhibit 6–2. This shape is referred to as *convex*.[3] The convexity of the price/yield relationship has important implications for the investment properties of a bond. We've devoted Chapter 7 to examining this relationship more closely.

3. In the exhibit, the curve representing the price/yield relationship intersects the price axis when the required yield is zero and is the maximum price for the bond. That price is simply the undiscounted value of the cash-flows.

EXHIBIT 6–2

Price/Yield Relationship

The Relationship among Coupon Rate, Required Yield, and Price

For a bond issue at a given point in time, the coupon rate and the term-to-maturity are fixed. Consequently, as yields in the marketplace change, the only variable that an investor can change to compensate for the new yield required in the market is the price of the bond. As we saw in the preceding section, as the required yield increases (decreases), the price of the bond decreases (increases).

Generally, when a bond is issued, the coupon rate is set at approximately the prevailing yield in the market.[4] The price of the bond then will be approximately equal to its par value. For example, in Exhibit 6–1, we see that when the required yield is equal to the coupon rate, the price of the bond is its par value. Consequently, we have the following properties:

When the coupon rate equals the required yield, the price equals the par value.

When the price equals the par value, the coupon rate equals the required yield.

When yields in the marketplace rise above the coupon rate *at a given time,* the price of the bond has to adjust so that the investor can realize some additional interest. This adjustment is accomplished by having the bond's price fall below the par value. The difference between the par value and the price is a capital gain and represents a form of interest to the investor to compensate for the coupon rate being lower than the required yield. When a bond sells below its par value, it is said to be selling at a *discount.* We can see this in Exhibit 6–1. When the required

4. The exception is an original-issue discount bond such as a zero-coupon bond.

yield is greater than the coupon rate of 9%, the price of the bond is always less than the par value. Consequently, we have the following properties:

When the coupon rate is less than the required yield, the price is less than the par value.

When the price is less than the par value, the coupon rate is less than the required yield.

Finally, when the required yield in the market is below the coupon rate, the price of the bond must be above its par value. This occurs because investors who could purchase the bond at par would be getting a coupon rate in excess of what the market requires. As a result, investors would bid up the price of the bond because its yield is attractive. It will be bid up to a price that offers the required yield in the market. A bond whose price is above its par value is said to be selling at a *premium*. Exhibit 6–1 shows that for a required yield less than the coupon rate of 9%, the price of the bond is greater than its par value. Consequently, we have the following properties:

When the coupon rate is greater than the required yield, the price is greater than the par value.

When the price is greater than the par value, the coupon rate is greater than the required yield.

Time Path of a Bond

If the required yield is unchanged between the time the bond is purchased and the maturity date, what will happen to the price of the bond? For a bond selling at par value, the coupon rate is equal to the required yield. As the bond moves closer to maturity, the bond will continue to sell at par value. Thus, for a bond selling at par, its price will remain at par as the bond moves toward the maturity date.

The price of a bond will *not* remain constant for a bond selling at a premium or a discount. For all discount bonds, the following is true: As the bond moves toward maturity, its price will increase if *the required yield* does not change. This can be seen in Exhibit 6–3, which shows the price of the 20-year, 9% coupon bond as it moves toward maturity, assuming that the required yield remains at 12%. For a bond selling at a premium, the price of the bond declines as it moves toward maturity. This can also be seen in Exhibit 6–3, which shows the time path of the 20-year, 9% coupon bond selling to yield 7%.

Reasons for the Change in the Price of a Bond

The price of a bond will change because of one or more of the following reasons:

- *A change in the level of interest rates in the economy.* For example, if interest rates in the economy increase (fall) because of Fed policy, the price of a bond will decrease (increase).

EXHIBIT 6–3

Time Paths of 20-Year, 9% Coupon Discount and Premium Bonds

Years Remaining to Maturity	Price of Discount Bond*	Price of Premium Bond†
20	$774.30	$1,213.55
18	780.68	1,202.90
16	788.74	1,190.89
14	798.91	1,176.67
12	811.75	1,160.59
10	827.95	1,142.13
8	848.42	1,120.95
6	874.24	1,096.63
4	906.85	1,068.74
2	948.02	1,036.73
1	972.50	1,019.00
0	1,000.00	1,000.00

*Selling to yield 12%.
†Selling to yield 7%.

- *A change in the price of the bond selling at a price other than par as it moves toward maturity without any change in the required yield.* As we demonstrated, over time a discount bond's price increases if yields do not change; a premium bond's price declines over time if yields do not change.
- *For non-Treasury bonds, a change in the required yield due to changes in the spread to Treasuries.* If the Treasury rate does not change but the spread to Treasuries changes (narrows or widens), non-Treasury bond prices will change.
- *A change in the perceived credit quality of the issuer.* Assuming that interest rates in the economy and yield spreads between non-Treasuries and Treasuries do not change, the price of a non-Treasury bond will increase (decrease) if its perceived credit quality has improved (deteriorated).
- *For bonds with embedded options (callable bonds, putable bonds, and convertible bonds), the price of the bond will change as the factors that affect the value of the embedded options change.*

Pricing a Zero-Coupon Bond

So far we have determined the price of coupon-bearing bonds. Some bonds do not make any periodic coupon payments. Instead, the investor realizes interest by the difference between the maturity value and the purchase price.

The pricing of a zero-coupon bond is no different from the pricing of a coupon bond: Its price is the present value of the expected cash-flows. In the case of a zero-coupon bond, the only cash-flow is the maturity value. Therefore, the price of a zero-coupon bond is simply the present value of the maturity value. The number of periods used to discount the maturity value is double the number of years to maturity. This treatment is consistent with the manner in which the maturity value of a coupon bond is handled.

Illustration 3. The price of a zero-coupon bond that matures in 10 years and has a maturity value of $1,000 if the required yield is 8.6% is equal to the present value of $1,000 20 periods from now discounted at 4.3%. That is,

$$\$1{,}000\left[\frac{1}{(1.043)^{20}}\right] = \$430.83$$

Determining the Price When the Settlement Date Falls between Coupon Periods

In our illustrations we assumed that the next coupon payment is six months away. This means that settlement occurs on the day after a coupon date. Typically, an investor will purchase a bond between coupon dates so that the next coupon payment is less than six months away. To compute the price, we have to answer the following three questions:

- How many days are there until the next coupon payment?
- How should we determine the present value of cash-flows received over fractional periods?
- How much must the buyer compensate the seller for the coupon interest earned by the seller for the fraction of the period that the bond was held?

The first question is the day-count question. The second is the compounding question. The last question asks how accrued interest is determined. Below we address these questions.

Day Count

Market conventions for each type of bond dictate the answer to the first question: The number of days until the next coupon payment.

For Treasury coupon securities, a nonleap year is assumed to have 365 days. The number of days between settlement and the next coupon payment is therefore the actual number of days between the two dates. The day count convention for a coupon-bearing Treasury security is said to be "actual/actual," which means the actual number of days in a month and the actual number of days in the coupon period. For example, consider a Treasury bond whose last coupon payment was on March 1; the next coupon would be six months later on September 1. Suppose that

this bond is purchased with a settlement date of July 17. The actual number of days between July 17 (the settlement date) and September 1 (the date of the next coupon payment) is 46 days (the actual number of days in the coupon period is 184), as shown below:

July 17 to July 31	14 days
August	31 days
September 1	1 day
	46 days

In contrast to the actual/actual day count convention for coupon-bearing Treasury securities, for corporate and municipal bonds and agency securities, the day count convention is "30/360." That is, each month is assumed to have 30 days and each year 360 days. For example, suppose that the security in our previous example is not a coupon-bearing Treasury security but instead either a coupon-bearing corporate bond, municipal bond, or agency security. The number of days between July 17 and September 1 is shown below:

Remainder of July	13 days
August	30 days
September 1	1 day
	44 days

Compounding

Once the number of days between the settlement date and the next coupon date is determined, the present value formula must be modified because the cash-flows will not be received six months (one full period) from now. The Street convention is to compute the price is as follows:

1. Determine the number of days in the coupon period.
2. Compute the following ratio:

$$w = \frac{\text{number of days between settlement and next coupon payment}}{\text{number of days in the coupon period}}$$

   For a corporate bond, a municipal bond, and an agency security, the number of days in the coupon period will be 180 because a year is assumed to have 360 days. For a coupon-bearing Treasury security, the number of days is the actual number of days. The number of days in the coupon period is called the *basis*.

3. For a bond with n coupon payments remaining to maturity, the price is

$$p = \frac{c}{(1+i)^{w}} + \frac{c}{(1+i)^{1+w}} + \frac{c}{(1+i)^{2+w}} + \cdots + \frac{c}{(1+i)^{n-1+w}} + \frac{M}{(1+i)^{n-1+w}}$$

where

p = price ($)
c = semiannual coupon payment ($)
M = maturity value
n = number of coupon payments remaining
i = periodic interest rate (required yield divided by 2) (in decimal)

The period (exponent) in the formula for determining the present value can be expressed generally as $t - 1 + w$. For example, for the first cash-flow, the period is $1 - 1 + w$, or simply w. For the second cash-flow, it is $2 - 1 + w$, or simply $1 + w$. If the bond has 20 coupon payments remaining, the last period is $20 - 1 + w$, or simply $19 + w$.

Illustration 4. Suppose that a corporate bond with a coupon rate of 10% maturing March 1, 2012 is purchased with a settlement date of July 17, 2006. What would the price of this bond be if it is priced to yield 6.5%?

The next coupon payment will be made on September 1, 2006. Because the bond is a corporate bond, based on a 30/360 day-count convention, there are 44 days between the settlement date and the next coupon date. The number of days in the coupon period is 180. Therefore,

$$w = \frac{44}{180} = 0.24444$$

The number of coupon payments remaining, n, is 12. The semiannual interest rate is 3.25% (6.5%/2).

The calculation based on the formula for the price is given in Exhibit 6–4. The price of this corporate bond would be $120.0281 per $100 par value. The price calculated in this way is called the *full price* or *dirty price* because it reflects the portion of the coupon interest that the buyer will receive but that the seller has earned.

Accrued Interest and the Clean Price

The buyer must compensate the seller for the portion of the next coupon interest payment the seller has earned but will not receive from the issuer because the issuer will send the next coupon payment to the buyer. This amount is called *accrued interest* and depends on the number of days from the last coupon payment to the settlement date.[5] The accrued interest is computed as follows:

$$\text{AI} = c\left(\frac{\text{number of days from last coupon payment to settlement date}}{\text{number of days in coupon period}}\right)$$

5. Accrued interest is not computed for all bonds. No accrued interest is computed for bonds in default or income bonds. A bond that trades without accrued interest is said to be traded "flat."

EXHIBIT 6–4

Price Calculation When a Bond Is Purchased between Coupon Payments

Period	Cash-Flow per $100 of Par	Present Value of $1 at 3.25%	Present Value of Cash-Flow
0.24444	$ 5.000	$0.992212	$4.961060
1.24444	5.000	0.960980	4.804902
2.24444	5.000	0.930731	4.653658
3.24444	5.000	0.901435	4.507175
4.24444	5.000	0.873060	4.365303
5.24444	5.000	0.845579	4.227896
6.24444	5.000	0.818963	4.094815
7.24444	5.000	0.793184	3.965922
8.24444	5.000	0.768217	3.841087
9.24444	5.000	0.744036	3.720181
10.24444	5.000	0.720616	3.603081
11.24444	105.000	0.697933	73.283000
		Total	$120.028100

where

AI = accrued interest ($)
c = semiannual coupon payment ($)

Illustration 5. Let's continue with the hypothetical corporate bond in Illustration 4. Because the number of days between settlement (July 17, 2006) and the next coupon payment (September 1, 2006) is 44 days and the number of days in the coupon period is 180, the number of days from the last coupon payment date (March 1, 2006) to the settlement date is 136 (180 – 44). The accrued interest per $100 of par value is

$$\text{AI} = \$5\left(\frac{136}{180}\right) = \$3.777778$$

The full or dirty price includes the accrued interest that the seller is entitled to receive. For example, in the calculation of the full price in Exhibit 6–4, the next coupon payment of $5 is included as part of the cash-flow. The *clean price* or *flat price* is the full price of the bond minus the accrued interest.

The price that the buyer pays the seller is the full price. It is important to note that in calculation of the full price, the next coupon payment is a discounted value, but in calculation of accrued interest, it is an undiscounted value. Because of this market practice, if a bond is selling at par and the settlement date is not a

coupon date, the yield will be slightly less than the coupon rate. Only when the settlement date and coupon date coincide is the yield equal to the coupon rate for a bond selling at par.

In the U.S. market, the convention is to quote a bond's clean or flat price. The buyer, however, pays the seller the full price. In some non-U.S. markets, the full price is quoted.

CONVENTIONAL YIELD MEASURES

In the preceding section we explained how to compute the price of a bond given the required yield. In this section we'll show how various yield measures for a bond are calculated given its price. First let's look at the sources of potential return from holding a bond.

An investor who purchases a bond can expect to receive a *dollar* return from one or more of the following sources:

- The coupon interest payments made by the issuer
- Any capital gain (or capital loss—negative dollar return) when the bond matures, is called, or is sold
- Income from reinvestment of the coupon interest payments

This last source of dollar return is referred to as *interest-on-interest.*

Three yield measures are commonly cited by market participants to measure the potential return from investing in a bond—current yield, yield-to-maturity, and yield-to-call. These yield measures are expressed as a *percent* return rather than as a dollar return. However, any yield measure should consider each of the three potential sources of return just cited. Below we discuss these three yield measures and assess whether they consider the three sources of potential return.

Current Yield

The current yield relates the *annual* coupon interest to the market price. The formula for the current yield is

$$\text{Current yield} = \frac{\text{annual dollar coupon interest}}{\text{price}}$$

Illustration 6. The current yield for an 18-year, 6% coupon bond selling for \$700.89 per \$1,000 par value is 8.56%, as shown below:

$$\begin{aligned}\text{Annual dollar coupon interest} &= \$1{,}000 \times 0.06 \\ &= \$60\end{aligned}$$

$$\text{Current yield} = \frac{\$60}{\$700.89} = 0.0856, \text{ or } 8.56\%$$

The current yield considers only the coupon interest and no other source of return that will affect an investor's return. For example, in Illustration 6, no consideration is given to the capital gain that the investor will realize when the bond matures. No recognition is given to a capital loss that the investor will realize when a bond selling at a premium matures. In addition, interest-on-interest from reinvesting coupon payments is ignored.

Yield-to-Maturity

The yield or internal rate of return on any investment is the interest rate that will make the present value of the cash-flows equal to the price (or initial investment).[6] The yield-to-maturity is computed in the same way as the yield; the cash-flows are those which the investor would realize by holding the bond to maturity. For a semiannual-pay bond, doubling the interest rate or discount rate gives the yield-to-maturity.

The calculation of a yield involves a trial-and-error procedure. Practitioners usually use calculators or software to obtain a bond's yield-to-maturity. The following illustration shows how to compute the yield-to-maturity for a bond.

Illustration 7. In Illustration 6 we computed the current yield for an 18-year, 6% coupon bond selling for $700.89. The maturity value for this bond is $1,000. The yield-to-maturity for this bond is 9.5%, as shown in Exhibit 6–5. Cash-flows for the bond are

- 36 coupon payments of $30 every six months
- $1,000 36 six-month periods from now

Different interest rates must be tried until one is found that makes the present value of the cash-flows equal to the price of $700.89. Because the coupon rate on the bond is 6% and the bond is selling at a discount, the yield must be greater than 6%. Exhibit 6–5 shows the present value of the cash-flows of the bond for semiannual interest rates from 3.25% to 4.75% (corresponding to annual interest rates from 6.5% to 9.50%). As can be seen, when a 4.75% interest rate is used, the present value of the cash-flows is $700.89. Therefore, the yield-to-maturity is 9.50% (4.75% × 2).

The yield-to-maturity considers the coupon income and any capital gain or loss that the investor will realize by *holding the bond to maturity.* The yield-to- maturity also considers the timing of the cash-flows. It does consider interest-on-interest; *however, it assumes that the coupon payments can be reinvested at an interest rate equal to the yield-to-maturity.* Thus, if the yield-to-maturity for a bond is 9.5%, to earn that yield, the coupon payments must be reinvested at an interest rate equal to 9.5%. The following example clearly demonstrates this.

6. For asset-backed and mortgage-backed securities, the equivalent measure is called the cash-flow yield. This measure is explained in Chapter 41.

EXHIBIT 6–5

Computation of Yield-to-Maturity for an 18-Year, 6% Coupon Bond Selling at $700.89

Objective: Find, by trial and error, the semiannual interest rate that will make the present value of the following cash-flows equal to $700.89:

36 coupon payments of $30 every six months
$1,000 36 six-month periods from now

Annual Interest Rate	Semi-annual Rate	Present Value of 36 Payments of $30*	Present Value of $1,000 10 Periods from Now†	Present Value of Cash-Flows
6.50%	3.25%	$631.20	$316.20	$947.40
7.00	3.50	608.71	289.83	898.54
7.50	3.75	587.42	265.72	853.14
8.00	4.00	567.25	243.67	810.92
8.50	4.25	548.12	223.49	771.61
9.00	4.50	529.98	205.03	735.01
9.50	4.75	512.76	188.13	700.89

$$^{*}30\left[\frac{1-\left\{\frac{1}{(1+\text{semiannual interest rate})^{36}}\right\}}{\text{semiannual interest rate}}\right]$$

$$^{\dagger}\$1{,}000\left[\frac{1}{(1+\text{semiannual interest rate})^{36}}\right]$$

Suppose that an investor has $700.89 and places the funds in a certificate of deposit (CD) that pays 4.75% every six months for 18 years, or 9.5% per year. At the end of 18 years, the $700.89 investment will grow to $3,726. Instead, suppose that the investor buys a 6%, 18-year bond selling for $700.89. This is the same as the price of our bond in Illustration 7. The yield-to-maturity for this bond is 9.5%. The investor would expect that at the end of 18 years, the total dollars from the investment will be $3,726.

Let's look at what he will receive. There will be 36 semiannual interest payments of $30, which will total $1,080. When the bond matures, the investor will receive $1,000. Thus the total dollars that he will receive is $2,080 if he holds the bond to maturity, but this is $1,646 less than the $3,726 necessary to produce a yield of 9.5% (4.75% semiannually). How is this deficiency supposed to be made up? If the investor reinvests the coupon payments at a semiannual interest rate of 4.75% (or a 9.5% annual rate), it is a simple exercise to demonstrate that the interest earned on the coupon payments will be $1,646. Consequently, of the

$3,025 total dollar return ($3,726 – $700.89) necessary to produce a yield of 9.5%, about 54% ($1,646 divided by $3,025) must be generated by reinvesting the coupon payments.

Clearly, the investor will realize the yield-to-maturity stated at the time of purchase only if (1) the coupon payments can be reinvested at the yield-to-maturity and (2) if the bond is held to maturity. With respect to the first assumption, the risk that an investor faces is that future reinvestment rates will be less than the yield-to-maturity at the time the bond is purchased. This risk is referred to as *reinvestment risk.* If the bond is not held to maturity, the price at which the bond may have to be sold is less than its purchase price, resulting in a return that is less than the yield-to-maturity. The risk that a bond will have to be sold at a loss because interest rates rise is referred to as *interest-rate risk.*

Reinvestment Risk

There are two characteristics of a bond that determine the degree of reinvestment risk. First, for a given yield-to-maturity and a given coupon rate, the longer the maturity, the more the bond's total dollar return is dependent on the interest-on-interest to realize the yield-to-maturity at the time of purchase. That is, the greater the reinvestment risk. The implication is that the yield-to-maturity measure for long-term coupon bonds tells little about the potential yield that an investor may realize if the bond is held to maturity. In high-interest-rate environments, the interest-on-interest component for long-term bonds may be as high as 80% of the bond's potential total dollar return.

The second characteristic that determines the degree of reinvestment risk is the coupon rate. For a given maturity and a given yield-to-maturity, the higher the coupon rate, the more dependent the bond's total dollar return will be on the reinvestment of the coupon payments in order to produce the yield-to-maturity at the time of purchase. This means that holding maturity and yield-to-maturity constant, premium bonds will be more dependent on interest-on-interest than bonds selling at par. For zero-coupon bonds, none of the bond's total dollar return is dependent on interest-on-interest; a zero-coupon bond carries no reinvestment risk if held to maturity.

Interest-Rate Risk

As we explained in the preceding section, a bond's price moves in the direction opposite to the change in interest rates. As interest rates rise (fall), the price of a bond will fall (rise). For an investor who plans to hold a bond to maturity, the change in the bond's price before maturity is of no concern; however, for an investor who may have to sell the bond prior to the maturity date, an increase in interest rates after the bond is purchased will mean the realization of a capital loss. Not all bonds have the same degree of interest-rate risk. In Chapter 7, the characteristics of a bond that determine its interest-rate risk are discussed.

Given the assumptions underlying yield-to-maturity, we can now demonstrate that yield-to-maturity has limited value in assessing the potential return of bonds.

Suppose that an investor who has a five-year investment horizon is considering the following four option-free bonds:

Bond	Coupon Rate	Maturity	Yield-to-Maturity
W	5%	3 years	9.0%
X	6	20	8.6
Y	11	15	9.2
Z	8	5	8.0

Assuming that all four bonds are of the same credit quality, which one is the most attractive to this investor? An investor who selects bond Y because it offers the highest yield-to-maturity is failing to recognize that the bond must be sold after five years, and the selling price of the bond will depend on the yield required in the market for 10-year, 11% coupon bonds at that time. Hence there could be a capital gain or capital loss that will make the return higher or lower than the yield-to-maturity promised now. Moreover, the higher coupon rate on bond Y relative to the other three bonds means that more of this bond's return will be dependent on the reinvestment of coupon interest payments.

Bond W offers the second highest yield-to-maturity. On the surface, it seems to be particularly attractive because it eliminates the problem faced by purchasing bond Y of realizing a possible capital loss when the bond must be sold before the maturity date. In addition, the reinvestment risk seems to be less than for the other three bonds because the coupon rate is the lowest. However, the investor would not be eliminating the reinvestment risk because after three years she must reinvest the proceeds received at maturity for two more years. The return that the investor will realize will depend on interest rates three years from now, when the investor must roll over the proceeds received from the maturing bond.

Which is the best bond? The yield-to-maturity doesn't seem to help us identify the best bond. The answer depends on the expectations of the investor. Specifically, it depends on the interest rate at which the coupon interest payments can be reinvested until the end of the investor's investment horizon. Also, for bonds with a maturity longer than the investment horizon, it depends on the investor's expectations about interest rates at the end of the investment horizon. Consequently, any of these bonds can be the best investment vehicle based on some reinvestment rate and some future interest rate at the end of the investment horizon. In the next section we present an alternative return measure for assessing the potential performance of a bond.

Yield-to-Maturity for a Zero-Coupon Bond

When there is only one cash-flow, it is much easier to compute the yield on an investment. A zero-coupon bond is characterized by a single cash-flow resulting from an investment. Consequently, the following formula can be applied to compute the yield-to-maturity for a zero-coupon bond:

$$y = (\text{future value per dollar invested})^{1/n} - 1$$

where

$$y = \text{one-half the yield-to-maturity}$$

$$\text{Future value per dollar invested} = \frac{\text{maturity value}}{\text{price}}$$

Once again, doubling y gives the yield-to-maturity. *Remember that the number of periods used in the formula is double the number of years.*

Illustration 8. The yield-to-maturity for a zero-coupon bond selling for $274.78 with a maturity value of $1,000, maturing in 15 years, is 8.8%, as computed below:

$$n = 15 \times 2 = 30$$

$$\text{Future value per dollar invested} = \frac{\$1{,}000.00}{\$274.78} = 3.639275$$

$$\begin{aligned} y &= (3.639275)^{1/30} - 1 \\ &= (3.639275)^{0.033333} - 1 \\ &= 1.044 - 1 \\ &= 0.044, \text{ or } 4.4\% \end{aligned}$$

Doubling 4.4% gives the yield-to-maturity of 8.8%.

Relationship among Coupon Rate, Current Yield, and Yield-to-Maturity

The following relationship should be recognized between the coupon rate, current yield, and yield-to-maturity:

Bond Selling at	Relationship
Par	Coupon rate = current yield = yield-to-maturity
Discount	Coupon rate < current yield < yield-to-maturity
Premium	Coupon rate > current yield > yield-to-maturity

Problem with the Annualizing Procedure

Multiplying a semiannual interest rate by 2 will give an underestimate of the effective annual yield. The proper way to annualize the semiannual yield is by applying the following formula:

$$\text{Effective annual yield} = (1 + \text{periodic interest rate})^k - 1$$

where

$$k = \text{number of payments per year}$$

For a semiannual-pay bond, the formula can be modified as follows:

$$\text{Effective annual yield} = (1 + \text{semiannual interest rate})^2 - 1$$

or

$$\text{Effective annual yield} = (1+y)^2 - 1$$

For example, in Illustration 7, the semiannual interest rate is 4.75%, and the effective annual yield is 9.73%, as shown below:

$$\begin{aligned}\text{Effective annual yield} &= (1.0475)^2 - 1\\ &= 1.0973 - 1\\ &= 0.0973, \text{ or } 9.73\%\end{aligned}$$

Although the proper way for annualizing a semiannual interest rate is given in the preceding formula, the convention adopted in the bond market is to double the semiannual interest rate. The yield-to-maturity computed in this manner—doubling the semiannual yield—is called a *bond-equivalent yield.* In fact, this convention is carried over to yield calculations for other types of fixed income securities.

Yield-to-Call

For a callable bond, investors also compute another yield (or internal rate of return) measure, the *yield-to-call*. The cash-flows for computing the yield-to-call are those which would result if the issue were called on some assumed call date. Two commonly used call dates are the *first call date* and the *first par call date*. The yield-to-call is the interest rate that will make the present value of the cash-flows if the bond is held to the assumed call date equal to the price of the bond (i.e., the full price).

Illustration 9. In Illustrations 6 and 7, we computed the current yield and yield-to-maturity for an 18-year, 6% coupon bond selling for $700.89. Suppose that this bond is first callable in five years at $1,030. The cash-flows for this bond if it is called in five years are

- 10 coupon payments of $30 every six months
- $1,030 in 10 six-month periods from now

The interest rate we seek is one that will make the present value of the cash-flows equal to $700.89. From Exhibit 6–6, it can be seen that when the interest rate is 7.6%, the present value of the cash-flows is $700.11, which is close enough to $700.89 for our purposes. Therefore, the yield-to-call on a bond-equivalent basis is 15.2% (double the periodic interest rate of 7.6%).

According to the conventional approach, conservative investors will compute the yield-to-call and yield-to-maturity for a callable bond selling at a premium, selecting the lower of the two as a measure of potential return. It is the smaller of the two yield measures that investors would use to evaluate the yield for a bond. Some investors calculate not just the yield to the first call date and yield to first par call date but the yield to all possible call dates. Because most bonds can be called

EXHIBIT 6–6

Computation of Yield-to-Call for an 18-Year, 6% Coupon Bond Callable in 5 Years at $1,030, Selling at $700.89

Objective: Find, by trial and error, the semiannual interest rate that will make the present value of the following cash-flows equal to $700.89:

10 coupon payments of $30 every six months
$1,030 10 six-month periods from now

Annual Interest Rate	Semi-annual Rate	Present Value of 10 Payments of $30*	Present Value of $1,030 10 Periods from Now†	Present Value of Cash Flows
11.20%	5.60%	$225.05	$597.31	$822.36
11.70	5.85	222.38	585.35	805.73
12.20	6.10	219.76	569.75	789.51
12.70	6.35	217.19	556.50	773.69
13.20	6.60	214.66	543.58	758.24
13.70	6.85	212.18	531.00	743.18
14.20	7.10	209.74	518.73	728.47
14.70	7.35	207.34	506.78	714.12
15.20	7.60	204.99	495.12	700.11

$$^{*}\$30\left[\frac{1-\left\{\frac{1}{(1+\text{semiannual interest rate})^{10}}\right\}}{\text{semiannual interest rate}}\right]$$

$$^{\dagger}\$1{,}030\left[\frac{1}{(1+\text{semiannual interest rate})^{10}}\right]$$

at any time after the first call date, the approach has been to compute the yield to every coupon anniversary date following the first call date. Then all calculated yields-to-call and the yield-to-maturity are compared. The lowest of these yields is called the *yield-to-worst*. The conventional approach would have us believe that this yield is the appropriate one a conservative investor should use.

Let's take a closer look at the yield-to-call as a measure of the potential return of a callable bond. The yield-to-call does consider all three sources of potential return from owning a bond. However, as in the case of the yield-to-maturity, it assumes that all cash-flows can be reinvested at the computed yield—in this case, the yield-to-call—until the assumed call date. As we noted earlier in this chapter, this assumption may be inappropriate. Moreover, the yield-to-call assumes that (1) the investor will hold the bond to the assumed call date and (2) the issuer will call the bond on that date.

The assumptions underlying the yield-to-call are often unrealistic. They do not take into account how an investor will reinvest the proceeds if the issue is called. For example, consider two bonds, M and N. Suppose that the yield-to-maturity for bond M, a five-year option-free bond, is 10%, whereas for bond N the yield-to-call, assuming that the bond will be called in three years, is 10.5%. Which bond is better for an investor with a five-year investment horizon? It's not possible to tell from the yields cited. If the investor intends to hold the bond for five years and the issuer calls the bond after three years, the total dollars that will be available at the end of five years will depend on the interest rate that can be earned from reinvesting funds from the call date to the end of the investment horizon.

More will be said about the analysis of callable bonds in Chapter 40.

Yield (Internal Rate of Return) for a Portfolio

The yield for a portfolio of bonds is not simply the average or weighted average of the yield-to-maturity of the individual bond issues. It is computed by determining the cash-flows for the portfolio and then finding the interest rate that will make the present value of the cash-flows equal to the market value of the portfolio.[7] As with any yield measure, it suffers from the same assumptions.

Illustration 10. Consider the following three-bond portfolio:[8]

Bond	Coupon Rate	Maturity	Par Value	Price Value	Yield-to-Maturity
A	7.0%	5 years	$ 10,000,000	$ 9,209,000	9.0%
B	10.5	7	20,000,000	20,000,000	10.5
C	6.0	3	30,000,000	28,050,000	8.5

The portfolio's total market value is $57,259,000. The cash-flow for each bond in the portfolio and for the whole portfolio is as follows:

Period Cash Flow Received	Bond A	Bond B	Bond C	Portfolio
1	$ 350,000	$ 1,050,000	$ 900,000	$ 2,300,000
2	350,000	1,050,000	900,000	2,300,000
3	350,000	1,050,000	900,000	2,300,000
4	350,000	1,050,000	900,000	2,300,000
5	350,000	1,050,000	900,000	2,300,000
6	350,000	1,050,000	30,900,000	32,300,000
7	350,000	1,050,000	—	1,400,000
8	350,000	1,050,000	—	1,400,000

(Continued)

7. Chapter 7 discusses the concept of duration. A good approximation to the yield for a portfolio can be obtained by using duration to weight the yield-to-maturity of the individual bonds in the portfolio.
8. To simplify the illustration, it is assumed that the coupon payment date is the same for each bond.

(Continued)

Period Cash Flow Received	Bond A	Bond B	Bond C	Portfolio
9	350,000	1,050,000	—	1,400,000
10	10,350,000	1,050,000	—	11,400,000
11	—	1,050,000	—	1,050,000
12	—	1,050,000	—	1,050,000
13	—	1,050,000	—	1,050,000
14	—	21,050,000	—	21,050,000

To determine the yield (internal rate of return) for this three-bond portfolio, the interest rate that makes the present value of the cash-flows shown in the last column of the table above equal to $57,259,000 (the total market value of the portfolio) must be found. If an interest rate of 4.77% is used, the present value of the cash-flows will equal $57,259,000. Doubling 4.77% gives 9.54%, which is the yield on the portfolio on a bond-equivalent basis.

Yield Measure for Floating-Rate Securities

The coupon rate for a floating-rate security changes periodically based on some reference rate (such as LIBOR).[9] Because the value for the reference rate in the future is not known, it is not possible to determine the cash-flows. This means that a yield-to-maturity cannot be calculated.

A conventional measure used to estimate the potential return for a floating-rate security is the security's *discount margin.* This measure estimates the average spread or margin over the reference rate that the investor can expect to earn over the life of the security. The procedure for calculating the discount margin is as follows:

1. Determine the cash-flows assuming that the reference rate does not change over the life of the security.
2. Select a margin (spread).
3. Discount the cash-flows found in step 1 by the current value of the reference rate plus the margin selected in step 2.
4. Compare the present value of the cash-flows as calculated in step 3 to the price. If the present value is equal to the security's price, the discount margin is the margin assumed in step 2. If the present value is not equal to the security's price, go back to step 2 and try a different margin.

For a security selling at par, the discount margin is simply the spread over the reference rate.

Illustration 11. To illustrate the calculation, suppose that a six-year floating-rate security selling for 99.3098 pays a rate based on some reference rate index plus 80 basis points. The coupon rate is reset every six months. Assume that the

9. Other spread measures are explained in Chapter 17.

current value for the reference rate is 10%. Exhibit 6–7 shows the calculation of the discount margin for this security. The second column shows the current discounted value for the reference rate (10%). The third column sets forth the cash-flows for the security. The cash-flow for the first 11 periods is equal to one-half the current value for the reference rate (5%) plus the semiannual spread of 40 basis points multiplied by 100. In the twelfth six-month period, the cash-flow is 5.4 plus the maturity value of 100. The top row of the last five columns shows the assumed margin. The rows below the assumed margin show the present value of each cash-flow. The last row gives the total present value of the cash-flows. For the five assumed yield spreads, the present value is equal to the price of the floating-rate security (99.3098) when the assumed margin is 96 basis points. Therefore, the discount margin on a semiannual basis is 48 basis points and 96 basis points on an annual basis. (Notice that the discount margin is 80 basis points, the same as the spread over the reference rate, when the security is selling at par.)

EXHIBIT 6–7

Calculation of the Discount Margin for a Floating-Rate Security

Floating-rate security: Maturity = 6 years
Coupon rate = reference rate + 80 basis points
Reset every six months

Period	Reference Rate	Cash Flow*	*Present Value of Cash-Flow: Assumed Annual Yield Spread (in bp)*				
			80	84	88	96	100
1	10%	5.4	5.1233	5.1224	5.1214	5.1195	5.1185
2	10	5.4	4.8609	4.8590	4.8572	4.8535	4.8516
3	10	5.4	4.6118	4.6092	4.6066	4.6013	4.5987
4	10	5.4	4.3755	4.3722	4.3689	4.3623	4.3590
5	10	5.4	4.1514	4.1474	4.1435	4.1356	4.1317
6	10	5.4	3.9387	3.9342	3.9297	3.9208	3.9163
7	10	5.4	3.7369	3.7319	3.7270	3.7171	3.7122
8	10	5.4	3.5454	3.5401	3.5347	3.5240	3.5186
9	10	5.4	3.3638	3.3580	3.3523	3.3409	3.3352
10	10	5.4	3.1914	3.1854	3.1794	3.1673	3.1613
11	10	5.4	3.0279	3.0216	3.0153	3.0028	2.9965
12	10	105.4	56.0729	55.9454	55.8182	55.5647	55.4385
Present value			100.0000	99.8269	99.6541	99.3098	99.138

*For periods 1–11: cash-flow = 100 (reference rate + assumed margin) (0.5); for period 12: cash-flow = 100 (reference rate + assumed margin) (0.5) + 100.

There are two drawbacks of the discount margin as a measure of the potential return from investing in a floating-rate security. First, this measure assumes that the reference rate will not change over the life of the security. Second, if the floating-rate security has a cap or floor, this is not taken into consideration. Techniques described in Chapter 40 can allow interest rate volatility to be considered and can handle caps or floors.

TOTAL RETURN ANALYSIS

If conventional yield measures such as the yield-to-maturity and yield-to-call offer little insight into the potential return of a bond, what measure of return can be used? The proper measure is one that considers all three sources of potential dollar return over the investment horizon. This requires that an investor first project the total future dollars over an investment horizon. The return is then the interest rate that will make the bond's price (full price) grow to the projected total future dollars at the end of the investment horizon. The yield computed in this way is known as the *total return,* also referred to as the *horizon return.* In this section we explain this measure and demonstrate how it can be applied in assessing the potential return from investing in a bond.

Calculating the Total Return

The total return requires that the investor specify

- An investment horizon
- A reinvestment rate
- A selling price for the bond at the end of the investment horizon (which depends on the assumed yield at which the bond will sell at the end of the investment horizon)

More formally, the steps for computing a total return over some investment horizon are as follows.

Step 1: Compute the total coupon payments plus the interest-on-interest based on an assumed reinvestment rate. The reinvestment rate is one-half the annual interest rate that the investor believes can be earned on the reinvestment of coupon interest payments.

The total coupon payments plus interest-on-interest can be calculated using the formula for the future value of an annuity (see the Appendix to this book) as shown:

$$\text{Coupon plus interest-on-interest} = \text{semiannual coupon}\left[\frac{\{(1+r)^h - 1)\}}{r}\right]$$

where

h = length of the investment horizon (in semiannual periods)
r = assumed semiannual reinvestment rate

Step 2: Determine the projected sale price at the end of the investment horizon. The projected sale price will depend on the projected yield on comparable bonds at the end of the investment horizon.

Step 3: Add the values computed in steps 1 and 2. The sum is the *total future dollars* that will be received from the investment given the assumed reinvestment rate and projected required yield at the end of the investment horizon.

Step 4: To obtain the semiannual total return, use the following formula:

$$\left(\frac{\text{total future dollars}}{\text{purchase price of bond}}\right)^{1/h} - 1$$

Step 5: Because coupon interest is assumed to be paid semiannually, double the interest rate found in step 4. The resulting interest rate is the total return expressed on a bond-equivalent basis. Alternatively, the total return can be expressed on an effective annual interest rate basis by using the following formula:

$$(1 + \text{semiannual total return})^2 - 1$$

Illustration 12. Suppose that an investor with a three-year investment horizon is considering purchasing a 20-year, 8% coupon bond for $828.40. The yield-to-maturity for this bond is 10%. The investor expects that he can reinvest the coupon interest payments at an annual interest rate of 6% and that at the end of the investment horizon the 17-year bond will be selling to offer a yield-to-maturity of 7%. The total return for this bond is computed in Exhibit 6–8.

Objections to the total return analysis cited by some portfolio managers are that it requires them to make assumptions about reinvestment rates and future yields and forces a portfolio manager to think in terms of an investment horizon. Unfortunately, some portfolio managers find comfort in meaningless measures such as the yield-to-maturity because it is not necessary to incorporate any expectations. As explained below, the total return framework enables the portfolio manager to analyze the performance of a bond based on different interest-rate scenarios for reinvestment rates and future market yields. By investigating multiple scenarios, the portfolio manager can see how sensitive the bond's performance is to each scenario. There is no need to assume that the reinvestment rate will be constant for the entire investment horizon.

For portfolio managers who want to use the market's expectations of short-term reinvestment rates and the yield on the bond at the end of the investment

EXHIBIT 6–8

Illustration of Total Return Calculation

Assumptions:

Bond = 8% 20-year bond selling for $828.40 (yield-to-maturity is 10%)

Annual reinvestment rate = 6%

Investment horizon = 3 years

Yield for 17-year bonds at end of investment horizon = 7%

Step 1: Compute the total coupon payments plus the interest-on-interest assuming an annual reinvestment rate of 6%, or 3% every six months. The coupon payments are $40 every six months for three years or six periods (the investment horizon). The total coupon interest plus interest-on-interest is

$$\text{Coupon plus interest-on-interest} = \$40\left(\frac{(1.03)^6 - 1}{0.03}\right) = \$258.74$$

Step 2: The projected sale price at the end of 3 years, assuming that the required yield-to-maturity for 17-year bonds is 7%, is found by determining the present value of 34 coupon payments of $40 plus the present value of the maturity value of $1,000, discounted at 3.5%. The price can be shown to be $1,098.51.

Step 3: Adding the amount in steps 1 and 2 gives total future dollars of $1,357.25.

Step 4: Compute the following:

$$\begin{aligned} &= \left(\frac{\$1,357.25}{828.40}\right)^{1/6} - 1 \\ &= (1.63840)^{0.16667} - 1 \\ &\quad 1.0858 - 1 \\ &= 0.0858, \text{or } 8.58\% \end{aligned}$$

Step 5: Doubling 8.58% gives a total return of 17.16% on a bond-equivalent basis. On an effective annual interest-rate basis, the total return is

$$\begin{aligned} &(1.0858)^2 - 1 \\ &= 1.1790 - 1 \\ &= 0.1790 \\ &= 17.90\% \end{aligned}$$

horizon, implied forward rates can be calculated from the yield-curve. Implied forward rates are explained in Chapters 8 and 36, and are calculated based on arbitrage arguments. A total return computed using implied forward rates is called an *arbitrage-free total return.*

Scenario Analysis

Because the total return depends on the reinvestment rate and the yield at the end of the investment horizon, portfolio managers assess performance over a wide range of scenarios for these two variables. This approach is referred to as *scenario analysis.*

Illustration 13. Suppose that a portfolio manager is considering the purchase of bond A, a 20-year, 9% option-free bond selling at $109.896 per $100 of par value. The yield-to-maturity for this bond is 8%. Assume also that the portfolio manager's investment horizon is three years and that the portfolio manager believes that the reinvestment rate can vary from 3% to 6.5% and that the yield at the end of the investment horizon can vary from 5% to 12%.

The top panel of Exhibit 6–9 shows the total future dollars at the end of three years under various scenarios. The bottom panel shows the total return (based on the effective annualizing of the six-month total return). The portfolio manager knows that the maximum and minimum total return for the scenarios analyzed will be 16.72% and –1.05%, respectively, and the scenarios under which each will be realized. If the portfolio manager faces three-year liabilities guaranteeing, say, 6%, the major consideration is scenarios that will produce a three-year total return of less than 6%. These scenarios can be determined from Exhibit 6–9.

Illustration 14. Suppose that the same portfolio manager owns bond B, a 14-year option-free bond with a coupon rate of 7.25% and a current price of $94.553 per $100 par value. The yield-to-maturity is 7.9%. Exhibit 6–10 reports the total future dollars and total return over a three-year investment horizon under the same scenarios as Exhibit 6–9. A portfolio manager considering swapping from bond B to bond A would compare the relative performance of the two bonds as reported in Exhibits 6–9 and 6–10. Exhibit 6–11 shows the difference between the performance of the two bonds in basis points. This comparative analysis assumes that the two bonds are of the same investment quality and ignores the financial accounting and tax consequences associated with the disposal of bond B to acquire bond A.

Evaluating Potential Bond Swaps

Portfolio managers commonly swap an existing bond in a portfolio for another bond. Bond swaps can be categorized as pure yield pickup swaps, substitution swaps, intermarket-spread swaps, or rate-anticipation swaps. Total return analysis can be used to assess the potential return from a swap.

- *Pure yield pickup swap.* Switching from one bond to another that has a higher yield is called a *pure yield pickup swap.* The swap may be undertaken to achieve either higher current coupon income or higher yield-to-maturity or both. No expectation is made about changes in interest rates, yield spreads, or credit quality.

EXHIBIT 6–9

Scenario Analysis for Bond A

Bond A:	9% coupon, 20-year option-free bond
Price:	$109.896
Yield-to-maturity:	8.00%
Investment horizon:	3 years

	Yield at End of Horizon							
	5.00%	**6.00%**	**7.00%**	**8.00%**	**9.00%**	**10.00%**	**11.00%**	**12.00%**
	Horizon Price							
	145.448	**131.698**	**119.701**	**109.206**	**100.000**	**91.9035**	**84.763**	**78.4478**
	Total Future Dollars							
Reinvestment Rate	**5.00%**	**6.00%**	**7.00%**	**8.00%**	**9.00%**	**10.00%**	**11.00%**	**12.00%**
3.0%	173.481	159.731	147.734	137.239	128.033	119.937	112.796	106.481
3.5	173.657	159.907	147.910	137.415	128.209	120.113	112.972	106.657
4.0	173.834	160.084	148.087	137.592	128.387	120.290	113.150	106.834
4.5	174.013	160.263	148.266	137.771	128.565	120.469	113.328	107.013
5.0	174.192	160.443	148.445	137.950	128.745	120.648	113.508	107.193
5.5	174.373	160.623	148.626	138.131	128.926	120.829	113.689	107.374
6.0	174.555	160.806	148.809	138.313	129.108	121.011	113.871	107.556
6.5	174.739	160.989	148.992	138.497	129.291	121.195	114.054	107.739
	Total Return (Effective Rate)							
Reinvestment Rate	**5.00%**	**6.00%**	**7.00%**	**8.00%**	**9.00%**	**10.00%**	**11.00%**	**12.00%**
3.0%	16.44	13.28	10.37	7.69	5.22	2.96	0.87	–1.05
3.5	16.48	13.32	10.41	7.73	5.27	3.01	0.92	–0.99
4.0	16.52	13.36	10.45	7.78	5.32	3.06	0.98	–0.94
4.5	15.56	13.40	10.50	7.83	5.37	3.11	1.03	–0.88
5.0	16.60	13.44	10.54	7.87	5.42	3.16	1.08	–0.83
5.5	16.64	13.49	10.59	7.92	5.47	3.21	1.14	–0.77
6.0	16.68	13.53	10.63	7.97	5.52	3.26	1.19	–0.72
6.5	16.72	13.57	10.68	8.02	5.57	3.32	1.25	–0.66

- *Rate-anticipation swap.* A portfolio manager who has expectations about the future direction of interest rates will use bond swaps to position the portfolio to take advantage of the anticipated interest-rate move. These are known as *rate-anticipation swaps.* If rates are expected to fall, for example, bonds with a greater price volatility will be swapped for existing bonds in the portfolio with lower price volatility (to take advantage of the larger change in price that will result if interest rates do in fact decline). The opposite will be done if rates are expected to rise.

EXHIBIT 6–10

Scenario Analysis for Bond B

Bond B:	7.25% coupon, 14-year option-free bond
Price:	$94.553
Yield-to-maturity:	7.90%
Investment horizon:	3 years

	Yield at End of Horizon							
	5.00%	**6.00%**	**7.00%**	**8.00%**	**9.00%**	**10.00%**	**11.00%**	**12.00%**
	Horizon Price							
	118.861	**109.961**	**101.896**	**94.5808**	**87.9386**	**81.9009**	**76.4066**	**71.4012**
	Total Future Dollars							
Reinvestment Rate	**5.00%**	**6.00%**	**7.00%**	**8.00%**	**9.00%**	**10.00%**	**11.00%**	**12.00%**
3.0%	141.443	132.543	124.478	117.163	110.521	104.483	98.989	93.983
3.5	141.585	132.685	124.620	117.448	110.663	104.625	99.131	94.125
4.0	141.728	132.828	124.763	117.448	110.806	104.768	99.273	94.268
4.5	141.872	132.971	124.907	117.592	110.949	104.912	99.417	94.412
5.0	142.017	133.116	125.051	117.736	111.094	105.056	99.562	94.557
5.5	142.162	133.262	125.197	117.882	111.240	105.202	99.708	94.703
6.0	142.309	133.409	125.344	118.029	111.387	105.349	99.855	94.849
6.5	142.457	133.556	125.492	118.176	111.534	105.497	100.002	94.997
	Total Return (Effective Rate)							
Reinvestment Rate	**5.00%**	**6.00%**	**7.00%**	**8.00%**	**9.00%**	**10.00%**	**11.00%**	**12.00%**
3.0%	14.37	11.92	9.60	7.41	5.34	3.38	1.54	–0.20
3.5	14.41	11.96	9.64	7.45	5.38	3.43	1.59	–0.15
4.0	14.44	12.00	9.68	7.50	5.43	3.48	1.64	–0.10
4.5	14.48	12.04	9.72	7.54	5.48	3.53	1.69	–0.05
5.0	14.52	12.08	9.77	7.58	5.52	3.57	1.74	0.00
5.5	14.56	12.12	9.81	7.63	5.57	3.62	1.79	0.05
6.0	14.60	12.16	9.85	7.67	5.61	3.67	1.84	0.10
6.5	14.64	12.20	9.90	7.72	5.66	3.72	1.89	0.16

- *Intermarket-spread swap.* These swaps are undertaken when the portfolio manager believes that the current yield spread between two bonds in the market is out of line with its historical yield spread and that the yield spread will realign by the end of the investment horizon. Yield spreads between bonds exist for the following reasons: (1) there is a difference in the credit quality of bonds (e.g., between Treasury bonds and double-A-rated public utility bonds of the same maturity),

EXHIBIT 6–11

Scenario Analysis Showing the Relative Performance of Bonds A and B

Reinvestment Rate	Total Return for Bond A minus Total Return for Bond B (in Basis Points)							
	5.00%	6.00%	7.00%	8.00%	9.00%	10.00%	11.00%	12.00%
3.0%	207	136	77	28	–12	–43	–67	–85
3.5	207	136	77	28	–11	–42	–66	–84
4.0	207	136	77	28	–11	–42	–66	–84
4.5	207	136	77	29	–11	–42	–66	–83
5.0	207	137	78	29	–10	–41	–65	–83
5.5	208	137	78	29	–10	–41	–65	–82
6.0	208	137	78	30	–10	–41	–64	–82
6.5	208	137	78	30	–9	–40	–64	–81

or (2) there are differences in the features of corporate bonds that make them more or less attractive to investors (for example, callable and noncallable bonds, and putable and nonputable bonds).

- *Substitution swap.* In a substitution swap, a portfolio manager swaps one bond for another bond that is thought to be identical in terms of coupon, maturity, price sensitivity to interest-rate changes, and credit quality, but that offers a higher yield. This swap depends on a capital market imperfection. Such situations sometimes exist in the bond market because of temporary market imbalances. The risk that the portfolio manager faces is that the bond purchased may not be identical to the bond for which it is exchanged. For example, if credit quality is not the same, the bond purchased may be offering a higher yield because of higher credit risk rather than because of a market imbalance.

Comparing Municipal and Corporate Bonds

The conventional methodology for comparing the relative performance of a tax-exempt municipal bond and a taxable corporate bond is to compute the *taxable equivalent yield.* The taxable equivalent yield is the yield that must be earned on a taxable bond in order to produce the same yield as a tax-exempt municipal bond. The formula is

$$\text{Taxable equivalent yield} = \frac{\text{tax-exempt yield}}{1 - \text{marginal tax rate}}$$

For example, suppose that an investor in the 35% marginal tax bracket is considering a 10-year municipal bond with a yield-to-maturity of 4.5%. The taxable equivalent yield is

$$\frac{4.5\%}{1-0.35} = 6.92\%$$

If the yield-to-maturity offered on a comparable-quality corporate bond with 10 years to maturity is more than 6.92%, those who use this approach would recommend that the corporate bond be purchased. If, instead, a yield-to-maturity of less than 6.92% on a comparable corporate bond is offered, the investor should invest in the municipal bond.

What's wrong with this approach? The tax-exempt yield of the municipal bond and the taxable equivalent yield suffer from the same limitations we discussed with respect to yield-to-maturity. Consider the difference in reinvestment opportunities for a corporate and a municipal bond. For the former, coupon payments will be taxed; therefore, the amount to be reinvested is not the entire coupon payment but an amount net of taxes. In contrast, because the coupon payments are free from taxes for a municipal bond, the entire coupon can be reinvested.

The total return framework can accommodate this situation by allowing us to explicitly incorporate the reinvestment opportunities. There is another advantage to the total return framework as compared with the conventional taxable equivalent yield approach. Changes in tax rates (because the investor expects either her tax rate to change or the tax structure to change) can be incorporated into the total return framework.

KEY POINTS

- The price of a bond is equal to the present value of the expected cash flow.
- For bonds with embedded options, the cash-flow is difficult to estimate.
- The required yield used to discount the cash-flow is determined by the yield offered on comparable securities.
- The two most popular yield measures cited in the bond market are the yield-to-maturity and yield-to-call. Both yield measures consider the coupon interest and any capital gain (or loss) at the maturity date or call date in the case of the yield-to-call.
- The coupon interest and capital gain (or loss), however, are only two of the three components of the potential dollar return from owning a bond until it matures or is called. The other component is the reinvestment of coupon income, commonly referred to as the interest-on-interest component. This component can be as large as 80% of a bond's total dollar return.

- The yield-to-maturity assumes that the coupon payments can be reinvested at the calculated yield-to-maturity.
- The yield-to-call assumes that the coupon payments can be reinvested at the calculated yield-to-call.
- A better measure of the potential return from holding a bond over a predetermined investment horizon is the total return measure. This measure considers all three sources of potential dollar return and can be used to analyze bond swaps and bond performance.

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CHAPTER
SEVEN

MEASURING INTEREST-RATE RISK

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

GERALD W. BUETOW, JR., PH.D., CFA
Chief Investment Officer
Innealta Capital

ROBERT R. JOHNSON, PH.D., CFA
Senior Managing Director
CFA Institute

BRIAN J. HENDERSON, PH.D., CFA
Assistant Professor
The George Washington University

The value of a bond changes in the opposite direction of the change in interest rates. A long bond position's value will decline if interest rates rise, resulting in a loss. For a short bond position, a loss will be realized if interest rates fall. However, an investor wants to know more than simply when a position will realize a loss. To control interest-rate risk, an investor must be able to quantify what will result.

The key to measuring interest-rate risk is the accuracy of the estimate of the value of the position after an adverse rate change. A valuation model is used to determine the value of a position after an adverse rate move. Consequently, if a reliable valuation model is not used, there is no way to properly measure interest-rate risk exposure.

There are two approaches to measuring interest-rate risk—*the full-valuation approach* and the *duration/convexity approach.* We begin with a discussion of the full-valuation approach. The balance of the chapter is devoted to the duration/convexity approach. As a background to the duration/convexity approach, we discuss

Parts of this chapter are adapted from several chapters in Frank J. Fabozzi, *Duration, Convexity, and Other Bond Risk Measures* (New Hope, PA: Frank J. Fabozzi Associates, 1999) and from Gerald W. Buetow and Robert R. Johnson, "A Primer on Effective Duration and Convexity," in Frank J. Fabozzi (ed.), *Professional Perspectives on Fixed Income Portfolio Management,* Vol. 1 (New Hope, PA: Frank J. Fabozzi Associates, 2000).

the price volatility characteristics of option-free bonds and bonds with embedded options. We then look at how duration can be used to estimate interest-rate risk and distinguish between various duration measures (effective, modified, and Macaulay). Next, we show how a measure referred to as "convexity" can be used to improve the duration estimate of the price volatility of a bond to rate changes. In the next to the last section we show the relationship between duration and another measure of price volatility used by investors, the price value of a basis point (or dollar value of an 01). In the last section we discuss the importance of incorporating yield volatility in estimates of exposure to interest-rate risk.

THE FULL-VALUATION APPROACH

The most obvious way to measure the interest-rate risk exposure of a bond position or a portfolio is to revalue it when interest rates change. The analysis is performed for a given scenario with respect to interest-rate changes. For example, an investor may want to measure the interest-rate exposure to a 50 basis point, 100 basis point, and 200 basis point instantaneous change in interest rates. This approach requires the revaluation of a bond or bond portfolio for a given interest-rate change scenario and is called the *full-valuation approach.* It is sometimes referred to as "scenario analysis" because it involves assessing the exposure to interest-rate change scenarios.

To illustrate this approach, suppose that an investor has a $10 million par value position in a 5% coupon 20-year bond. The bond is option-free. The current price is 106.5484 for a yield (i.e., yield to maturity) of 4.5%. The market value of the position is $10,654,840 (106.5484% × $10 million). Since the investor owns the bond, she is concerned with a rise in yield, since this will decrease the market value of the position. To assess the exposure to a rise in market yields, the investor decides to look at how the value of the bond will change if yields change instantaneously for the following three scenarios: (1) 50 basis point increase, (2) 100 basis point increase, and (3) 200 basis point increase. This means that the investor wants to assess what will happen to the bond position if the yield on the bond increases from 4.5% to (1) 5%, (2) 5.5%, and (3) 6.5%. Because this is an option-free bond, valuation is straightforward. We will assume that one yield is used to discount each of the cash-flows. That is, we will assume a flat yield-curve. The price of this bond per $100 par value and the market value of the $10 million par position is shown in Exhibit 7–1. Also shown is the change in the market value and the percentage change.

In the case of a portfolio, each bond is valued for a given scenario, and then the total value of the portfolio is computed for the scenario. For example, suppose that a manager has a portfolio with the following two option-free bonds: (1) 4% coupon 5-year bond and (2) 5% coupon 20-year bond. For the shorter-term bond, $5 million of par value is owned, and the price is 109.4713 for a yield of 2%. For the longer-term bond, $10 million of par value is owned, and the price is 106.5484 for a yield of 4.5%. Suppose that the manager wants to assess the interest-rate risk

EXHIBIT 7–1

Illustration of Full-Valuation Approach to Assess the Interest-Rate Risk of a Bond Position for Three Scenarios

Current bond position: 5% coupon 20-year bond (option-free)
Price: 106.5484
Yield to maturity: 4.5%
Par value owned: $10 million
Market value of position: $10,654,840.00

Scenario	Yield Change (bp)	New Yield	New Price	New Market Value ($)	Percentage Change in Market Value (%)
1	50	5.0%	100.0000	10,000,000	–6.15%
2	100	5.5%	93.9805	9,398,050	–11.80%
3	200	6.5%	83.3437	8,334,370	–21.78%

of this portfolio for a 50, 100, and 200 basis point increase in interest rates assuming that both the 5-year yield and the 20-year yield change by the same number of basis points. Exhibit 7–2 shows the exposure. Panel *a* of the exhibit shows the market value of the 5-year bond for the three scenarios. Panel *b* does the same for the 20-year bond. Panel *c* shows the total market value of the portfolio and the percentage change in the market value for the three scenarios.

In Exhibit 7–2, it is assumed that both the 5-year and the 20-year yields changed by the same number of basis points. The full-valuation approach also can handle scenarios where the yield-curve does not change in a parallel fashion. Exhibit 7–3 illustrates this for our portfolio that includes the 5-year and the 20-year bonds. The scenario analyzed is a yield-curve shift scenario combined with scenarios for shifts in the level of yields. In the illustration in Exhibit 7–3, the following yield changes for the 5-year and 20-year yields are assumed:

Scenario	Change in 5-Year Rate (bp)	Change in 20-Year Rate (bp)
1	50	10
2	100	50
3	200	100

The last panel in Exhibit 7–3 shows how the market value of the portfolio changes for each scenario.

The full-valuation approach seems straightforward. If one has a good valuation model, assessing how the value of a portfolio or individual bond will change

EXHIBIT 7–2

Illustration of Full-Valuation Approach to Assess the Interest-Rate Risk of a Bond Portfolio for Three Scenarios Assuming a Parallel Shift in the Yield-Curve

Two-bond portfolio (both bonds are option-free bonds)

Panel a

Bond 1:	4% coupon 5-year bond	Par value:	$5,000,000
Initial price:	109.4713	Market value:	$5,473,565
Yield:	2%		

Scenario	Yield Change (bp)	New Yield	New Price	New Market Value ($)
1	50	2.5%	107.0091	5,350,455
2	100	3.0%	104.6111	5,230,555
3	200	4.0%	100.0000	5,000,000

Panel b

Bond 2:	5% coupon 20-year bond	Par value:	$10,000,000
Initial price:	106.5484	Market value:	$10,654,838
Yield:	4.5%		

Scenario	Yield Change (bp)	New Yield	New Price	New Market Value ($)
1	50	5.0%	100.0000	10,000,000
2	100	5.5%	93.9805	9,398,050
3	200	6.5%	83.3437	8,334,370

Panel c

Portfolio Market value: $16,128,403

		Market Value of			
Scenario	Yield Change (bp)	Bond 1 ($)	Bond 2 ($)	Portfolio ($)	Percentage Change in Market Value (%)
1	50	5,350,455	10,000,000	15,350,455	–4.82%
2	100	5,230,555	9,398,050	14,628,605	–9.30%
3	200	5,000,000	8,334,370	13,334,370	–17.32%

for different scenarios for parallel and nonparallel yield-curve shifts measures the interest-rate risk of a portfolio.

A common question that often arises when using the full-valuation approach is what scenarios should be evaluated to assess interest-rate risk exposure. For some regulated entities, there are specified scenarios established by regulators.

EXHIBIT 7–3

Illustration of Full-Valuation Approach to Assess the Interest-Rate Risk of a Bond Portfolio for Three Scenarios Assuming a Nonparallel Shift in the Yield-Curve

Two-bond portfolio (both bonds are option-free bonds)

Panel a

Bond 1:	4% coupon 5-year bond	Par value:	$5,000,000
Initial price:	109.4713	Market value:	$5,473,565
Yield:	2%		

Scenario	Yield Change (bp)	New Yield	New Price	New Market Value ($)
1	50	2.5%	107.0091	5,350,455
2	100	3.0%	104.6111	5,230,555
3	200	4.0%	100.0000	5,000,000

Panel b

Bond 2:	5% coupon 20-year bond	Par value:	$10,000,000
Initial price:	106.5484	Market value:	$10,654,838
Yield:	4.5%		

Scenario	Yield Change (bp)	New Yield	New Price	New Market Value ($)
1	10	4.6%	105.1940	10,519,400
2	50	5.0%	100.0000	10,000,000
3	100	5.5%	93.9805	9,398,050

Panel c

Portfolio market value: $16,128,403

	Market Value of			
Scenario	Bond 1 ($)	Bond 2 ($)	Portfolio ($)	Percentage Change in Market Value (%)
1	5,350,455	10,519,400	15,869,855	–1.60%
2	5,230,555	10,000,000	15,230,555	–5.57%
3	5,000,000	9,398,050	14,398,050	–10.73%

For example, it is common for regulators of depository institutions to require entities to determine the impact on the value of their bond portfolio for a 100, 200, and 300 basis point instantaneous change in interest rates (up and down). (Regulators tend to refer to this as "simulating" interest-rate scenarios rather than scenario analysis.) Risk managers and highly leveraged investors such as hedge

funds tend to look at extreme scenarios to assess exposure to interest-rate changes. This practice is called *stress testing*.

Of course, in assessing how changes in the yield-curve can affect the exposure of a portfolio, there are an infinite number of scenarios that can be evaluated. The state-of-the-art technology involves using a complex statistical procedure to determine a likely set of yield-curve shift scenarios from historical data.

We can use the full-valuation approach to assess the exposure of a bond or portfolio to interest-rate change to evaluate any scenario, assuming—and this must be repeated continuously—*that the investor has a good valuation model to estimate what the price of the bonds will be in each interest-rate scenario.* While the full-valuation approach is the recommended approach for assessing the position of a single bond or a portfolio of a few bonds, for a portfolio with a large number of bonds and with even a minority of those bonds being complex (i.e., having embedded options), the full-valuation process is time-consuming. Investors want one measure they can use to get an idea of how a portfolio or even a single bond will change if rates change in a parallel fashion rather than having to revalue a portfolio to obtain that answer. Such a measure is duration. We will discuss this measure as well as a supplementary measure (convexity). To build a foundation to understand the limitations of these measures, we describe next the basic price volatility characteristics of bonds. The fact that there are limitations of using one or two measures to describe the interest-rate exposure of a position or portfolio should not be surprising. What is important to understand is that these measures provide a starting point for assessing interest-rate risk.

PRICE VOLATILITY CHARACTERISTICS OF BONDS

The characteristics of a bond that affect its price volatility are (1) maturity, (2) coupon rate, and (3) presence of embedded options. We also will see how the level of yields affects price volatility.

Price Volatility Characteristics of Option-Free Bonds

We begin by focusing on option-free bonds (i.e., bonds that do not have embedded options). A fundamental characteristic of an option-free bond is that the price of the bond changes in the opposite direction from a change in the bond's required yield. Exhibit 7–4 illustrates this property for four hypothetical bonds assuming a par value of $100.

When the price/yield relationship for any option-free bond is graphed, it exhibits the shape shown in Exhibit 7–5. Notice that as the required yield increases, the price of an option-free bond declines. However, this relationship is not linear (i.e., not a straight-line relationship). The shape of the price/yield relationship

EXHIBIT 7–4

Price/Yield Relationship for Four Hypothetical Option-Free Bonds

	Price ($)			
Yield (%)	4%/5 Year	4%/20 Year	5%/5 Year	5%/20 Year
2.00	109.4713	132.8347	114.2070	149.2520
3.00	104.6111	114.9579	109.2222	129.9158
3.50	102.2753	107.1486	106.8259	121.4457
3.90	100.4503	101.3798	104.9534	115.1783
3.99	100.0449	100.1369	104.5374	113.8266
4.00	100.0000	100.0000	104.4913	113.6777
4.01	99.9551	99.8633	104.4452	113.5291
4.10	99.5520	98.6441	104.0316	112.2027
4.50	97.7834	93.4516	102.2166	106.5484
5.00	95.6240	87.4486	100.0000	100.0000
6.00	91.4698	76.8852	95.7349	88.4426

for any option-free bond is called *convex*. This price/yield relationship is for an instantaneous change in the required yield.

The price sensitivity of a bond to changes in the required yield can be measured in terms of the dollar price change or the percentage price change. Exhibit 7–6 uses the four hypothetical bonds in Exhibit 7–4 to show the percentage change in each bond's price for various changes in yield, assuming that the initial yield for all

EXHIBIT 7–5

Price/Yield Relationship for a Hypothetical Option-Free Bond

EXHIBIT 7–6

Instantaneous Percentage Price Change for Four Hypothetical Bonds (Initial yield for all four bonds is 4%)

	Percentage Price Change			
New Yield	**4%/5 Year**	**4%/20 Year**	**5%/5 Year**	**5%/20 Year**
2.00	9.47	32.83	9.30	31.29
3.00	4.61	14.96	4.53	14.28
3.50	2.28	7.15	2.23	6.83
3.90	0.45	1.38	0.44	1.32
3.99	0.04	0.14	0.04	0.13
4.01	–0.04	–0.14	–0.04	–0.13
4.10	–0.45	–1.36	–0.44	–1.30
4.50	–2.22	–6.55	–2.18	–6.27
5.00	–4.38	–12.55	–4.30	–12.03
6.00	–8.53	–23.11	–8.38	–22.20

four bonds is 4%. An examination of Exhibit 7–6 reveals the following properties concerning the price volatility of an option-free bond:

Property 1: Although the price moves in the opposite direction from the change in required yield, the percentage price change is not the same for all bonds.

Property 2: For small changes in the required yield, the percentage price change for a given bond is roughly the same, whether the required yield increases or decreases.

Property 3: For large changes in required yield, the percentage price change is not the same for an increase in required yield as it is for a decrease in required yield.

Property 4: For a given large change in basis points in the required yield, the percentage price increase is greater than the percentage price decrease.

While the properties are expressed in terms of percentage price change, they also hold for dollar price changes.

The implication of Property 4 is that if an investor is long a bond, the price appreciation that will be realized if the required yield decreases is greater than the capital loss that will be realized if the required yield increases by the same number of basis points. For an investor who is short a bond, the reverse is true: The potential capital loss is greater than the potential capital gain if the yield changes by a given number of basis points.

Bond Features That Affect Interest-Rate Risk

The degree of sensitivity of a bond's price to changes in market interest rates (i.e., a bond's interest-rate risk) depends on various features of the issue, such as maturity, coupon rate, and embedded options.

The Impact of Maturity

All other factors constant, *the longer the bond's maturity, the greater is the bond's price sensitivity to changes in interest rates.* For example, for a 4% 20-year bond selling to yield 4%, a rise in the yield required by investors to 4.5% will cause the bond's price to decline from 100 to 93.4516, a 6.55% price decline. For a 4% 5-year bond selling to yield 4%, the price is 100. A rise in the yield required by investors from 4% to 4.5% would decrease the price to 97.7834. The decline in the bond's price is only 2.22%.

The Impact of Coupon Rate

A property of a bond is that all other factors constant, *the lower the coupon rate, the greater is the bond's price sensitivity to changes in interest rates.* For example, consider a 5% 20-year bond selling to yield 4%. The price of this bond would be 113.6777. If the yield required by investors increases by 50 basis points to 4.5%, the price of this bond would fall by 6.27% to 106.5484. This decline is less than the 6.55% decline for the 4% 20-year bond selling to yield 4%.

An implication is that zero-coupon bonds have greater price sensitivity to interest-rate changes than same-maturity bonds bearing a coupon rate and trading at the same yield.

The Impact of Embedded Options

In Chapter 1 the various embedded options that may be included in a bond issue were discussed. The value of a bond with embedded options will change depending on how the value of the embedded options changes when interest rates change. For example, as interest rates decline, the price of a callable bond may not increase as much as an otherwise option-free bond (i.e., a bond with no embedded options).

To understand why, we decompose the price of a callable bond into two parts, as shown below:

Price of callable bond

= price of option-free bond − price of embedded call option

The reason for subtracting the price of the embedded call option from the price of the option-free bond is that the call option is a benefit to the issuer and a disadvantage to the bondholder. This reduces the price of a callable bond relative to an option-free bond.

Now, when interest rates decline, the price of an option-free bond increases. However, the price of the embedded call option increases when interest rates decline because the call option becomes more valuable to the issuer. Thus, when interest

rates decline, both components increase, *but* the change in the price of the callable bond depends on the relative price change of the two components. Typically, a decline in interest rates will result in an increase in the price of the callable bond but not by as much as the price change of an otherwise comparable option-free bond.

Similarly, when interest rates rise, the price of a callable bond will not fall by as much as an otherwise option-free bond. The reason is that the price of the embedded call option declines. When interest rates rise, the price of the option-free bond declines but is partially offset by the decrease in the price of the embedded call option.

Price Volatility Characteristics of Bonds with Embedded Options

In this section we examine the price/yield relationship for bonds with both types of options (calls and puts) and implications for price volatility.

Bonds with Call and Prepay Options

In the discussion below we will refer to a bond that may be called or is prepayable as a callable bond. Exhibit 7–7 shows the price/yield relationship for an option-free bond and a callable bond. The convex curve given by a–a' is the price/yield relationship for an option-free bond. The unusually shaped curve denoted by a–b in the exhibit is the price/yield relationship for the callable bond.

EXHIBIT 7–7

Price/Yield Relationship for a Callable Bond and an Option-Free Bond

The reason for the price/yield relationship for a callable bond is as follows. When the prevailing market yield for comparable bonds is higher than the coupon rate on the callable bond, it is unlikely that the issuer will call the issue. For example, if the coupon rate on a bond is 3% and the prevailing market yield on comparable bonds is 6%, it is highly unlikely that the issuer will call a 3% coupon bond so that it can issue a 6% coupon bond. Since the bond is unlikely to be called, the callable bond will have a similar price/yield relationship as an otherwise comparable option-free bond. Consequently, the callable bond is going to be valued as if it is an option-free bond. However, since there is still some value to the call option, the bond won't trade exactly like an option-free bond.

As yields in the market decline, the concern is that the issuer will call the bond. The issuer won't necessarily exercise the call option as soon as the market yield drops below the coupon rate. Yet the value of the embedded call option increases as yields approach the coupon rate from higher yield levels. For example, if the coupon rate on a bond is 3% and the market yield declines to 3.50%, the issuer most likely will not call the issue. However, market yields are at a level at which the investor is concerned that the issue eventually may be called if market yields decline further. Cast in terms of the value of the embedded call option, that option becomes more valuable to the issuer, and therefore, it reduces the price relative to an otherwise comparable option-free bond.[1] In Exhibit 7–7, the value of the embedded call option at a given yield can be measured by the difference between the price of an option-free bond (the price shown on the curve a–a') and the price on the curve a–b. Notice that at low yield levels (below y^* on the horizontal axis), the value of the embedded call option is high.

Let's look at the difference in the price volatility properties relative to an option-free bond given the price/yield relationship for a callable bond shown in Exhibit 7–7. Exhibit 7–8 blows up the portion of the price/yield relationship for the callable bond where the two curves in Exhibit 7–7 depart (segment b–b' in Exhibit 7–7). We know from our discussion of the price/yield relationship that for a large change in yield of a given number of basis points, the price of an option-free bond increases by more than it decreases (Property 4 discussed previously). Is that what happens for a callable bond in the region of the price/yield relationship shown in Exhibit 7–8? No, it is not. In fact, as can be seen in the exhibit, the opposite is true! That is, for a given large change in yield, the price appreciation is less than the price decline.

The price volatility characteristic of a callable bond is important to understand. The characteristic of a callable bond that its price appreciation is less than its price decline when rates change by a large number of basis points is called *negative convexity.*[2] But notice from Exhibit 7–7 that callable bonds do not exhibit this characteristic at every yield level. When yields are high (relative to

1. For readers who are already familiar with option theory, this characteristic can be restated as follows: When the coupon rate for the issue is below the market yield, the embedded call option is said to be "out-of-the-money." When the coupon rate for the issue is above the market yield, the embedded call option is said to be "in-the-money."
2. Mathematicians refer to this shape as being "concave."

EXHIBIT 7–8

Negative Convexity Region of the Price/Yield Relationship for a Callable Bond

the issue's coupon rate), the bond exhibits the same price/yield relationship as an option-free bond and therefore at high-yield levels also has the characteristic that the gain is greater than the loss. Because market participants have referred to the shape of the price/yield relationship shown in Exhibit 7–8 as negative convexity, market participants call the relationship for an option-free bond *positive convexity.* Consequently, a callable bond exhibits negative convexity at low yield levels and positive convexity at high-yield levels.

As can be seen from the exhibits, when a bond exhibits negative convexity, as rates decline, the bond compresses in price. That is, at a certain yield level there is very little price appreciation when rates decline. When a bond enters this region, the bond is said to exhibit "price compression."

Bonds with Embedded Put Options

Putable bonds may be redeemed by the bondholder on the dates and at the put price specified in the indenture. Typically, the put price is par value. The advantage to the investor is that if yields rise such that the bond's value falls below the put price, the investor will exercise the put option. If the put price is par value, this means that if market yields rise above the coupon rate, the bond's value will fall below par, and the investor will then exercise the put option.

The value of a putable bond is equal to the value of an option-free bond plus the value of the put option. Thus the difference between the value of a putable bond and the value of an otherwise comparable option-free bond is the value of the embedded

EXHIBIT 7–9

Price/Yield Relationship for a Putable Bond and an Option-Free Bond

put option. This can be seen in Exhibit 7–9 which shows the price/yield relationship for a putable bond (the curve a'–b) and an option-free bond (the curve a'–a').

At low yield levels (low relative to the issue's coupon rate), the price of the putable bond is basically the same as the price of the option-free bond because the value of the put option is small. As rates rise, the price of the putable bond declines, but the price decline is less than that for an option-free bond. The divergence in the price of the putable bond and an otherwise comparable option-free bond at a given yield level is the value of the put option. When yields rise to a level where the bond's price would fall below the put price, the price at these levels is the put price.

Interest-Rate Risk for Floating-Rate Securities

The change in the price of a fixed-rate coupon bond when market interest rates change is due to the fact that the bond's coupon rate differs from the prevailing market interest rate. For a floating-rate security, the coupon rate is reset periodically based on the prevailing value for the reference rate plus the quoted margin. The quoted margin is set for the life of the security. The price of a floating-rate security will fluctuate depending on three factors.

First, the longer the time to the next coupon reset date, the greater is the potential price fluctuation.[3] For example, consider a floating-rate security whose coupon resets every six months and the coupon formula is the six-month Treasury rate plus

3. The coupon rate is set at the beginning of the period but is not paid until the end of the period.

20 basis points. Suppose that on the coupon reset date the six-month Treasury rate is 0.35%. If on the day after the coupon is reset the six-month Treasury rate rises to 0.75%, this means that this security is offering a six-month coupon rate that is less than the prevailing six-month rate for the remaining six months. The price of the security must decline to reflect this. Suppose instead that the coupon resets every month at the one-month Treasury rate and that this rate rises immediately after the coupon rate is reset. In this case, while the investor would be realizing a submarket one-month coupon rate, it is for only a month. The price decline will be less than for the security that resets every six months.

The second reason why a floating-rate security's price will fluctuate is that the required margin that investors demand in the market changes. For example, consider once again the security whose coupon formula is the six-month Treasury rate plus 20 basis points. If market conditions change such that investors want a margin of 30 basis points rather than 20 basis points, this security would be offering a coupon rate that is 10 basis points below the market rate. As a result, the security's price will decline.

Finally, a floating-rate security typically will have a cap. Once the coupon rate as specified by the coupon formula rises above the cap rate, the coupon will be set at the cap rate, and the security then will offer a below-market coupon rate, and its price will decline. In fact, once the cap is reached, the security's price will react much the same way to changes in market interest rates as that of a fixed-rate coupon security. This risk for a floating-rate security is called *cap risk.*

The Impact of the Yield Level

Because of credit risk, different bonds trade at different yields, even if they have the same coupon rate, maturity, and embedded options. How, then, holding other factors constant, does the level of interest rates affect a bond's price sensitivity to changes in interest rates? As it turns out, the higher the level of interest rates that a bond trades, the lower is the price sensitivity.

To see this, we can compare a 5% 20-year bond initially selling at a yield of 5% and a 5% 20-year bond initially selling at a yield of 9%. The former is initially at a price of 100, and the latter, 63.20. Now, if the yield on both bonds increases by 100 basis points, the first bond trades down by 11.56 points (11.56%) to a price of 88.44. After the assumed increase in yield, the second bond will trade at a price of 57.10, for a price decline of only 6.09 points (or 9.64%). Thus we see that the bond that trades at a lower yield is more volatile in both percentage price change and absolute price change as long as the other bond characteristics are the same. An implication is that for a given change in interest rates, price sensitivity is lower when the level of interest rates in the market is high, and price sensitivity is higher when the level of interest rates is low.

DURATION

With this background about the price volatility characteristics of a bond, we can now turn to an alternate approach to full valuation: the duration/convexity approach. *Duration is a measure of the approximate sensitivity of a bond's value to rate changes.* More specifically, *it is the approximate percentage change in value for a 100 basis point change in rates.* We'll see in this section that duration is the first approximation of the percentage price change. To improve the estimate provided by duration a measure called *convexity* can be used. Hence, using duration combined with convexity to estimate the percentage price change of a bond to changes in interest rates is called the *duration/convexity approach.*

Calculating Duration

The duration of a bond is estimated as follows:

$$\frac{\text{Price if yields decline} - \text{price if yields rise}}{2(\text{initial price})(\text{change in yield in decimal})}$$

If we let

$$\Delta y = \text{change in yield in decimal}$$
$$V_0 = \text{initial price}$$
$$V_- = \text{price if yields decline by } \Delta y$$
$$V_+ = \text{price if yields increase by } \Delta y$$

then duration can be expressed as

$$\text{Duration} = \frac{V_- - V_+}{2(V_0)(\Delta y)} \tag{7–1}$$

For example, consider a 5% coupon 20-year option-free bond selling at 113.6777 to yield 4% (see Exhibit 7–4). Let's change (i.e., shock) the yield down and up by 20 basis points and determine what the new prices will be for the numerator. If the yield is decreased by 20 basis points from 4.0% to 3.8%, the price would increase to 116.7049. If the yield increases by 20 basis points, the price would decrease to 110.7527. Thus

$$\Delta y = 0.002$$
$$V_0 = 113.6777$$
$$V_- = 116.7049$$
$$V_+ = 110.5727$$

Then

$$\text{Duration} = \frac{116.7049 - 110.7527}{2 \times (113.6777) \times (0.002)} = 13.09$$

Duration is interpreted as the approximate percentage change in price for a 100 basis point change in rates. Consequently, a duration of 13.09 means that the approximate change in price for this bond is 13.09% for a 100 basis point change in rates.

A common question asked about this interpretation of duration is the consistency between the yield change that is used to compute duration using Eq. (7–1) and the interpretation of duration. For example, recall that in computing the duration of the 5% coupon 20-year bond, we used a 20 basis point yield change to obtain the two prices to use in the numerator of Eq. (7–1). Yet we interpret the duration computed as the approximate percentage price change for a 100 basis point change in yield. The reason is that regardless of the yield change used to estimate duration in Eq. (7–1), the interpretation is the same. If we used a 25 basis point change in yield to compute the prices used in the numerator of Eq. (7–1), the resulting duration is interpreted as the approximate percentage price change for a 100 basis point change in yield. Later we will use different changes in yield to illustrate the sensitivity of the computed duration.

Approximating the Percentage Price Change Using Duration

The following formula is used to approximate the percentage price change for a given change in yield and a given duration:

$$\text{Approximate percentage price change} = -\text{duration} \times \Delta y \times 100 \qquad (7\text{–}2)$$

The reason for the negative sign on the right-hand side of Eq. (7–2) is due to the inverse relationship between price change and yield change.

For example, consider the 5% 20-year bond trading at 113.6777 whose duration we just showed is 13.09. The approximate percentage price change for a 10 basis point increase in yield (i.e., $\Delta y = +0.001$) is

$$\text{Approximate percentage price change} = -13.09 \times (+0.001) \times 100 = -1.309\%$$

How good is this approximation? The actual percentage price change is –1.30% (as shown in Exhibit 7–6 when yield increases to 4.10%). Duration, in this case, did an excellent job in estimating the percentage price change. We would come to the same conclusion if we used duration to estimate the percentage price change if the yield declined by 10 basis points (i.e., $\Delta y = -0.001$). In this case, the approximate percentage price change would be +1.309% (i.e., the direction of the estimated price change is the reverse but the magnitude of the change is the same). Exhibit 7–6 shows that the actual percentage price change is +1.32%.

In terms of estimating the new price, let's see how duration performed. The initial price is 113.6777. For a 10 basis point increase in yield, duration estimates that the price will decline by 1.309%. Thus the price will decline to 112.1897 (found by multiplying 113.6777 by 1 minus 0.01309). The actual price from Exhibit 7–4 if the

yield increases by 10 basis points is 112.2027. Thus the price estimated using duration is close to the actual price. For a 10 basis point decrease in yield, the actual price from Exhibit 7–4 is 115.1783, and the estimated price using duration is 115.1658 (a price increase of 1.309%). Consequently, the new price estimated by duration is close to the actual price for a 10 basis point change in yield.

Let's look at how well duration does in estimating the percentage price change if the yield increases by 200 basis points instead of 10 basis points. In this case, Δy is equal to +0.02. Substituting into Eq. (7–2) we have

$$\text{Approximate percentage price change} = -13.09 \times (+0.02) \times 100 = -26.18\%$$

How good is this estimate? From Exhibit 7–6 we see that the actual percentage price change when the yield increases by 200 basis points to 6% is –22.20%. Thus the estimate is not as accurate as when we used duration to approximate the percentage price change for a change in yield of only 10 basis points. If we use duration to approximate the percentage price change when the yield decreases by 200 basis points, the approximate percentage price change in this scenario is +26.18%. The actual percentage price change as shown in Exhibit 7–6 is +31.29%.

Again, let's look at the use of duration in terms of estimating the new price. Since the initial price is 113.6777 and a 200 basis point increase in yield will decrease the price by 26.18%, the estimated new price using duration is 83.9169 (found by multiplying 113.6777 by 1 minus 0.2618). From Exhibit 7–4 the actual price if the yield is 6% is 88.4426. Consequently, the estimate is not as accurate as the estimate for a 10 basis point change in yield. The estimated new price using duration for a 200 basis point decrease in yield is 143.4386 compared with the actual price (from Exhibit 7–4) of 149.2520. Once again, the estimation of the price using duration is not as accurate as for a 10 basis point change. *Notice that whether the yield is increased or decreased by 200 basis points, duration underestimates what the new price will be.* We will see why shortly.

Let's summarize what we found in our application of duration to approximate the percentage price change:

		New Price		***Percent Price Change***		
Yield Change (bp)	**Initial Price**	**Based on Duration**	**Actual**	**Based on Duration**	**Actual**	**Comment**
+10	113.6777	112.1897	112.2027	–1.309	–1.30	Estimated price close to new price
–10	113.6777	115.1658	115.1783	+1.309	+1.32	Estimated price close to new price
+200	113.6777	83.9169	88.4426	–26.180	–22.20	Underestimates new price
–200	113.6777	143.4386	149.2520	+26.180	+31.29	Underestimates new price

Look again at Eq. (7–2). Notice that whether the change in yield is an increase or a decrease, the approximate percentage price change will be the same except that the sign is reversed. This violates Properties 3 and 4 with respect to the price volatility of option-free bonds when yields change. Recall that Property 3 states that the percentage price change will not be the same for a large increase and decrease in yield by the same number of basis points. This is one reason why we see that the estimate is inaccurate for a 200 basis point yield change. Why did the duration estimate of the price change do a good job for a small change in yield of 10 basis points? Recall from Property 2 that the percentage price change will be approximately the same whether there is an increase or decrease in yield by a small number of basis points. We also can explain these results in terms of the graph of the price/yield relationship. We will do this next.

Graphic Depiction of Using Duration to Estimate Price Changes

The shape of the price/yield relationship for an option-free bond is convex. Exhibit 7–10 shows this relationship. In the exhibit, a tangent line is drawn to the price/yield relationship at yield y^*. [For those unfamiliar with the concept of a tangent line, it is a straight line that just touches a curve at one point within a relevant (local) range.] In Exhibit 7–10, the tangent line touches the curve at the point where the yield is equal to y^* and the price is equal to p^*. The tangent line

EXHIBIT 7–10

Price/Yield Relationship for an Option-Free Bond with a Tangent Line

can be used to estimate the new price if the yield changes. If we draw a vertical line from any yield (on the horizontal axis), as in Exhibit 7–10, the distance between the horizontal axis and the tangent line represents the price approximated by using duration starting with the initial yield y^*.

Now how is the tangent line, used to approximate what the new price will be if yields change, related to duration? Duration tells us the approximate percentage price change. Given the initial price and the approximate percentage price change provided by duration [i.e., as given by Eq. (7–2)], the approximate new price can be estimated. Mathematically, it can be demonstrated that the estimated price that is provided by duration is on the tangent line.

This helps us to understand why duration did an effective job of estimating the percentage price change or, equivalently, the new price when the yield changes by a small number of basis points. Look at Exhibit 7–11. Notice that for a small change in yield, the tangent line does not depart much from the price/yield relationship. Hence, when the yield changes up or down by 10 basis points, the tangent line does a good job of estimating the new price, as we found in our earlier numerical illustration.

Exhibit 7–11 also shows what happens to the estimate using the tangent line when the yield changes by a large number of basis points. Notice that the error in the estimate gets larger the further one moves from the initial yield. The estimate is less accurate the more convex the bond. This is illustrated in Exhibit 7–12.

EXHIBIT 7–11

Estimating the New Price Using a Tangent Line

EXHIBIT 7–12

Estimating the New Price for a Large Yield Change for Bonds with Different Convexities

Also note that regardless of the magnitude of the yield change, the tangent line always underestimates what the new price will be for an option-free bond because the tangent line is below the price/yield relationship. This explains why we found in our illustration that when using duration we underestimated what the actual price will be.

Rate Shocks and Duration Estimate

In calculating duration using Eq. (7–1), it is necessary to shock interest rates (yields) up and down by the same number of basis points to obtain the values for V_- and V_+. In our illustration, 20 basis points was arbitrarily selected. But how large should the shock be? That is, how many basis points should be used to shock the rate?

In Exhibit 7–13, the duration estimate for our four hypothetical bonds using Eq. (7–1) for rate shocks of 1 basis point to 200 basis points is reported. The duration estimates for the two 5-year bonds are not affected by the size of the shock. The two 5-year bonds are less convex than the two 20-year bonds. But even for the two 20-year bonds, for the size of the shocks reported in Exhibit 7–13, the duration estimates are not materially affected by the greater convexity.

Thus it would seem that the size of the shock is unimportant. However, the results reported in Exhibit 7–13 are for option-free bonds. When we deal with more

EXHIBIT 7–13

Duration Estimates for Different Rate Shocks

Bond	1 bp	10 bps	20 bps	50 bps	100 bps	150 bps	200 bps
4% 5-year	4.49	4.49	4.49	4.49	4.49	4.50	4.50
4% 20-year	13.68	13.68	13.68	13.70	13.75	13.85	13.99
5% 5-year	4.41	4.41	4.41	4.41	4.41	4.42	4.42
5% 20-year	13.09	13.09	13.09	13.10	13.16	13.25	13.37

Initial yield: 4%

complicated securities, small rate shocks that do not reflect the types of rate changes that may occur in the market do not permit the determination of how prices can change because expected cash-flows may change when dealing with bonds with embedded options. In comparison, if large rate shocks are used, we encounter the asymmetry caused by convexity. Moreover, large rate shocks may cause dramatic changes in the expected cash-flows for bonds with embedded options that may be far different from how the expected cash-flows will change for smaller rate shocks.

There is another potential problem with using small rate shocks for complicated securities. The prices that are inserted into the duration formula as given by Eq. (7–1) are derived from a valuation model. In Chapters 40 and 41 we will discuss various valuation models and their underlying assumptions. The duration measure depends crucially on a valuation model. If the rate shock is small and the valuation model used to obtain the prices for Eq. (7–1) is poor, dividing poor price estimates by a small shock in rates in the denominator will have a significant effect on the duration estimate.

What is done in practice by dealers and vendors of analytical systems? Each system developer uses rate shocks he or she believes to be realistic based on historical rate changes.

MODIFIED DURATION VERSUS EFFECTIVE DURATION

One form of duration that is cited by practitioners is *modified duration.* Modified duration is the approximate percentage change in a bond's price for a 100 basis point change in yield *assuming that the bond's expected cash-flows do not change when the yield changes.* What this means is that in calculating the values of V_- and V_+ in Eq. (7–1), the same cash-flows used to calculate V_0 are used. Therefore, the change in the bond's price when the yield is changed is due solely to discounting cash-flows at the new yield level.

The assumption that the cash-flows will not change when the yield is changed makes sense for option-free bonds such as noncallable Treasury securities. This is so because the payments made by the U.S. Department of the Treasury to holders of its obligations do not change when interest rates change. However, the same

EXHIBIT 7–14

Modified Duration versus Effective Duration

cannot be said for bonds with embedded options (i.e., callable and putable bonds and mortgage-backed securities). For these securities, a change in yield may alter the expected cash-flows significantly.

Earlier we showed the price/yield relationship for callable and prepayable bonds. Failure to recognize how changes in yield can alter the expected cash-flows will produce two values used in the numerator of Eq. (7–1) that are not good estimates of how the price actually will change. The duration is then not a good number to use to estimate how the price will change.

In later chapters where valuation models for bonds with embedded options will be discussed, it will be explained how these models take into account how changes in yield will affect the expected cash-flows. Thus, when V_- and V_+ are the values produced from these valuation models, the resulting duration takes into account both the discounting at different interest rates and how the expected cash-flows may change. When duration is calculated in this manner, it is called *effective duration* or *option-adjusted duration.* Exhibit 7–14 summarizes the distinction between modified duration and effective duration.

The difference between modified duration and effective duration for bonds with embedded options can be quite dramatic. For example, a callable bond could have a modified duration of 5 but an effective duration of only 3. For certain collateralized mortgage obligations, the modified duration could be 7 and the effective duration 20! Thus, using modified duration as a measure of the price sensitivity of a security with embedded options to changes in yield would be misleading. The more appropriate measure for any bond with an embedded option is effective duration.

Macaulay Duration and Modified Duration

It is worth comparing the relationship between modified duration and Macaulay duration. Modified duration also can be written as[4]

$$\frac{1}{(1+\text{yield}/k)}\left(\frac{1\times\text{PVCF}_1+2\times\text{PVCF}_2+\cdots+n\times\text{PVCF}_n}{k\times\text{price}}\right) \tag{7–3}$$

4. More specifically, this is the formula for the modified duration of a bond on a coupon anniversary date.

where

k = number of periods, or payments, per year (e.g., $k = 2$ for semiannual-pay bonds and $k = 12$ for monthly-pay bonds)
n = number of periods until maturity (i.e., number of years to maturity times k)
yield = yield to maturity of the bond
PVCF_t = present value of the cash-flow in period t discounted at the yield to maturity

The expression in the parentheses on the right of the modified duration formula given by Eq. (7–3) is a measure formulated in 1938 by Frederick Macaulay.[5] This measure is popularly called the *Macaulay duration.* Thus modified duration is commonly expressed as

$$\text{Modified duration} = \frac{\text{Macaulay duration}}{(1 + \text{yield}/k)}$$

The general formulation for duration as given by Eq. (7–1) provides a shortcut procedure for determining a bond's modified duration. Because it is easier to calculate the modified duration using the shortcut procedure, most vendors of analytical software will use Eq. (7–1) rather than Eq. (7–3) to reduce computation time.

However, it must be understood clearly that modified duration is a flawed measure of a bond's price sensitivity to interest-rate changes for a bond with an embedded option, and therefore, so is Macaulay duration. The use of the formula for duration given by Eq. (7–3) *misleads* the user because it masks the fact that changes in the expected cash-flows must be recognized for bonds with embedded options. Although Eq. (7–3) will give the same estimate of percent price change for an option-free bond as Eq. (7–1), Eq. (7–1) is still better because it acknowledges that cash-flows and thus value can change owing to yield changes.

Interpretations of Duration

At the outset of this section we defined duration as the approximate percentage change in price for a 100 basis point change in rates. If you understand this definition, you need never use the equation for the approximate percentage price change given by Eq. (7–2), and you can easily calculate the change in a bond's value.

For example, suppose that we want to know the approximate percentage change in price for a 50 basis point change in yield for our hypothetical 5% coupon 20-year bond selling for 113.6777. Since the duration is 13.09, a 100 basis point change in yield would change the price by about 13.09%. For a 50 basis point

5. Frederick Macaulay, *Some Theoretical Problems Suggested by the Movement of Interest Rates, Bond Yields, and Stock Prices in the U.S. Since 1856* (New York: National Bureau of Economics Research, 1938).

change in yield, the price will change by approximately 6.545% (= 13.09%/2). Thus, if the yield changes by 50 basis points, the price will change by 6.545% from 113.6777 to 106.2375.

Now let's look at some other definitions or interpretations of duration that have been used.

Duration Is the "First Derivative"

Sometimes a market participant will refer to duration as the "first derivative of the price/yield function" or simply the "first derivative." *Derivative* here has nothing to do with "derivative instruments" (i.e., futures, swaps, options, etc.). A derivative as used in this context is obtained by differentiating a mathematical function. There are first derivatives, second derivatives, and so on. When market participants say that duration is the first derivative, here is what they mean. If it were possible to write a mathematical equation for a bond in closed form, the first derivative would be the result of differentiating that equation the first time. While it is a correct interpretation of duration, it is an interpretation that in no way helps us understand what the interest-rate risk is of a bond. That is, it is an operationally meaningless interpretation.

Why is it an operationally meaningless interpretation? Go back to the $10 million bond position with a duration of 6. Suppose that a client is concerned with the exposure of the bond to changes in interest rates. Now, tell that client the duration is 6 and that it is the first derivative of the price function for that bond. What have you told the client? Not much. In contrast, tell that client that the duration is 6 and that duration is the approximate price sensitivity of a bond to a 100 basis point change in rates, and you've told the client a great deal with respect to the bond's interest-rate risk.

Duration Is Some Measure of Time

When the concept of duration was introduced by Macaulay in 1938, he used it as a gauge of the time that the bond was outstanding. More specifically, Macaulay defined *duration* as the weighted average of the time to each coupon and principal payment of a bond. Subsequently, *duration* has too often been thought of in temporal terms, that is, years. This is most unfortunate for two reasons.

First, in terms of dimensions, there is nothing wrong with expressing duration in terms of years because that is the proper dimension of this value. But the proper interpretation is that duration is the price volatility of a zero-coupon bond with that number of years to maturity. Thus, when a manager says that a bond has a duration of four years, it is not useful to think of this measure in terms of time, but rather that the bond has the price sensitivity to rate changes of a four-year zero-coupon bond.

Second, thinking of duration in terms of years makes it difficult for managers and their clients to understand the duration of some complex securities. Here are a few examples. For a mortgage-backed security that is an interest-only security, the duration is negative. What does a negative number of, say, −4 mean? In terms of our interpretation as a percentage price change, it means that when rates

change by 100 basis points, the price of the bond changes by about 4%, but the change is in the same direction as the change in rates.

As a second example, consider the duration of an option that expires in one year. Suppose that it is reported that its duration is 60. What does that mean? To someone who interprets duration in terms of time, does that mean 60 years, 60 days, or 60 seconds? It doesn't mean any of these. It simply means that the option tends to have the price sensitivity to rate changes of a 60-year zero-coupon bond.

Forget First Derivatives and Temporal Definitions

The bottom line is that one should not care if it is technically correct to think of duration in terms of years (volatility of a zero-coupon bond) or in terms of first derivatives. There are even some who interpret duration in terms of the "half life" of a security. Subject to the limitations that we will describe later, duration is used as a measure of the sensitivity of a security's price to changes in yield. We will fine-tune this definition as we move along.

Users of this interest-rate risk measure are interested in what it tells them about the price sensitivity of a bond (or a portfolio) to changes in rates. Duration provides the investor with a feel for the dollar price exposure or the percentage price exposure to potential rate changes.

Spread Duration

For non-Treasury securities, the yield is equal to the Treasury yield plus a spread to the Treasury yield-curve. Non-Treasury securities are called *spread products.* The risk that the price of a bond changes due to changes in spreads is called *spread risk.* A measure of how a spread product's price changes if the spread sought by the market changes is called *spread duration.* Spread duration indicates the approximate percentage change in price for a 100 basis point change in the spread, holding the Treasury yield constant. For example, suppose that the spread duration of a corporate bond is 1. This means that for a 100 basis point change in the spread, the value of the corporate bond will change by approximately 1%.

Portfolio Duration

A portfolio's duration can be obtained by calculating the weighted average of the duration of the bonds in the portfolio. The weight is the proportion of the portfolio that a security comprises. Mathematically, a portfolio's duration can be calculated as follows:

$$w_1 D_1 + w_2 D_2 + w_3 D_3 + \cdots + w_K D_K$$

where

w_i = market value of bond i/market value of the portfolio
D_i = duration of bond i
K = number of bonds in the portfolio

To illustrate this calculation, consider the following three-bond portfolio in which all three bonds are option free:

Bond	Price ($)	Yield (%)	Par Amount Owned	Market Value	Duration
9% 5-year	122.4565	4	$5 million	$6,122,823	4.147
5% 20-year	113.6777	4	2 million	2,273,555	13.087
5.5% 30-year	126.0707	4	2 million	2,521,413	16.290

In this illustration it is assumed that the next coupon payment for each bond is exactly six months from now (i.e., there is no accrued interest). The market value for the portfolio is $10,917,791. Since each bond is option free, the modified duration can be used. The market price per $100 par value of each bond, its yield, and its duration are given below:

In this illustration, K is equal to 3 and:

$$w_1 = \$6{,}122{,}823/\$10{,}917{,}791 = 0.561 \quad D_1 = 4.147$$
$$w_2 = \$2{,}273{,}555/\$10{,}917{,}791 = 0.208 \quad D_2 = 13.087$$
$$w_3 = \$2{,}521{,}413/\$10{,}917{,}791 = 0.231 \quad D_3 = 16.290$$

The portfolio's duration is:

$$0.561\ (4.147) + 0.208\ (13.087) + 0.231\ (16.290) = 8.81$$

A portfolio duration of 8.81 means that for a 100 basis point change in the yield of all three bonds, the market value of the portfolio will change by approximately 8.81%. But keep in mind that the yield on all three bonds must change by 100 basis points for the duration measure to be useful. This is a *critical assumption,* and its importance cannot be overemphasized.[6]

An alternative procedure for calculating the duration of a portfolio is to calculate the dollar price change for a given number of basis points for each security in the portfolio and then add up all the price changes. Dividing the total of the price changes by the initial market value of the portfolio produces a percentage price change that can be adjusted to obtain the portfolio's duration.

For example, consider the three-bond portfolio shown above. Suppose that we calculate the dollar price change for each bond in the portfolio based on its respective duration for a 50 basis point change in yield. We would then have

6. This is equivalent to saying that the correlation between the yield change for every maturity is equal to 1.

Bond	Market Value	Duration	Change in Value for 50 bp Yield Change
9% 5-year	$6,122,823	4.147	$126,957
5% 20-year	2,273,555	13.087	148,770
5.5% 30-year	2,521,413	16.290	205,369
		Total	$481,096

Thus a 50 basis point change in all rates changes the market value of the three-bond portfolio by $481,096. Since the market value of the portfolio is $10,917,791, a 50 basis point change produced a change in value of 4.41% ($481,096 divided by $10,917,791). Since duration is the approximate percentage change for a 100 basis point change in rates, this means that the portfolio duration is 8.82 (found by doubling 4.41). This is the same value for the portfolio's duration as found earlier.

The spread duration for a portfolio or a bond index is computed as a market-weighted average of the spread duration for each sector.

Contribution to Portfolio Duration

Some portfolio managers look at exposure of a portfolio or a benchmark index to an issue or to a sector simply in terms of the market value percentage of that issue or sector in the portfolio. A better measure of exposure to an individual issue or sector is its *contribution to portfolio duration* or *contribution to benchmark index duration*. This is found by multiplying the percentage of the market value of the portfolio represented by the individual issue or sector by the duration of the individual issue or sector. That is,

$$\text{Contribution to portfolio duration} = \text{weight of issue or sector in portfolio} \times \text{duration of issue or sector}$$

$$\text{Contribution to benchmark index duration} = \text{weight of issue or sector in benchmark index} \times \text{duration of issue or sector}$$

A portfolio manager who wants to determine the contribution of a sector to portfolio duration relative to the contribution of the same sector in a broad-based market index can compute the difference between the two contributions. The difference in the percentage distribution by sector is not as meaningful as is the difference in the contribution to duration.

CONVEXITY

The duration measure indicates that regardless of whether interest rates increase or decrease, the approximate percentage price change is the same. However, as we noted earlier, this is not consistent with Property 3 of a bond's price volatility. Specifically, while for small changes in yield the percentage price change will be

the same for an increase or decrease in yield, for large changes in yield this is not true. This suggests that duration is only a good approximation of the percentage price change for small changes in yield.

We demonstrated this property earlier using a 5% 20-year bond selling to yield 4% with a duration of 13.09. For a 10 basis point change in yield, the estimate was accurate for both an increase or a decrease in yield. However, for a 200 basis point change in yield, the approximate percentage price change was off considerably.

The reason for this result is that duration is in fact a first (linear) approximation for a small change in yield.[7] The approximation can be improved by using a second approximation. This approximation is referred to as "convexity." *The use of this term in the industry is unfortunate because the term convexity is also used to describe the shape or curvature of the price/yield relationship.* The *convexity measure* of a security can be used to approximate the change in price that is not explained by duration.

Convexity Measure

The convexity measure of a bond is approximated using the following formula:

$$\text{Convexity measure} = \frac{V_+ + V_- - 2V_0}{2V_0(\Delta y)^2} \tag{7–4}$$

where the notation is the same as used earlier for duration as given by Eq. (7–1).

For our hypothetical 5% 20-year bond selling to yield 4%, we know that for a 20 basis point change in yield ($\Delta y = 0.002$),

$$V_0 = 113.6777, \quad V_- = 116.7049, \quad \text{and} \quad V_+ = 110.7527$$

Substituting these values into the convexity measure given by Eq. (7–4) gives

$$\text{Convexity measure} = \frac{110.7527 + 116.7049 - 2(113.6777)}{2(113.6777)(0.002)^2} = 112.38$$

We'll see how to use this convexity measure shortly. Before doing so, there are three points that should be noted. First, there is no simple interpretation of the convexity measure. Second, in contrast to duration, it is more common for market participants to refer to the value computed in Eq. (7–4) as the "convexity of a bond" rather than the "convexity measure of a bond." Finally, the convexity measure reported by dealers and vendors will differ for an option-free bond. The reason is that the value obtained from Eq. (7–4) is often scaled for the reason explained after we demonstrate how to use the convexity measure.

7. The reason it is a linear approximation can be seen in Exhibit 7–11, where the tangent line is used to estimate the new price. That is, a straight line is being used to approximate a nonlinear (i.e., convex) relationship.

Convexity Adjustment to Percentage Price Change

Given the convexity measure, the approximate percentage price change adjustment due to the bond's convexity (i.e., the percentage price change not explained by duration) is

$$\text{Convexity adjustment} = \text{convexity measure} \times (\Delta y)^2 \times 100 \qquad (7\text{–}5)$$

For example, for the 5% coupon bond maturing in 20 years, the convexity adjustment to the percentage price change based on duration if the yield increases from 4% to 6% is

$$112.38 \times (0.02)^2 \times 100 = 4.50\%$$

If the yield decreases from 4% to 2%, the convexity adjustment to the approximate percentage price change based on duration also would be 4.50%.

The approximate percentage price change based on duration and the convexity adjustment is found by adding the two estimates. Thus, for example, if yields change from 4% to 6%, the estimated percentage price change would be

$$\begin{aligned} \text{Estimated change using duration} &= -26.18\% \\ \text{Convexity adjustment} &= \underline{+4.50\%} \\ \text{Total estimated percentage price change} &= -21.68\% \end{aligned}$$

The actual percentage price change is –22.20%.

For a decrease of 200 basis points, from 4% to 2%, the approximate percentage price change would be as follows:

$$\begin{aligned} \text{Estimated change using duration} &= +26.18\% \\ \text{Convexity adjustment} &= \underline{+4.50\%} \\ \text{Total estimated percentage price change} &= +30.68\% \end{aligned}$$

The actual percentage price change is +31.29%. Thus duration combined with the convexity adjustment does a better job of estimating the sensitivity of a bond's price change to large changes in yield.

Notice that when the convexity measure is positive, we have the situation described earlier that the gain is greater than the loss for a given large change in rates. That is, the bond exhibits positive convexity. We can see this in the preceding example. However, if the convexity measure is negative, we have the situation where the loss will be greater than the gain. For example, suppose that a callable bond has an effective duration of 4 and a convexity measure of –30. This means that the approximate percentage price change for a 200 basis point change is 8%. The convexity adjustment for a 200 basis point change in rates is then

$$-30 \times (0.02)^2 \times 100 = -1.2$$

The convexity adjustment is −1.2%, and therefore, the bond exhibits the negative convexity property illustrated in Exhibit 7–7. The approximate percentage price change after adjusting for convexity is

$$\begin{aligned} \text{Estimated change using duration} &= -8.0\% \\ \text{Convexity adjustment} &= -1.2\% \\ \hline \text{Total estimated percentage price change} &= -9.2\% \end{aligned}$$

For a decrease of 200 basis points, the approximate percentage price change would be as follows:

$$\begin{aligned} \text{Estimated change using duration} &= +8.0\% \\ \text{Convexity adjustment} &= -1.2\% \\ \hline \text{Total estimated percentage price change} &= 6.8\% \end{aligned}$$

Notice that the loss is greater than the gain—a property called *negative convexity* that we discussed earlier and illustrated in Exhibit 7–7.

Scaling the Convexity Measure

The convexity measure as given by Eq. (7–4) means nothing in isolation. It is the substitution of the computed convexity measure into Eq. (7–5) that provides the estimated adjustment for convexity. Therefore, it is possible to scale the convexity measure in any way and obtain the same convexity adjustment.

For example, in some books the convexity measure is defined as follows:

$$\text{Convexity measure} = \frac{V_+ + V_- - 2V_0}{V_0(\Delta y)^2} \tag{7–6}$$

Equation (7–6) differs from Eq. (7–4) because it does not include 2 in the denominator. Thus the convexity measure computed using Eq. (7–6) will be double the convexity measure using Eq. (7–4). Thus, for our earlier illustration, since the convexity measure using Eq. (7–4) is 112.38, the convexity measure using Eq. (7–6) would be 224.76.

Which is correct, 112.38 or 224.76? The answer is both. The reason is that the corresponding equation for computing the convexity adjustment would not be given by Eq. (7–5) if the convexity measure is obtained from Eq. (7–6). Instead, the corresponding convexity adjustment formula would be

$$\text{Convexity adjustment} = (\text{convexity measure}/2) \times (\Delta y)^2 \times 100 \tag{7–7}$$

Equation (7–7) differs from Eq. (7–5) in that the convexity measure is divided by 2. Thus the convexity adjustment will be the same whether one uses Eq. (7–4)

to get the convexity measure and Eq. (7–5) to get the convexity adjustment or one uses Eq. (7–6) to compute the convexity measure and Eq. (7–7) to determine the convexity adjustment.

Some dealers and vendors scale the convexity measure in a different way. One also can compute the convexity measure as follows:

$$\text{Convexity measure} = \frac{V_+ + V_- - 2V_0}{2V_0(\Delta y)^2(100)} \tag{7–8}$$

Equation (7–8) differs from Eq. (7–4) by the inclusion of 100 in the denominator. In our illustration, the convexity measure would be 1.1238 rather than 112.38 using Eq. (7–4). The convexity adjustment formula corresponding to the convexity measure given by Eq. (7–8) is then

$$\text{Convexity adjustment} = \text{convexity measure} \times (\Delta y)^2 \times 10{,}000 \tag{7–9}$$

Similarly, one can express the convexity measure as shown in Eq. (7–10):

$$\text{Convexity measure} = \frac{V_+ + V_- - 2V_0}{V_0(\Delta y)^2(100)} \tag{7–10}$$

For the bond we have been using in our illustrations, the convexity measure is 2.2476. The corresponding convexity adjustment is

$$\text{Convexity adjustment} = (\text{convexity measure}/2) \times (\Delta y)^2 \times 10{,}000 \tag{7–11}$$

Consequently, the convexity measures (or just simply "convexity" as it is referred to by some market participants) that could be reported for this option-free bond are 112.38, 224.76, 1.1238, and 2.2476. All these values are correct, but they mean nothing in isolation. To use them to obtain the convexity adjustment to the price change estimated by duration requires knowing how they are computed so that the correct convexity adjustment formula is used. *It is the convexity adjustment that is important—not the convexity measure in isolation.*

It is also important to understand this when comparing the convexity measures reported by dealers and vendors. For example, if one dealer shows a portfolio manager bond A with a duration of 4 and a convexity measure of 50, and a second dealer shows the manager bond B with a duration of 4 and a convexity measure of 80, which bond has the greater percentage price change response to changes in interest rates? Since the duration of the two bonds is identical, the bond with the larger convexity measure will change more when rates decline. However, not knowing how the two dealers computed the convexity measure means that the manager does not know which bond will have the greater convexity adjustment. If the first dealer used Eq. (7–4) and the second dealer used Eq. (7–6), then the convexity measures must be adjusted in terms of either equation. For example, using Eq. (7–4), the convexity measure of 80 computed using Eq. (7–6) is equal to a convexity measure of 40 based on Eq. (7–4).

Modified Convexity and Effective Convexity

The prices used in Eq. (7–4) to calculate convexity can be obtained by assuming that when the yield changes the expected cash-flows either do not change or they do change. In the former case, the resulting convexity is called *modified convexity.* (Actually, in the industry, convexity is not qualified by the adjective *modified.*) In contrast, *effective convexity* assumes that the cash-flows do change when yields change. This is the same distinction made for duration.

As with duration, there is little difference between modified convexity and effective convexity for option-free bonds. However, for bonds with embedded options, there can be quite a difference between the calculated modified convexity and the effective convexity measures. In fact, for all option-free bonds, either convexity measure will have a positive value. For bonds with embedded options, the calculated effective convexity can be negative when the calculated modified convexity measure is positive.

Illustrations of Effective Duration and Convexity

As noted earlier, modified duration and effective duration are two ways to measure the price sensitivity of a fixed income security. Modified duration ignores any effect on cash-flows that might take place as a result of changes in interest rates. Effective duration does not ignore the potential for such changes in cash-flows. For example, bonds with embedded options will have very different cash-flow properties as interest rates (or yields) change. Modified duration ignores these effects completely. In order to apply effective duration, an available interest-rate model and corresponding valuation model are needed. The example in this section shows how to compute the effective duration of securities with cash-flows that are dependent on interest rates.

There is no difference between modified and effective duration for option-free or straight bonds. In fact, it can be shown that they are mathematically identical when the change in rates (or yields) becomes very small. As shown in the example, even for bonds with embedded options, the differences between the two measures are minimal over certain ranges of yields. For example, when the embedded option is far out-of-the-money, the cash-flows of the bond are not affected by small changes in yields, resulting in almost no difference in cash-flows between the two measures.

Convexity (sometimes referred to as "standard convexity") suffers the same limitations as modified duration and therefore is not generally useful for securities with embedded options. However, similar to the duration measures, in ranges of rates (or yields) where the cash-flows are not materially affected by small changes in yields, the two convexity measures are almost identical.

The following example illustrates how to calculate and interpret effective duration and effective convexity for option-free bonds and bonds with embedded options.

Suppose that we need to measure the interest-rate sensitivity of the following three securities:

1. A five-year 2.50% coupon option-free semiannual coupon bond with a current price of 97.69% of par
2. A five-year 2.25% coupon bond, callable at par in years 2 through 5 on the semiannual coupon dates, with a current price of 96.54% of par
3. A five-year 2.75% coupon bond, putable at par in years 2 through 5 on the semiannual coupon dates, with a current price of 100.4410453 of par

The cash-flows of these securities are very different as interest rates change. Consequently, the sensitivities to changes in interest rates are also very different.

Using an interest-rate model that is based on the existing term structure,[8] the term structure of interest rates is shifted up and down by 10 basis points (bps), and the resulting price changes are recorded. Using the notation for duration and convexity earlier in this chapter, V_- corresponds to the price after a downward shift in interest rates, V_+ corresponds to the price after an upward shift in interest rates, V_0 is the current price, and Δy is the assumed shift in the term structure.[9] Exhibit 7–15 shows these prices for each bond using Eq. (7–1) for duration and Eq. (7–6) for the convexity measure.

It is very important to realize the importance of the valuation model in this exercise. The model must account for the change in cash-flows of the securities as interest rates change. The callable and putable bonds have very different cash-flow characteristics that depend on the level of interest rates. The valuation model used must account for this property. (Note that when calculating the measures, users are cautioned not to round values. Since the denominators of both the duration and convexity terms are very small, any rounding will have a significant impact on results.)

Option-Free Bond

The effective duration for the straight bond is found by recording the price changes from shifting the term structure up (V_+) and down (V_-) by 10 bps and then substituting these values into Eq. (7–1). The prices are shown in Exhibit 7–15. Consequently, the computation is

$$\text{Effective duration} = \frac{99.3018797 - 98.3796865}{2(98.8395557)(0.001)} = 4.67$$

8. The Black-Derman-Toy no arbitrage binomial model was used to perform this analysis. See Fischer Black, Emanuel Derman, and William Toy, "A One-Factor Model of Interest Rates and Its Application to Treasury Bond Options," *Financial Analysts Journal* (January–February 1990), pp. 24–32.
9. Note that shifting the term structure in a parallel manner will result in a change in yields equal to the shift for option-free bonds.

EXHIBIT 7–15

Original Prices and Resulting Prices from a Downward and Upward 10 Basis Point Interest-Rate Shift and the Corresponding Effective Duration and Effective Convexity for Three Bonds Based on the Black-Derman-Toy Model

Price Changes Following 10-bp Shift

Variable	Original Price, V_0	Upward Shift of 10 bp, V_+	Downward Shift of 10 bp, V_-
Option-free bond price	98.8395557	98.3796865	99.3018797
Callable bond price	97.6550524	97.2132182	98.0922517
Putable bond price	100.4410453	100.1343384	100.7706854

Effective Duration and Effective Convexity Measures Calculated from Using the Price Changes Resulting from the 10-bp Shifts in the Term Structure

	Effective Duration	Effective Convexity
Option-free bond	4.67	24.84
Callable bond	4.50	–47.46
Putable bond	3.17	228.32

Similarly, the calculation for effective convexity is found by substituting the corresponding prices into Eq. (7–6):

$$\text{Effective convexity} = \frac{99.3018797 + 98.3796865 - 2(98.8395557)}{98.8395557(0.001)^2}$$
$$= 24.84$$

For the option-free bond, the modified duration is 4.67 and the convexity is 24.84. These are very close to the effective measures shown in Exhibit 7–15. This demonstrates that, for option-free bonds, the two measures are almost the same for small changes in yields.

Exhibit 7–16 shows the effects of the term structure shifts on the effective duration and effective convexity of the option-free bond. The effective duration increases as yields decrease because as yields decrease the slope of the price/yield relationship for option-free bonds becomes steeper and effective duration (and modified duration) is directly proportional to the slope of this relationship. For example, the effective duration at very low yields (–250-bp shift) is 4.74 and decreases to 4.44 at very high rates (+1,000 bps). Exhibit 7–17 illustrates this phenomenon; as yields increase, notice how the slope of the price/yield relationship decreases (becomes more horizontal or flatter).

As the term structure shifts up (i.e., as rates rise), the yield to maturity on an option-free bond increases by approximately the same amount. As the yield

EXHIBIT 7–16

Effective Duration and Effective Convexity for Various Shifts in the Term Structure for Three Bonds

Term Structure Shift (bps)	*Option-Free Bond*		*Callable Bond*		*Putable Bond*	
	Effective Duration	Effective Convexity	Effective Duration	Effective Convexity	Effective Duration	Effective Convexity
–250	4.74	25.59	1.97	4.88	4.72	25.43
0	4.67	24.84	4.50	–47.46	3.17	228.32
250	4.59	24.10	4.61	24.28	1.91	4.62
500	4.51	23.39	4.54	23.57	1.88	4.50
1,000	4.44	22.70	4.47	22.89	1.86	4.39

increases, the bond's convexity decreases. Exhibit 7–17 illustrates this property. As yields increase, the curvature (or the rate of change of the slope) decreases. The results in Exhibit 7–16 for the option-free bond also bear this out. The effective convexity values become smaller as yields increase. For example, the effective convexity at very low yields (–250-bp shift) is 25.59 and decreases to 22.70 at very high rates (+1,000-bp shift).

These are both well-documented properties of option-free bonds. The modified duration and convexity numbers for the option-free bond are almost identical to the effective measures for the option-free bond shown in Exhibit 7–16.

EXHIBIT 7–17

Price/Yield Relationship of the Option-Free Bond

Callable Bond

The effective duration for the callable bond is found by recording the price changes from shifting the term structure up (V_+) and down (V_-) by 10 bps and then substituting these values into Eq. (7–1). The prices are shown in Exhibit 7–15. Note that these prices take into account the changing cash-flows resulting from the embedded call option. Consequently, the computation is

$$\text{Effective duration} = \frac{98.0922517 - 97.2132182}{2(97.6550524)(0.001)} = 4.50$$

Similarly, the calculation for effective convexity is found by substituting the corresponding prices into Eq. (7–6):

$$\text{Effective convexity} = \frac{98.0922517 + 97.2132182 - 2(97.6550524)}{97.6550524(0.001)^2}$$
$$= -47.46$$

The relationship between the shift in rates and effective duration is shown in Exhibit 7–16 and in Exhibit 7–18. As rates increase, the effective duration of the callable bond becomes larger. For example, the effective duration at very low yields (–250-bp shift) is 1.97 and increases to 4.47 at very high rates (+1,000 bps). This reflects the fact that as rates increase, the likelihood of the bond being called decreases, and as a result, the bond behaves more like an option-free bond; hence its effective duration increases. Conversely, as rates drop, this likelihood increases, and the bond and its effective duration behave more like a bond with a two-year maturity because of the call option becoming effective in two years. As rates decrease significantly, the likelihood of the issuer calling the bond in two years increases. Consequently, at very low and intermediate rates, the difference between the effective duration measure and modified duration is large, and at very high rates, the difference is small.

EXHIBIT 7–18

Price /Yield Relationship of the Callable Bond

Effective convexity measures the curvature of the price/yield relationship of bonds. Low values for effective convexity simply mean that the relationship is becoming linear (an effective convexity of zero represents a linear relationship). As shown in Exhibit 7–16, the effective convexity values of the callable bond at extremely low interest rates (i.e., for the –250-bp shift in the term structure) are very small positive numbers 4.88. This means that the relationship is almost linear but exhibits slight convexity. This is due to the call option being delayed by two years. At these extremely low interest rates, the callable bond exhibits slight positive convexity because the price compression at the call price is not complete for another two years.[10] If this bond were immediately callable, the price/yield relationship would exhibit positive convexity at high-yields and negative convexity at low yields. At the current level of interest rates, the effective convexity is negative, as expected. At these rate levels, the embedded call option causes enough price compression to cause the curvature of the price/yield relationship to be negatively convex (i.e., concave). Exhibit 7–18 illustrates these properties. It is at these levels that the embedded option has a significant effect on the cash-flows of the callable bond.

Exhibit 7–16 shows that for large positive yield-curve shifts (i.e., for the +250-bp, +500-bp, and +1,000-bp shifts in the term structure), the effective convexity of the callable bond becomes positive and very close to the effective convexity values of the straight bond. For example, the effective convexity at the +250-bp shift is 24.28 for the callable bond and 24.10 for the straight bond. The only reason they are not the same is because the coupon rates of the bonds are not equal. Consequently, at very low and intermediate rates, the difference between effective convexity and standard convexity is large, and at very high rates, the difference is small. The intuition behind these findings is straightforward. At low rates, the cash-flows of the callable bond are severely affected by the likelihood of the embedded call option being exercised by the issuer. At high rates, the embedded call option is so far out-of-the-money that it has almost no effect on the cash-flows of the callable bond, and so the callable bond behaves like an option-free bond.

Putable Bond

The effective duration for the putable bond is found by recording the price changes from shifting the term structure up (V_+) and down (V_-) by 10 bps and then substituting these values into Eq. (7–1). The prices are shown in Exhibit 7–15. Note that these prices take into account the changing cash-flows resulting from the embedded put option. Consequently, the computation is

$$\text{Effective duration} = \frac{100.7706854 - 100.1343384}{2(100.4410453)(0.001)} = 3.17$$

10. As noted earlier in this chapter, price compression for a callable bond refers to the property that a callable bond's price appreciation potential is severely limited as yields decline. As shown in Exhibit 7–18, as yields fall below a certain level (i.e., where the yield corresponds to the call price), the price appreciation of the callable bond is being compressed.

Similarly, the calculation for effective convexity is found by substituting the corresponding prices into Eq. (7–6):

$$\text{Effective convexity} = \frac{100.7706854 + 100.1343384 - 2(100.4410453)}{100.4410453(0.001)^2}$$
$$= 228.32$$

Because the putable bond behaves so differently from the other two bonds, the effective duration and effective convexity values are very different. As rates increase, the bond behaves more like a two-year bond because the owner will, in all likelihood, exercise his right to put the bond back at the put price as soon as possible. As a result, the effective duration of the putable bond is expected to decrease as rates increase. This is due to the embedded put option severely affecting the cash-flows of the putable bond. Conversely, as rates fall, the putable bond behaves more like a five-year straight bond because the embedded put option is so far out-of-the-money and has little effect on the cash-flows of the putable bond. Effective duration should reflect these properties. Exhibit 7–16 shows that this is indeed the case. For example, the effective duration at very low yields (–250-bp shift) is 4.72 and decreases to 1.86 at very high rates (+1,000 bps). Consequently, at very high and intermediate rates, the difference between the effective duration and modified duration measures is large, and at low rates, the difference is small.

Exhibit 7–16 shows that the effective convexity of the putable bond is positive for all rate shifts, as would be expected, but it becomes smaller as rates increase (i.e., for the +250-bp, +500-bp, and +1,000-bp shifts in the term structure). As rates increase, the putable bond price/yield relationship will become linear because of the bond's price truncation at the put price.[11] This is the reason for the small effective convexity values for the putable bond for the three positive shifts in the term structure (4.62, 4.50, and 4.39, respectively). It is at these levels that the embedded put option has a significant effect on the cash-flows of the putable bond. Consequently, at very high and intermediate rates, the difference between the effective convexity and standard convexity is very large. Exhibit 7–19 illustrates these properties.

At very low rates (i.e., for the 250-bp downward shift in the term structure), the putable bond behaves like a five-year straight bond because the put option is so far out-of-the-money. Therefore, as the term structure is shifted downward, the putable bond's effective convexity values approach those of a comparable five-year option-free bond. Comparing the effective convexity measures for the putable bond and the option-free bond illustrates this characteristic. For example, the effective convexity at the –250-bp shift is 25.43 for the putable bond and 25.59 for the option-free bond. The two convexity measures are almost identical. In fact, they would be identical if their coupon rates were equal.

11. *Price truncation* for a putable bond refers to the property that the putable bond's price depreciation potential is severely limited as yields increase. As shown in Exhibit 7–19, as yields rise above a certain level (i.e., where the yield corresponds to the put price), the price depreciation of the putable bond is truncated.

EXHIBIT 7–19

Price/Yield Relationship of the Putable Bond

Exhibit 7–19 illustrates these properties. Also notice how the transition from low yields to high-yields forces the price/yield relationship to have a very high convexity at intermediate levels of yields. For example, the current effective convexity of the putable bond is 228.32 compared with 24.84 for the straight bond and 47.46 for the callable bond. This is so because as yields increase, the embedded put option moves from out-of-the-money to in, and the behavior of the bond goes from that of a five-year bond to a two-year bond as a result. This corresponding price truncation causes the price/yield relationship to have to transition very quickly from the five-year (high effective duration) to the two-year (low effective duration), resulting in very high effective convexity.

Putting It All Together

Notice in Exhibit 7–16 how effective duration changes much more across yields for the callable and putable bonds than it does for the option-free bond. This is to be expected because the embedded options have such a significant influence over cash-flows as yields change over a wide spectrum. Interestingly, at high (low) yields, the callable (putable) bond's effective duration is very close to the option-free bond. This is where the embedded call (put) option is so far out-of-the-money that the two securities behave similarly. The same intuition holds for the effective convexity measures.

As explained and illustrated earlier, the common use of effective duration and effective convexity is to estimate the percentage price changes in fixed income securities for assumed changes in yield. In fact, it is not uncommon for effective duration and effective convexity to be presented in terms of estimated percentage price change for a given change in yield (typically 100 bp). Exhibits 7–20 and 7–21 show this alternative presentation for a ±100-bp change in yield using Eqs. (7–2) and (7–7).

EXHIBIT 7–20

Using Effective Duration and Effective Convexity to Illustrate the impact of 100 bps Increase in Yield Across Different Term Structure Levels

	Option-Free Bond			*Callable Bond*			*Putable Bond*		
Starting Term Structure Level Relative to Current Term Structure (bps)	**% Price Change Using Effective Duration**	**% Price Change Using Effective Convexity**	**Total % Price Change**	**% Price Change Using Effective Duration**	**% Price Change Using Effective Convexity**	**Total % Price Change**	**% Price Change Using Effective Duration**	**% Price Change Using Effective Convexity**	**Total % Price Change**
–250	–4.74	0.1280	–4.6143	–1.97	0.0244	–1.9408	–4.72	0.1271	–4.5930
0	–4.67	0.1242	–4.5409	–4.50	–0.2373	–4.7380	–3.17	1.1416	–2.0261
250	–4.59	0.1205	–4.4681	–4.61	0.1214	–4.4924	–1.91	0.0231	–1.8854
500	–4.51	0.1169	–4.3958	–4.54	0.1179	–4.4214	–1.88	0.0225	–1.8619
1,000	–4.44	0.1135	–4.3239	–4.47	0.1144	–4.3508	–1.86	0.0220	–1.8389

EXHIBIT 7–21

Using Effective Duration and Effective Convexity to Illustrate the Impact of 100 bps Decline in Yield Across Different Term Structure Levels

	Option-Free Bond			*Callable Bond*			*Putable Bond*		
Starting Term Structure Level Relative to Current Term Structure (bps)	**% Price Change Using Effective Duration**	**% Price Change Using Effective Convexity**	**Total % Price Change**	**% Price Change Using Effective Duration**	**% Price Change Using Effective Convexity**	**Total % Price Change**	**% Price Change Using Effective Duration**	**% Price Change Using Effective Convexity**	**Total % Price Change**
–250	4.74	0.1280	4.8702	1.97	0.0244	1.9896	4.72	0.1271	4.8473
0	4.67	0.1242	4.7893	4.50	–0.2373	4.2634	3.17	1.1416	4.3094
250	4.59	0.1205	4.7091	4.61	0.1214	4.7352	1.91	0.0231	1.9315
500	4.51	0.1169	4.6297	4.54	0.1179	4.6571	1.88	0.0225	1.9069
1,000	4.44	0.1135	4.5508	4.47	0.1144	4.5797	1.86	0.0220	1.8828

PRICE VALUE OF A BASIS POINT

Some managers use another measure of the price volatility of a bond to quantify interest-rate risk—*the price value of a basis point* (PVBP). This measure, also called the *dollar value of an 01* (DV01), is the absolute value of the change in the price of a bond for a 1 basis point change in yield. That is,

$$\text{PVBP} = \left| \text{initial price} - \text{price if yield is changed by 1 basis point} \right|$$

Does it make a difference if the yield is increased or decreased by 1 basis point? It does not because of Property 2—the change will be about the same for a small change in basis points.

To illustrate the computation, we use the values in Exhibit 7–4. If the initial yield is 4%, we can compute the PVBP by using the prices for either the yield at 3.99% or 4.01%. The PVPB for both for each bond is shown below:

Coupon	**4.0%**	**4.0%**	**5.0%**	**5.0%**
Maturity	**5**	**20**	**5**	**20**
Initial price	$100.0000	$100.0000	$104.4913	$113.6777
Price at 3.99%	100.0449	100.1369	104.5374	113.8266
PVBP at 3.99%	$0.0449	$0.1369	$0.0461	$0.1489
Price at 4.01%	99.9551	99.8633	104.4452	113.5291
PVPB at 4.01%	$0.0449	$0.1367	$0.0461	$0.1486

The PVBP is related to duration. In fact, PVBP is simply a special case of dollar duration. We know that the duration of a bond is the approximate percentage price change for a 100 basis point change in interest rates. We also know how to compute the approximate percentage price change for any number of basis points given a bond's duration using Eq. (7–2). Given the initial price and the approximate percentage price change for 1 basis point, we can compute the change in price for a 1 basis point change in rates.

For example, consider the 5% 20-year bond. The duration for this bond is 13.09. Using Eq. (7–2), the approximate percentage price change for a 1 basis point increase in interest rates (i.e., $\Delta y = 0.0001$) ignoring the negative sign in Eq. (7–2) is

$$13.09 \times (0.0001) \times 100 = 0.1309\%$$

Given the initial price of 113.6777, the dollar price change estimated using duration is

$$0.1309\% \times 113.6777 = \$0.1488$$

This is the same price change as shown above for a PVPB for this bond. Below is (1) the PVPB based on a 1 basis point increase for each bond and (2) the estimated price change using duration for a 1 basis point increase for each bond:

Coupon	4.0%	4.0%	5.0%	5.0%
Maturity	**5**	**20**	**5**	**20**
PVBP for 1 bp increase	$0.0449	$0.1367	$0.0461	$0.1486
Duration of bond	4.4913	13.6777	4.4107	13.0871
Duration estimate	$0.0449	$0.1368	$0.0461	$0.01488

THE IMPORTANCE OF YIELD VOLATILITY

What we have not considered thus far is the volatility of interest rates. All other factors equal, the higher the coupon rate, the lower is the price volatility of a bond to changes in interest rates. In addition, the higher the level of yields, the lower is the price volatility of a bond to changes in interest rates. This is illustrated in Exhibit 7–22, which shows the price/yield relationship for an option-free bond. When the yield level is high (Y_H in the exhibit), a change in interest rates does not produce a large change in the initial price (P_H in the exhibit). However, when the yield level is low (Y_L in the exhibit), a change in interest rates of the same number of basis points as shown when the yield is high does produce a large change in the initial price (P_L in the exhibit).

This also can be cast in terms of duration properties: the higher the coupon, the lower is the duration, and the higher the yield level, the lower is the duration. Given these two properties, a 10-year non-investment-grade bond has a lower

EXHIBIT 7–22

The Effect of Yield Level on Price Volatility

$$(Y_H' - Y_H) = (Y_H - Y_H'') = (Y_L' - Y_L) = (Y_L - Y_L'')$$
$$(P_H - P_H') < (P_L - P_L') \text{ and}$$
$$(P_H - P_H'') < (P_L - P_L'')$$

duration than a current coupon 10-year Treasury note because the former has a higher coupon rate and trades at a higher yield level. Does this mean that a 10-year non-investment-grade bond has less interest-rate risk than a current coupon 10-year Treasury note? Consider also that a 10-year Swiss government bond has a lower coupon rate than a current coupon 10-year U.S. Treasury note and trades at a lower yield level. Therefore, a 10-year Swiss government bond will have a higher duration than a current coupon 10-year Treasury note. Does this mean that a 10-year Swiss government bond has greater interest-rate risk than a current coupon 10-year U.S. Treasury note? The missing link is the relative volatility of rates, which we shall call *yield volatility* or *interest-rate volatility.*

The greater the expected yield volatility, the greater is the interest-rate risk for a given duration and current value of a position. In the case of non-investment-grade bonds, while their durations are less than current coupon Treasuries of the same maturity, the yield volatility of non-investment-grade bonds is greater than that of current coupon Treasuries. For the 10-year Swiss government bond, while the duration is greater than for a current coupon 10-year U.S. Treasury note, the yield volatility of 10-year Swiss bonds is considerably less than that of 10-year U.S. Treasury notes.

A framework that ties together the price sensitivity of a bond position to rate changes and yield volatility is the value-at-risk (VaR) framework. *Risk* in this framework is defined as the maximum estimated loss in market value of a given position that is expected to happen with a specified probability.

KEY POINTS

- The full-valuation approach to interest-rate risk management involves repricing bonds under different interest rate scenarios to quantify price sensitivity to interest-rate changes.
- Important bond price volatility properties for option-free bonds are (1) prices move inversely to yields, but percentage price changes are not the same for all bonds; (2) for small changes in yield, the percentage price change is roughly the same, whether yields increase or decrease; (3) for large changes in yield, the percentage price change is not the same for yield increases compared with yield decreases, and; (4) for a given large change in yield, the percentage price increase is greater than the percentage price decrease.
- Bond features affect interest-rate risk. For option-free bonds, a longer maturity leads to more interest-rate risk, a higher coupon rate leads to less interest-rate risk, and interest-rate risk is greater at lower yields. Additionally, embedded options affect interest-rate risk.
- An alternative to the full-valuation approach is the duration/convexity approach. Duration is the approximate percentage price change in a bond's value for a 100 basis point change in rates.

- Duration assumes the term structure is flat and all interest-rate changes result from parallel shifts.
- Convexity adjustments improve duration estimates, particularly for large interest-rate changes.
- Bonds with embedded options, such as the issuer's right to call the bond or an investor's right to put the bond, have cash-flows that change as interest rates change. Effective duration accounts for changes in the bond's cash-flow. For this purpose, a term structure model is required.
- Callable bonds exhibit negative convexity and price compression at low interest rates. Putable bonds exhibit price truncation at high-yields and high convexity at low yields.

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CHAPTER
EIGHT

THE STRUCTURE OF INTEREST RATES

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

There is no single interest rate for any economy; rather, there is an interdependent structure of interest rates. The interest rate that a borrower has to pay depends on a myriad of factors. In this chapter we describe these factors. We begin with a discussion of the *base interest rate:* the interest rate on U.S. government securities. Next, we explain the factors that affect the yield spread or risk premium for non-Treasury securities. Finally, we focus on one particular factor that affects the interest rate demanded in an economy for a particular security: maturity. The relationship between yield and maturity (or term) is called the *term structure of interest rates*, and this relationship is critical in the valuation of securities. Determinants of the *general* level of interest rates in the economy will not be discussed.

THE BASE INTEREST RATE

The securities issued by the U.S. Department of the Treasury are backed by the full faith and credit of the U.S. government. Despite the credit concerns arising from the U.S. budget deficit and the downgrading of the U.S. government credit rating from triple A to AA+ by the credit rating agency of Standard & Poor's in August 2011 (Moody's and Fitch still maintained a triple A rating), market participants throughout the world view U.S. government obligations as having minimal credit risk. Therefore, interest rates on Treasury securities are the benchmark interest rates throughout the U.S. economy. The large sizes of Treasury issues have contributed to making the Treasury market the most active and hence the most liquid market in the world.

The minimum interest rate or *base interest rate* that investors will demand for investing in a non-Treasury security is the yield offered on a comparable maturity for an on-the-run Treasury security. The base interest rate is also referred to as the *benchmark interest rate.*

RISK PREMIUM

Market participants describe interest rates on non-Treasury securities as trading at a spread to a particular on-the-run Treasury security. For example, if the yield on a 10-year non-Treasury security is 5% and the yield on a 10-year Treasury security is 4%, the spread is 100 basis points. This spread reflects the additional risks the investor faces by acquiring a security that is not issued by the U.S. government and therefore can be called a *risk premium.* Thus we can express the interest rate offered on a non-Treasury security as

Base interest rate + spread

or equivalently,

Base interest rate + risk premium

The factors that affect the spread include (1) the type of issuer, (2) the issuer's perceived creditworthiness, (3) the term or maturity of the instrument, (4) provisions that grant either the issuer or the investor the option to do something, (5) the taxability of the interest received by investors, and (6) the expected liquidity of the issue.

Types of Issuers

A key feature of a debt obligation is the nature of the issuer. In addition to the U.S. government, there are agencies of the U.S. government, municipal governments, corporations (domestic and foreign), and foreign governments that issue bonds.

The bond market is classified by the type of issuer. These are referred to as *market sectors.* The spread between the interest rate offered in two sectors of the bond market with the same maturity is referred to as an *intermarket-sector spread.*

Excluding the Treasury market sector, other market sectors have a wide range of issuers, each with different abilities to satisfy bond obligations. For example, within the corporate market sector, issuers are classified as utilities, transportations, industrials, and banks and finance companies. The spread between two issues within a market sector is called an *intramarket-sector spread.*

Perceived Creditworthiness of Issuer

Default risk or *credit risk* refers to the risk that the issuer of a bond may be unable to make timely payment of principal or interest payments. Most market participants rely primarily on commercial rating companies (Fitch Ratings, Moody's Investors Service, and Standard & Poor's) to assess the default risk of an issuer. The spread between Treasury securities and non-Treasury securities that are identical in all respects except for quality is referred to as a *credit spread* or *quality spread.*

Term-to-Maturity

As we explained in Chapter 6, the price of a bond will fluctuate over its life as yields in the market change. As demonstrated in Chapter 7, the volatility of a bond's price is dependent on its maturity. With all other factors constant, the longer the maturity of a bond, the greater is the price volatility resulting from a change in market yields.

The spread between any two maturity sectors of the market is called a *yield-curve spread* or *maturity spread.* The relationship between the yields on comparable securities with different maturities, as mentioned earlier, is called the *term structure of interest rates.*

The term-to-maturity topic is very important, and we have devoted more time to this topic later in this chapter.

Inclusion of Options

It is not uncommon for a bond issue to include a provision that gives the bondholder or the issuer an option to take some action against the other party. An option that is included in a bond issue is referred to as an *embedded option.* We discussed the various types of embedded options in Chapter 1. The most common type of option in a bond issue is the call provision, which grants the issuer the right to retire the debt, fully or partially, before the scheduled maturity date. The inclusion of a call feature benefits issuers by allowing them to replace an old bond issue with a lower-interest-cost issue when interest rates in the market decline. In effect, a call provision allows the issuer to alter the maturity of a bond. The exercise of a call provision is disadvantageous to the bondholder because the bondholder must reinvest the proceeds received at a lower interest rate.

The presence of an embedded option affects both the spread of an issue relative to a Treasury security and the spread relative to otherwise comparable issues that do not have an embedded option. In general, market participants will require a larger spread to a comparable Treasury security for an issue with an embedded option that is favorable to the issuer (such as a call option) than for an issue without such an option. In contrast, market participants will require a smaller spread to a comparable Treasury security for an issue with an embedded option that is favorable to the investor (such as a put option or a conversion option). In fact, the interest rate on a bond with an option that is favorable to an investor may be less than that on a comparable Treasury security.

Taxability of Interest

Unless exempted under the federal income tax code, interest income is taxable at the federal level. In addition to federal income taxes, there may be state and local taxes on interest income.

The federal tax code specifically exempts the interest income from qualified municipal bond issues. Because of this tax exemption, the yield on municipal bonds

is less than on Treasuries with the same maturity. The difference in yield between tax-exempt securities and Treasury securities is typically measured not in basis points but in percentage terms. More specifically, it is measured as the percentage of the yield on a tax-exempt security relative to a comparable Treasury security.

The yield on a taxable bond issue after federal income taxes are paid is equal to

$$\text{After-tax yield} = \text{pretax yield} \times (1 - \text{marginal tax rate})$$

For example, suppose that a taxable bond issue offers a yield of 4% and is acquired by an investor facing a marginal tax rate of 35%. The after-tax yield would be

$$\text{After-tax yield} = 0.04 \times (1 - 0.35) = 0.026 = 2.60\%$$

Alternatively, we can determine the yield that must be offered on a taxable bond issue to give the same after-tax yield as a tax-exempt issue. This yield is called the *equivalent taxable yield* and is determined as follows:

$$\text{Equivalent taxable yield} = \frac{\text{tax-exempt yield}}{(1 - \text{marginal tax rate})}$$

For example, consider an investor facing a 35% marginal tax rate who purchases a tax-exempt issue with a yield of 2.6%. The equivalent taxable yield is then

$$\text{Equivalent taxable yield} = \frac{0.026}{(1 - 0.35)} = 0.04 = 4\%$$

Notice that the lower the marginal tax rate, the lower is the equivalent taxable yield. For example, in our previous example, if the marginal tax rate is 25% rather than 35%, the equivalent taxable yield would be 3.47% rather than 4%, as shown below.

$$\text{Equivalent taxable yield} = \frac{0.026}{(1 - 0.25)} = 0.0347 = 3.47\%$$

State and local governments may tax interest income on bond issues that are exempt from federal income taxes. Some municipalities exempt interest income from all municipal issues from taxation; others do not. Some states exempt interest income from bonds issued by municipalities within the state but tax the interest income from bonds issued by municipalities outside the state. The implication is that two municipal securities of the same quality rating and the same maturity may trade at some spread because of the relative demand for bonds of municipalities in different states. For example, in a high-income-tax state such as New York, the demand for bonds of municipalities will drive down their yield relative to municipalities in a low-income-tax state such as Florida, holding all credit issues aside.

Municipalities are not permitted to tax the interest income from securities issued by the U.S. Treasury. Thus part of the spread between Treasury securities and taxable non-Treasury securities of the same maturity reflects the value of the exemption from state and local taxes.

Expected Liquidity of an Issue

Bonds trade with different degrees of liquidity. The greater the expected liquidity at which an issue will trade, the lower is the yield that investors require. As noted earlier, Treasury securities are the most liquid securities in the world. The lower yield offered on Treasury securities relative to non-Treasury securities reflects the difference in liquidity as well as perceived credit risk. Even within the Treasury market, on-the-run issues have greater liquidity than off-the-run issues.

THE TERM STRUCTURE OF INTEREST RATES

In future chapters we will see the key role that the term structure of interest rates plays in the valuation of bonds. For this reason, we devote a good deal of space to this important topic.

The Yield Curve

The graphic depiction of the relationship between the yield on bonds of the same credit quality but different maturities is known as the *yield curve.* In the past, most market participants have constructed yield curves from the observations of prices and yields in the Treasury market. Two reasons account for this tendency. First, Treasury securities are free of default risk, and differences in creditworthiness do not affect yield estimates. Second, as the most active bond market, the Treasury market offers the fewest problems of illiquidity or infrequent trading. Exhibit 8–1 shows the shape of three hypothetical Treasury yield curves that have been observed in the United States, as well as other countries.

From a practical viewpoint, as we explained earlier in this chapter, the key function of the Treasury yield curve is to serve as a benchmark for pricing bonds and setting yields in other sectors of the debt market. However, market participants are coming to realize that the traditionally constructed Treasury yield curve is an unsatisfactory measure of the relation between required yield and maturity. The key reason is that securities with the same maturity actually may carry different yields. As we will explain, this phenomenon reflects the impact of differences in the bonds' coupon rates. Hence it is necessary to develop more accurate and reliable estimates of the Treasury yield curve. We will show the problems posed by traditional approaches to the Treasury yield curve, and we will explain the proper approach to building a yield curve. The approach consists of identifying yields that apply to zero-coupon bonds and, therefore, eliminates the problem of nonuniqueness in the yield-maturity relationship.

Using the Yield Curve to Price a Bond

The price of a bond is the present value of its cash flows. However, in our discussion of the pricing of a bond in Chapter 6, we assumed that one interest rate should be used to discount all the bond's cash flows. The appropriate interest rate

EXHIBIT 8–1

Three Hypothetical Yield Curves

is the yield on a Treasury security with the same maturity as the bond plus an appropriate risk premium or spread.

However, there is a problem with using the Treasury yield curve to determine the appropriate yield at which to discount the cash flow of a bond. To illustrate this problem, consider two hypothetical five-year Treasury bonds, A and B. The difference between these two Treasury bonds is the coupon rate, which is 12% for A and 3% for B. The cash flow for these two bonds per $100 of par value for the 10 six-month periods to maturity would be as follows:

Period	Cash Flow for A	Cash Flow for B
1–9	$ 6.00	$ 1.50
10	106.00	101.50

Because of the different cash flow patterns, it is not appropriate to use the same interest rate to discount all cash flows. Instead, each cash flow should be discounted at a unique interest rate that is appropriate for the time period in which the cash flow will be received. But what should be the interest rate for each period?

The correct way to think about bonds A and B is not as bonds but as packages of cash flows. More specifically, they are packages of zero-coupon instruments. Thus the interest earned is the difference between the maturity value and the price paid. For example, bond A can be viewed as 10 zero-coupon instruments: One with a maturity value of $6 maturing six months from now, a second with a maturity value of $6 maturing one year from now, a third with a maturity value of $6 maturing 1.5 years from now, and so on. The final zero-coupon instrument matures 10 six-month periods from now and has a maturity value of $106. Likewise, bond B can be viewed as 10 zero-coupon instruments: One with a maturity value of $1.50 maturing six months from now, one with a maturity value of $1.50 maturing one year from now, one with a maturity value of $1.50 maturing 1.5 years from now, and so on. The final zero-coupon instrument matures 10 six-month periods from now and has a maturity value of $101.50. Obviously, in the case of each coupon bond, the value or price of the bond is equal to the total value of its component zero-coupon instruments.

In general, any bond can be viewed as a package of zero-coupon instruments. That is, each zero-coupon instrument in the package has a maturity equal to its coupon payment date or, in the case of the principal, the maturity date. The value of the bond should equal the value of all the component zero-coupon instruments. If this does not hold, a market participant may generate riskless profits by stripping the security and creating stripped securities.

To determine the value of each zero-coupon instrument, it is necessary to know the yield on a zero-coupon Treasury with that same maturity. This yield is called the *spot rate,* and the graphic depiction of the relationship between the spot rate and its maturity is called the *spot-rate curve.* Because there are no zero-coupon Treasury debt issues with a maturity greater than one year, it is not possible to construct such a curve solely from observations of Treasury yields. Rather, it is necessary to derive this curve from theoretical considerations as applied to the yields of actual Treasury securities. Such a curve is called a *theoretical spot-rate curve.*

Constructing the Theoretical Spot-Rate Curve

The theoretical spot-rate curve is constructed from the yield curve based on the observed yields of Treasury bills and Treasury coupon securities. The process of creating a theoretical spot-rate curve in this way is called *bootstrapping.*[1]

1. In practice, the securities used to construct the theoretical spot-rate curve are the most recently auctioned Treasury securities of a given maturity. Such issues are referred to as the *on-the-run Treasury issues.* As explained in Chapter 9, there are actual zero-coupon Treasury securities with a maturity greater than one year that are outstanding in the market. These securities are not issued by the U.S. Treasury but are created by market participants from actual coupon Treasury securities. It would seem logical that the observed yield on zero-coupon Treasury securities can be used to construct an actual spot-rate curve. However, there are problems with this approach. First, the liquidity of these securities is not as great as that of the coupon Treasury market. Second, there are maturity sectors of the zero-coupon Treasury market that attract specific investors who may be willing to trade yield in exchange for an attractive feature associated with that particular maturity sector, thereby distorting the term-structure relationship.

EXHIBIT 8–2

Maturity and Yield-to-Maturity for 20 Hypothetical Treasury Securities

Maturity	Coupon Rate	Yield-to-Maturity	Price
0.50 years	0.0000	0.0800	$ 96.15
1.00	0.0000	0.0830	92.19
1.50	0.0850	0.0890	99.45
2.00	0.0900	0.0920	99.64
2.50	0.1100	0.0940	103.49
3.00	0.0950	0.0970	99.49
3.50	0.1000	0.1000	100.00
4.00	0.1000	0.1040	98.72
4.50	0.1150	0.1060	103.16
5.00	0.0875	0.1080	92.24
5.50	0.1050	0.1090	98.38
6.00	0.1100	0.1120	99.14
6.50	0.0850	0.1140	86.94
7.00	0.0825	0.1160	84.24
7.50	0.1100	0.1180	96.09
8.00	0.0650	0.1190	72.62
8.50	0.0875	0.1200	82.97
9.00	0.1300	0.1220	104.30
9.50	0.1150	0.1240	95.06
10.00	0.1250	0.1250	100.00

To explain this process, we use the data for the hypothetical price, annualized yield (yield-to-maturity), and maturity of the 20 Treasury securities shown in Exhibit 8–2.

Throughout the analysis and illustrations to come, it is important to remember that the basic principle of bootstrapping is that the value of a Treasury coupon security should be equal to the value of the package of zero-coupon Treasury securities that duplicates the coupon bond's cash flow.

Consider the six-month Treasury bill in Exhibit 8–2. As explained in Chapter 9, a Treasury bill is a zero-coupon instrument. Therefore, its annualized yield of 8% is equal to the spot rate. Similarly, for the one-year Treasury bill, the cited yield of 8.3% is the one-year spot rate. Given these two spot rates, we can compute the spot rate for a theoretical 1.5-year zero-coupon Treasury. The price of a theoretical 1.5-year Treasury should equal the present value of three cash flows from an actual 1.5-year coupon Treasury, where the yield used for discounting is

the spot rate corresponding to the cash flow. Using \$100 as par, the cash flow for the 1.5-year coupon Treasury is as follows:

0.5 years	$0.085 \times \$100 \times 0.5$	=	\$4.25
1.0 years	$0.085 \times \$100 \times 0.5$	=	\$4.25
1.5 years	$0.085 \times \$100 \times 0.5 + 100$	=	\$104.25

The present value of the cash flow is then

$$\frac{4.25}{(1+z_1)^1} + \frac{4.25}{(1+z_2)^2} + \frac{104.25}{(1+z_3)^3}$$

where

z_1 = one-half the annualized six-month theoretical spot rate
z_2 = one-half the one-year theoretical spot rate
z_3 = one-half the 1.5-year theoretical spot rate

Because the six-month spot rate and one-year spot rate are 8.0% and 8.3%, respectively, we know that

$$z_1 = 0.04 \qquad \text{and} \qquad z_2 = 0.0415.$$

We can compute the present value of the 1.5-year coupon Treasury security as

$$\frac{4.25}{(1.0400)^1} + \frac{4.25}{(1.0415)^2} + \frac{104.25}{(1+z_3)^3}$$

Because the price of the 1.5-year coupon Treasury security (from Exhibit 8–2) is \$99.45, the following relationship must hold:

$$99.45 = \frac{4.25}{(1.0400)^1} + \frac{4.25}{(1.0415)^2} + \frac{104.25}{(1+z_3)^3}$$

We can solve for the theoretical 1.5-year spot rate as follows:

$$99.45 = 4.08654 + 3.91805 + \frac{104.25}{(1+z_3)^3}$$

$$91.44541 = \frac{104.25}{(1+z_3)^3}$$

$$(1+z_3)^3 = 1.140024$$

$$z_3 = 0.04465$$

Doubling this yield, we obtain the bond-equivalent yield of 0.0893, or 8.93%, which is the theoretical 1.5-year spot rate. This rate is the rate that the market would apply to a 1.5-year zero-coupon Treasury security, if such a security existed.

Given the theoretical 1.5-year spot rate, we can obtain the theoretical two-year spot rate. The cash flow for the two-year coupon Treasury in Exhibit 8–2 is

0.5 years	$0.090 \times \$100 \times 0.5$	=	\$4.50
1.0 years	$0.090 \times \$100 \times 0.5$	=	\$4.50
1.5 years	$0.090 \times \$100 \times 0.5$	=	\$4.50
2.0 years	$0.090 \times \$100 \times 0.5 + 100$	=	\$104.50

The present value of the cash flow is then

$$\frac{4.50}{(1+z_1)^1} + \frac{4.50}{(1+z_2)^2} + \frac{4.50}{(1+z_3)^3} + \frac{104.50}{(1+z_4)^4}$$

where

z_4 = one-half the two-year theoretical spot rate

Because the six-month spot rate, the one-year spot rate, and the 1.5-year spot rate are 8.0%, 8.3%, and 8.93%, respectively, then

$$z_1 = 0.04 \qquad z_2 = 0.0415 \qquad \text{and} \qquad z_3 = 0.04465$$

Therefore, the present value of the two-year coupon Treasury security is

$$\frac{4.50}{(1.0400)^1} + \frac{4.50}{(1.0415)^2} + \frac{4.50}{(1.04465)^3} + \frac{104.50}{(1+z_4)^4}$$

Because the price of the two-year coupon Treasury security is \$99.64, the following relationship must hold:

$$99.64 = \frac{4.50}{(1.0400)^1} + \frac{4.50}{(1.0415)^2} + \frac{4.50}{(1.04465)^3} + \frac{104.50}{(1+z_4)^4}$$

We can solve for the theoretical two-year spot rate as follows:

$$99.64 = 4.32692 + 4.14853 + 3.94730 + \frac{104.50}{(1+z_4)^4}$$

$$87.21725 = \frac{104.50}{(1+z_4)^4}$$

$$(1+z_4)^4 = 1.198158$$

$$z_4 = 0.046235$$

Doubling this yield, we obtain the theoretical two-year spot rate bond-equivalent yield of 9.247%.

One can follow this approach sequentially to derive the theoretical 2.5-year spot rate from the calculated values of z_1, z_2, z_3, and z_4 (the six-month, one-year, 1.5-year, and two-year rates) and the price and coupon of the bond with a maturity of 2.5 years. Further, one could derive theoretical spot rates for the remaining

EXHIBIT 8–3

Theoretical Spot Rates

Maturity	Yield-to-Maturity	Theoretical Spot Rate
0.50 years	0.0800	0.08000
1.00	0.0830	0.08300
1.50	0.0890	0.08930
2.00	0.0920	0.09247
2.50	0.0940	0.09468
3.00	0.0970	0.09787
3.50	0.1000	0.10129
4.00	0.1040	0.10592
4.50	0.1060	0.10850
5.00	0.1080	0.11021
5.50	0.1090	0.11175
6.00	0.1120	0.11584
6.50	0.1140	0.11744
7.00	0.1160	0.11991
7.50	0.1180	0.12405
8.00	0.1190	0.12278
8.50	0.1200	0.12546
9.00	0.1220	0.13152
9.50	0.1240	0.13377
10.00	0.1250	0.13623

15 half-yearly rates. The spot rates thus obtained are shown in Exhibit 8–3. They represent the term structure of interest rates for maturities up to 10 years at the particular time to which the bond price quotations refer.

Why Treasuries Must Be Priced Based on Spot Rates

Financial theory tells us that the theoretical price of a Treasury security should be equal to the present value of the cash flows, where each cash flow is discounted at the appropriate theoretical spot rate. What we did not do, however, is demonstrate the economic force that ensures that the actual market price of a Treasury security does not depart significantly from its theoretical price.

To demonstrate this, we will use the 20 hypothetical Treasury securities introduced in Exhibit 8–2. The longest-maturity bond given in that exhibit is the 10-year, 12.5% coupon bond selling at par with a yield-to-maturity of 12.5%. Suppose that a government dealer buys the issue at par and strips it, expecting to sell the zero-coupon Treasury securities at the yields-to-maturity indicated in Exhibit 8–3 for the corresponding maturity.

EXHIBIT 8–4

Illustration of Arbitrage Profit from Coupon Stripping

Maturity	Cash Flow	Present Value at 12.5%	Yield-to-Maturity	Present Value at Yield-to-Maturity
0.50 years	$ 6.25	$ 5.8824	0.0800	$6.0096
1.00	6.25	5.5363	0.0830	5.7618
1.50	6.25	5.2107	0.0890	5.4847
2.00	6.25	4.9042	0.0920	5.2210
2.50	6.25	4.6157	0.0940	4.9676
3.00	6.25	4.3442	0.0970	4.7040
3.50	6.25	4.0886	0.1000	4.4418
4.00	6.25	3.8481	0.1040	4.1663
4.50	6.25	3.6218	0.1060	3.9267
5.00	6.25	3.4087	0.1080	3.6938
5.50	6.25	3.2082	0.1090	3.4863
6.00	6.25	3.0195	0.1120	3.2502
6.50	6.25	2.8419	0.1140	3.0402
7.00	6.25	2.6747	0.1160	2.8384
7.50	6.25	2.5174	0.1180	2.6451
8.00	6.25	2.3693	0.1190	2.4789
8.50	6.25	2.2299	0.1200	2.3210
9.00	6.25	2.0987	0.1220	2.1528
9.50	6.25	1.9753	0.1240	1.9930
10.00	106.25	31.6046	0.1250	31.6046
Total		100.0000		$104.1880

Exhibit 8–4 shows the price that would be received for each zero-coupon Treasury security created. The price for each is the present value of the cash flow from the stripped Treasury discounted at the yield-to-maturity corresponding to the maturity of the security (from Exhibit 8–2). The total proceeds received from selling the zero-coupon Treasury securities created would be $104.1880 per $100 of par value of the original Treasury issue. This would result in an arbitrage profit of $4.1880 per $100 of the 10-year, 12.5% coupon Treasury security purchased.

To understand why the government dealer has the opportunity to realize this profit, look at the third column of Exhibit 8–4, which shows how much the government dealer paid for each cash flow by buying the entire package of cash flows (i.e., by buying the bond). For example, consider the $6.25 coupon payment in four years. By buying the 10-year Treasury bond priced to yield 12.5%, the dealer effectively pays a price based on 12.5% (6.25% semiannually) for that coupon payment or, equivalently, $3.8481. Under the assumptions of this illustration, however, investors were willing to accept a lower yield-to-maturity, 10.4% (5.2% semiannually), to

purchase a zero-coupon Treasury security with four years to maturity. Thus investors were willing to pay $4.1663. On this one coupon payment, the government dealer realizes a profit equal to the difference between $4.1663 and $3.8481 (or $0.3182). From all the cash flows, the total profit is $4.1880. In this instance, coupon stripping shows that the sum of the parts is greater than the whole.

Suppose that instead of the observed yield-to-maturity from Exhibit 8–2, the yields investors want are the same as the theoretical spot rates shown in Exhibit 8–3. If we use these spot rates to discount the cash flows, the total proceeds from the sale of the zero-coupon Treasury securities would be equal to $100, making coupon stripping uneconomic.

In our illustration of coupon stripping, the price of the Treasury security is less than its theoretical price. Suppose instead that the price of the Treasury security is greater than its theoretical price. In such cases, investors can purchase a package of zero-coupon Treasury securities such that the cash flow of the package of securities replicates the cash flow of the mispriced coupon Treasury security. By doing so, the investor will realize a yield higher than the yield on the coupon Treasury security. For example, suppose that the market price of the 10-year Treasury security we used in our illustration (Exhibit 8–4) is $106. By buying the 20 zero-coupon bonds shown in Exhibit 8–4 with a maturity value identical to the cash flow shown in the second column, the investor is effectively purchasing a 10-year Treasury coupon security at a cost of $104.1880 instead of $106.

The process of coupon stripping and reconstituting prevents the actual spot-rate curve observed on zero-coupon Treasuries from departing significantly from the theoretical spot-rate curve. As more stripping and reconstituting occurs, forces of demand and supply will cause rates to return to their theoretical spot-rate levels. This is what has happened in the Treasury market.

Forward Rates

Consider an investor who has a one-year investment horizon and is faced with the following two alternatives:

Alternative 1: Buy a one-year Treasury bill.

Alternative 2: Buy a six-month Treasury bill, and when it matures in six months, buy another six-month Treasury bill.

The investor will be indifferent between the two alternatives if they produce the same return over the one-year investment horizon. The investor knows the spot rate on the six-month Treasury bill and the one-year Treasury bill. However, she does not know what yield will be available on a six-month Treasury bill that will be purchased six months from now. The yield on a six-month Treasury bill six months from now is called a *forward rate.* Given the spot rates for the six-month Treasury bill and the one-year bill, we wish to determine the forward rate on a six-month Treasury bill that will make the investor indifferent between the two alternatives. That rate can be readily determined.

At this point, however, we need to digress briefly and recall several present-value and investment relationships. First, if you invested in a one-year Treasury bill, you would receive \$100 at the end of one year. The price of the one-year Treasury bill would be

$$\frac{100}{(1+z_2)^2}$$

where z_2 is one-half the bond-equivalent yield of the theoretical one-year spot rate.

Second, suppose that you purchased a six-month Treasury bill for \$$X$. At the end of six months, the value of this investment would be

$$X(1+z_1)$$

where z_1 is one-half the bond-equivalent yield of the theoretical six-month spot rate.

Let f represent one-half the forward rate (expressed as a bond-equivalent basis) on a six-month Treasury bill available six months from now. If the investor were to renew her investment by purchasing that bill at that time, then the future dollars available at the end of one year from the \$$X$ investment would be

$$X(1+z_1)(1+f)$$

Third, it is easy to use this formula to find out how many \$$X$ the investor must invest in order to get \$100 one year from now. This can be found as follows:

$$X(1+z_1)(1+f)=100$$

which gives us

$$X=\frac{100}{(1+z_1)(1+f)}$$

We are now prepared to return to the investor's choices and analyze what that situation says about forward rates. The investor will be indifferent between the two alternatives confronting her if she makes the same dollar investment and receives \$100 from both alternatives at the end of one year. That is, the investor will be indifferent if

$$\frac{100}{(1+z_2)^2}=\frac{100}{(1+z_1)(1+f)}$$

Solving for f, we get

$$f=\frac{(1+z_2)^2}{(1+z_1)^1}-1$$

Doubling f gives the bond-equivalent yield for the six-month forward rate six months from now.

We can illustrate the use of this formula with the theoretical spot rates shown in Exhibit 8–3. From that exhibit, we know that

$$\text{Six-month bill spot rate} = 0.080 \quad \text{so} \quad z_1 = 0.0400$$
$$\text{One-year bill spot rate} = 0.083 \quad \text{so} \quad z_2 = 0.0415$$

Substituting into the formula, we have

$$f = \frac{(1.0415)^2}{1.0400} - 1$$
$$= 0.043$$

Therefore, the forward rate on a six-month Treasury security, quoted on a bond-equivalent basis, is 8.6% (0.043 × 2). Let's confirm our results. The price of a one-year Treasury bill with a $100 maturity value is

$$\frac{100}{(1.0415)^2} = 92.19$$

If $92.19 is invested for six months at the six-month spot rate of 8%, the amount at the end of six months would be

$$92.19(1.0400) = 95.8776$$

If $95.8776 is reinvested for another six months in a six-month Treasury offering 4.3% for six months (8.6% annually), the amount at the end of one year would be

$$95.8776(1.043) = 100$$

Both alternatives will have the same $100 payoff if the six-month Treasury bill yield six months from now is 4.3% (8.6% on a bond-equivalent basis). This means that if an investor is guaranteed a 4.3% yield (8.6% bond-equivalent basis) on a six-month Treasury bill six months from now, she will be indifferent between the two alternatives.

We used the theoretical spot rates to compute the forward rate. The resulting forward rate is also called the *implied forward rate.*

We can take this sort of analysis much further. It is not necessary to limit ourselves to implied forward rates six months from now. The yield curve can be used to calculate the implied forward rate for any time in the future for any investment horizon. For example, the following can be calculated:

- The two-year implied forward rate five years from now
- The six-year implied forward rate two years from now
- The seven-year implied forward rate three years from now

Relationship between Spot Rates and Short-Term Forward Rates

Suppose that an investor purchases a five-year zero-coupon Treasury security for \$58.42 with a maturity value of \$100. He could instead buy a six-month Treasury bill and reinvest the proceeds every six months for five years. The number of dollars that will be realized depends on the six-month forward rates. Suppose that the investor actually can reinvest the proceeds maturing every six months at the implied six-month forward rates. Let's see how many dollars would accumulate at the end of five years. The implied six-month forward rates were calculated for the yield curve given in Exhibit 8–3. Letting f_t denote the six-month forward rate beginning t six-month periods from now, the semiannual implied forward rates using the spot rates shown in that exhibit are as follows:

$$f_1 = 0.043000 \quad f_2 = 0.050980 \quad f_3 = 0.051005 \quad f_4 = 0.051770$$
$$f_5 = 0.056945 \quad f_6 = 0.060965 \quad f_7 = 0.069310 \quad f_8 = 0.064625$$
$$f_9 = 0.062830$$

If he invests the \$58.48 at the six-month spot rate of 4% (8% on a bond-equivalent basis) and reinvests at the forward rates shown above, the number of dollars accumulated at the end of five years would be

$$\$58.48(1.04)(1.043)(1.05098)(1.051005)(1.05177)(1.056945)$$
$$\times (1.060965)(1.069310)(1.064625)(1.06283) = \$100$$

Therefore, we see that if the implied forward rates are realized, the \$58.48 investment will produce the same number of dollars as an investment in a five-year zero-coupon Treasury security at the five-year spot rate. From this illustration, we can see that the five-year spot rate is related to the current six-month spot rate and the implied six-month forward rates.

In general, the relationship between a t-period spot rate, the current six-month spot rate, and the implied six-month forward rates is as follows:

$$z_t = [(1+z_1)(1+f_1)(1+f_2)(1+f_3)\cdots(1+f_{t-1})]^{1/t} - 1$$

Why should an investor care about forward rates? There are actually very good reasons for doing so. Knowledge of the forward rates implied in the current long-term rate is relevant in formulating an investment policy. In addition, forward rates are key inputs into the valuation of bonds with embedded options.

For example, suppose that an investor wants to invest for one year (two six-month periods); the current six-month or short rate (z_1) is 7%, and the one-year (two-period) rate (z_2) is 6%. Using the formulas we have developed, the investor finds that by buying a two-period security, she is effectively making a forward contract to lend money six months from now at the rate of 5% for six months. If the investor believes that the second-period rate will turn out to be higher than 5%, it will be to her advantage to lend initially on a one-period contract and then

at the end of the first period to reinvest interest and principal in the one-period contract available for the second period.

Determinants of the Shape of the Term Structure

If we plot the term structure—the yield-to-maturity, or the spot rate, at successive maturities against maturity—what will it look like? Exhibit 8–1 shows three shapes that have appeared with some frequency over time. Panel *a* shows an upward-sloping yield curve; that is, yield rises steadily as maturity increases. This shape is commonly referred to as a *normal* or *upward-sloping yield curve.* Panel *b* shows a *downward-sloping* or *inverted yield curve,* where yields decline as maturity increases. Finally, panel *c* shows a *flat yield curve.*

Two major theories have evolved to account for these shapes: the *expectations theory* and the *market-segmentation theory*.

There are three forms of the expectations theory: the *pure expectations theory,* the *liquidity theory*, and the *preferred-habitat theory*. All share a hypothesis about the behavior of short-term forward rates and also assume that the forward rates in current long-term bonds are closely related to the market's expectations about future short-term rates. These three theories differ, however, on whether other factors also affect forward rates and how. The pure expectations theory postulates that no systematic factors other than expected future short-term rates affect forward rates; the liquidity theory and the preferred-habitat theory assert that there are other factors. Accordingly, the last two forms of the expectations theory are sometimes referred to as *biased expectations theories.*

The Pure Expectations Theory

According to the pure expectations theory, the forward rates exclusively represent expected future rates. Thus the entire term structure at a given time reflects the market's current expectations of future short-term rates. Under this view, a rising term structure, as shown in panel *a* of Exhibit 8–1, must indicate that the market expects short-term rates to rise throughout the relevant future. Similarly, a flat term structure reflects an expectation that future short-term rates will be mostly constant, and a falling term structure must reflect an expectation that future short-term rates will decline steadily.

We can illustrate this theory by considering how an expectation of a rising short-term future rate would affect the behavior of various market participants to result in a rising yield curve. Assume an initially flat term structure, and suppose that economic news leads market participants to expect interest rates to rise.

- Market participants interested in a long-term investment would not want to buy long-term bonds because they would expect the yield structure to rise sooner or later, resulting in a price decline for the bonds and a capital loss on the long-term bonds purchased. Instead, they would want to invest in short-term debt obligations until the rise in yield had occurred, permitting them to reinvest their funds at the higher yield.

- Speculators expecting rising rates would anticipate a decline in the price of long-term bonds and therefore would want to sell any long-term bonds they own and possibly to "short sell" some they do not now own. (Should interest rates rise as expected, the price of longer-term bonds will fall. Because the speculator sold these bonds short and can then purchase them at a lower price to cover the short sale, a profit will be earned.) The proceeds received from the selling of long-term debt issues or the shorting of longer-term bonds will be invested in short-term debt obligations.
- Borrowers wishing to acquire long-term funds would be pulled toward borrowing now, in the long end of the market, by the expectation that borrowing at a later time would be more expensive.

All these responses would tend either to lower the net demand for or to increase the supply of long-maturity bonds, and two responses would increase demand for short-term debt obligations. This would require a rise in long-term yields in relation to short-term yields; that is, these actions by investors, speculators, and borrowers would tilt the term structure upward until it is consistent with expectations of higher future interest rates. By analogous reasoning, an unexpected event leading to the expectation of lower future rates will result in a downward-sloping yield curve.

Unfortunately, the pure expectations theory suffers from one serious shortcoming. It does not account for the risks inherent in investing in bonds and like instruments. If forward rates were perfect predictors of future interest rates, then the future prices of bonds would be known with certainty. The return over any investment period would be certain and independent of the maturity of the instrument initially acquired and of the time at which the investor needed to liquidate the instrument. However, with uncertainty about future interest rates and hence about future prices of bonds, these instruments become risky investments in the sense that the return over some investment horizon is unknown.

There are two risks that cause uncertainty about the return over some investment horizon. The first is the uncertainty about the price of the bond at the end of the investment horizon. For example, an investor who plans to invest for five years might consider the following three investment alternatives: (1) invest in a 5-year bond and hold it for five years, (2) invest in a 12-year bond and sell it at the end of five years, and (3) invest in a 30-year bond and sell it at the end of five years. The return that will be realized for the second and third alternatives is not known because the price of each long-term bond at the end of five years is not known. In the case of the 12-year bond, the price will depend on the yield on 7-year debt securities five years from now, and the price of the 30-year bond will depend on the yield on 25-year bonds five years from now. Because forward rates implied in the current term structure for a future 7-year bond and a future 25-year bond are not perfect predictors of the actual future rates, there is uncertainty about the price for both bonds five years from now. Thus there is *price risk:* The risk that the price of the bond will be lower than currently expected at the end of the

investment horizon. As explained in Chapter 7, an important feature of price risk is that it increases as the maturity of the bond increases.

The second risk involves the uncertainty about the rate at which the proceeds from a bond that matures during the investment horizon can be reinvested and is known as *reinvestment risk*. For example, an investor who plans to invest for five years might consider the following three alternative investments: (1) invest in a five-year bond and hold it for five years, (2) invest in a six-month instrument and, when it matures, reinvest the proceeds in six-month instruments over the entire five-year investment horizon, and (3) invest in a two-year bond and, when it matures, reinvest the proceeds in a three-year bond. The risk in the second and third alternatives is that the return over the five-year investment horizon is unknown because rates at which the proceeds can be reinvested are unknown.

Several interpretations of the pure expectations theory have been put forth by economists. These interpretations are not exact equivalents, nor are they consistent with each other, in large part because they offer different treatments of price risk and reinvestment risk.[2]

The broadest interpretation of the pure expectations theory suggests that investors expect the return for any investment horizon to be the same, regardless of the maturity strategy selected.[3] For example, consider an investor who has a five-year investment horizon. According to this theory, it makes no difference if a 5-year, 12-year, or 30-year bond is purchased and held for five years because the investor expects the return from all three bonds to be the same over five years. A major criticism of this very broad interpretation of the theory is that because of price risk associated with investing in bonds with a maturity greater than the investment horizon, the expected returns from these three very different bond investments should differ in significant ways.[4]

A second interpretation, referred to as the *local-expectations* form of the pure expectations theory, suggests that the return will be the same over a short-term investment horizon starting today. For example, if an investor has a six-month investment horizon, buying a 5-year, 10-year, or 20-year bond will produce the same six-month return. It has been demonstrated that the local expectations formulation, which is narrow in scope, is the only interpretation of the pure expectations theory that can be sustained in equilibrium.[5]

The third interpretation of the pure expectations theory suggests that the return an investor will realize by rolling over short-term bonds to some investment horizon will be the same as holding a zero-coupon bond with a maturity that is the same as that investment horizon. (A zero-coupon bond has no reinvestment risk, so future interest rates over the investment horizon do not affect the return.)

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2. These formulations are summarized by John Cox, Jonathan Ingersoll, Jr., and Stephen Ross, "A Re-Examination of Traditional Hypotheses about the Term Structure of Interest Rates," *Journal of Finance* (September 1981), pp. 769–799.
3. F Lutz, "The Structure of Interest Rates," *Quarterly Journal of Economics* (1940–41), pp. 36–63.
4. Cox, Ingersoll, and Ross, *op. cit.*, pp. 774–775.
5. Cox, Ingersoll, and Ross, *op. cit.*, p. 788.

This variant is called the *return-to-maturity expectations* interpretation. For example, let's once again assume that an investor has a five-year investment horizon. If he buys a five-year zero-coupon bond and holds it to maturity, his return is the difference between the maturity value and the price of the bond, all divided by the price of the bond. According to the return-to-maturity expectations, the same return will be realized by buying a six-month instrument and rolling it over for five years. At this time, the validity of this interpretation is subject to considerable doubt.

The Liquidity Theory

We have explained that the drawback of the pure expectations theory is that it does not account for the risks associated with investing in bonds. Nonetheless, we have just shown that there is indeed risk in holding a long-term bond for one period, and that risk increases with the bond's maturity because maturity and price volatility are directly related.

Given this uncertainty, and the reasonable consideration that investors typically do not like uncertainty, some economists and financial analysts have suggested a different theory. This theory states that investors will hold longer-term maturities if they are offered a long-term rate higher than the average of expected future rates by a risk premium that is positively related to the term to maturity.[6] Put differently, the forward rates should reflect both interest-rate expectations and a liquidity premium (which is really a risk premium), and the premium should be higher for longer maturities.

According to this theory, which is called the *liquidity theory of the term structure,* the implied forward rates will not be an unbiased estimate of the market's expectations of future interest rates because they include a liquidity premium. Thus an upward-sloping yield curve may reflect expectations that future interest rates either will rise or will be flat (or even fall) but with a liquidity premium increasing fast enough with maturity so as to produce an upward-sloping yield curve.

The Preferred-Habitat Theory

Another theory, known as the *preferred-habitat theory,* also adopts the view that the term structure reflects the expectation of the future path of interest rates as well as a risk premium. However, the preferred-habitat theory rejects the assertion that the risk premium must rise uniformly with maturity.[7] Proponents of the preferred-habitat theory say that the latter conclusion could be accepted if all investors intend to liquidate their investment at the shortest possible date and all borrowers are anxious to borrow long. This assumption can be rejected because institutions have holding periods dictated by the nature of their liabilities.

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6. John R. Hicks, *Value and Capital*, 2d ed. (London: Oxford University Press, 1946), pp. 141–145.
7. Franco Modigliani and Richard Sutch, "Innovations in Interest Rate Policy," *American Economic Review* (May 1966), pp. 178–197.

The preferred-habitat theory asserts that, to the extent that the demand and supply of funds in a given maturity range do not match, some lenders and borrowers will be induced to shift to maturities showing the opposite imbalances. However, they will need to be compensated by an appropriate risk premium that reflects the extent of aversion to either price or reinvestment risk.

Thus this theory proposes that the shape of the yield curve is determined by both expectations of future interest rates and a risk premium, positive or negative, to induce market participants to shift out of their preferred habitat. Clearly, according to this theory, yield curves sloping up, down, flat, or humped are all possible.

Market-Segmentation Theory

The *market-segmentation theory* recognizes that investors have preferred habitats dictated by the nature of their liabilities. This theory also proposes that the major reason for the shape of the yield curve lies in asset/liability management constraints (either regulatory or self-imposed) and creditors (borrowers) restricting their lending (financing) to specific maturity sectors.[8] However, the market-segmentation theory differs from the preferred-habitat theory in that it assumes that neither investors nor borrowers are willing to shift from one maturity sector to another to take advantage of opportunities arising from differences between expectations and forward rates. Thus, for the segmentation theory, the shape of the yield curve is determined by supply of and demand for securities within each maturity sector.

KEY POINTS

- In all economies, there is not just one interest rate but a structure of interest rates. The yield spread is the difference between the yields on any two bonds.
- The base interest rate is the yield on a Treasury security.
- The yield spread between a non-Treasury security and a comparable on-the-run Treasury security is called a risk premium. The factors that affect the spread include (1) the type of issuer (e.g., agency, corporate, municipality), (2) the issuer's perceived creditworthiness as measured by the rating system of commercial rating companies, (3) the term or maturity of the instrument, (4) the embedded options in a bond issue (e.g., call, put, or conversion provisions), (5) the taxability of interest income at the federal and municipal levels, and (6) the expected liquidity of the issue.
- The relationship between yield and maturity is referred to as the term structure of interest rates. The graphic depiction of the relationship between the yield on bonds of the same credit quality but different maturities is known as the yield curve.

8. This theory was suggested in J. M. Culbertson, "The Term Structure of Interest Rates," *Quarterly Journal of Economics* (November 1957), pp. 489–504.

- Because the yield on Treasury securities is the base rate from which a nongovernment bond's yield often is benchmarked, the most commonly constructed yield curve is the Treasury yield curve.
- There is a problem with using the Treasury yield curve to determine the one yield at which to discount all the cash payments of any bond. Each cash flow should be discounted at a unique interest rate that is applicable to the time period in which the cash flow is to be received. Because any bond can be viewed as a package of zero-coupon instruments, its value should equal the value of all the component zero-coupon instruments. The zero-coupon rate is also known as the spot rate.
- The theoretical spot-rate curve for Treasury securities can be estimated from the Treasury yield curve using a bootstrapping method.
- Under certain assumptions, the market's expectation of future interest rates can be extrapolated from the theoretical Treasury spot-rate curve. The resulting forward rate is called the implied forward rate.
- Several theories have been proposed about the determinants of the term structure: the pure expectations theory, the biased expectations theories (the liquidity theory and the preferred-habitat theory), and the market-segmentation theory.
- All the expectation theories hypothesize that the one-period forward rates represent the market's expectations of future rates. The pure expectations theory asserts that these rates constitute the only factor. The biased expectations theories assert that there are other factors that determine the term structure.

PART

TWO

GOVERNMENT SECURITIES AND CORPORATE DEBT OBLIGATIONS

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CHAPTER
NINE

U.S. TREASURY SECURITIES

MICHAEL J. FLEMING
Vice President
Federal Reserve Bank of New York

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

U.S. Treasury securities are direct obligations of the U.S. government issued by the Department of the Treasury. They are backed by the full faith and credit of the U.S. government and are therefore considered to be free of credit risk. Issuance to pay off maturing debt and raise needed funds has created a stock of marketable Treasury securities that totaled $8.9 trillion on December 31, 2010.[1] The creditworthiness and supply of the securities has resulted in a highly liquid round-the-clock secondary market with high levels of trading activity and narrow bid/ask spreads.

Because of their liquidity, Treasury securities are commonly used to price and hedge positions in other fixed income securities and to speculate on the course of interest rates. The securities' creditworthiness and liquidity also makes them a widespread benchmark for risk-free rates. These same attributes make Treasury securities a key reserve asset of central banks and other financial institutions. Moreover, exemption of interest income from state and local taxes helps make the securities a popular investment asset to institutions and individuals.

As of June 30, 2010, foreign and international investors held 46% of the publicly held Treasury debt.[2] Federal Reserve Banks held an additional 9% of the debt. The remaining public debt was held by pension funds (8%), mutual funds (7%),

1. The stock of nonmarketable Treasury securities on the same date totaled $5.2 trillion. Of this, $4.6 trillion was nonpublic debt (held in government accounts), $0.2 trillion was held by private investors in the form of U.S. savings bonds, and $0.2 trillion was held in a special series by state and local governments (Monthly Statement of the Public Debt, www.treasurydirect.gov/govt/reports/pd/mspd/mspd.htm).
2. The publicly held debt includes marketable and nonmarketable securities held in non-government accounts. Figures are calculated from Table OFS-2 of the *Treasury Bulletin* and the Federal Reserve's H.4.1 statistical release.

state and local treasuries (6%), depository institutions (3%), insurance companies (3%), and other miscellaneous investors, including individuals (17%).

In this chapter, we discuss U.S. Treasury securities. Our focus is on marketable Treasury securities.

TYPES OF SECURITIES

Treasury securities are issued as either *discount* or *coupon securities*. Discount securities pay a fixed amount at maturity, called *face value* or *par value*, with no intervening interest payments. Discount securities are so called because they are issued at a price below face value with the return to the investor being the difference between the face value and the issue price. Coupon securities are issued with a stated rate of interest, pay interest every six months, and are redeemed at par value (or *principal value*) at maturity. Coupon securities are issued at a price close to par value with the return to the investor being primarily the coupon payments received over the security's life.

The Treasury issues securities with original maturities of one year or less as discount securities. These securities are called *Treasury bills*. The Treasury currently issues bills with original maturities of 4 weeks (1 month), 13 weeks (3 months), 26 weeks (6 months), and 52 weeks (1 year) as well as cash-management bills with various maturities. On December 31, 2010, Treasury bills accounted for $1.8 trillion (20%) of the $8.9 trillion in outstanding marketable Treasury securities.

Securities with original maturities of more than one year are issued as coupon securities. Coupon securities with original maturities of more than 1 year but not more than 10 years are called *Treasury notes*. The Treasury currently issues notes with maturities of 2 years, 3 years, 5 years, 7 years, and 10 years. On December 31, 2010, Treasury notes accounted for $5.6 trillion (63%) of the outstanding marketable Treasury securities.

Coupon securities with original maturities of more than 10 years are called *Treasury bonds*. The Treasury currently issues bonds with a maturity of 30 years. On December 31, 2010, Treasury bonds accounted for $893 billion (10%) of the outstanding marketable Treasury securities. In the past, the Treasury issued callable bonds. The last callable bond was issued in 1984 and the last callable bond outstanding was called in 2009.

In January 1997, the Treasury began selling *Treasury Inflation-Protected Securities* (TIPS). The principal of these securities is adjusted for inflation using the consumer price index for urban consumers. Semiannual interest payments are a fixed percentage of the inflation-adjusted principal and the inflation-adjusted principal is paid at maturity. On December 31, 2010, TIPS accounted for $616 billion (7%) of the outstanding marketable Treasury securities. As these securities are discussed in Chapter 18, the remainder of this section focuses on nominal (or fixed-principal) Treasury securities.

THE PRIMARY MARKET

Marketable Treasury securities are sold in the primary market through sealed-bid, *single-price* (or *uniform price*) *auctions*. Each auction is announced one or more days in advance by means of a Treasury Department press release. The announcement provides details of the offering, including the offering amount and the term and type of security being offered, and describes some of the auction rules and procedures.

Treasury auctions are open to all entities. Bids must be made in multiples of $100 (with a $100 minimum) and submitted to the Treasury or through an authorized financial institution. Competitive bids must be made in terms of yield and must typically be submitted by 1:00 p.m. eastern time on auction day. Noncompetitive bids must typically be submitted by noon on auction day.[3]

All noncompetitive bids from the public up to $5 million are accepted. The lowest yield (i.e., highest price) competitive bids are then accepted up to the yield required to cover the amount offered (less the amount of noncompetitive bids). The highest yield accepted is often called the *stop-out yield*. All accepted tenders (competitive and noncompetitive) are awarded at the stop-out yield. There is no maximum acceptable yield, and the Treasury does not add to or reduce the size of the offering according to the strength of the bids.

Historically, the Treasury auctioned securities through *multiple-price* (or *discriminatory*) *auctions*. With multiple-price auctions, the Treasury still accepted the lowest-yielding bids up to the yield required to sell the amount offered (less the amount of noncompetitive bids), but accepted bids were awarded at the particular yields bid, rather than at the stop-out yield. Noncompetitive bids were awarded at the weighted-average yield of the accepted competitive bids rather than at the stop-out yield. In September 1992 the Treasury started conducting single-price auctions for the 2- and 5-year notes. In November 1998 the Treasury adopted the single-price method for all auctions.

Within minutes of the 1:00 p.m. auction deadline, the Treasury announces the auction results. Announced results include the stop-out yield, the associated price, and the proportion of securities awarded to those investors who bid exactly the stop-out yield. For notes and bonds, the announcement includes the coupon rate of the new security. The coupon rate is set to be that rate (in increments of 1/8 of 1%) that produces the price closest to, but not above, par when evaluated at the yield awarded to successful bidders.

Accepted bidders make payment on issue date through a Federal Reserve account or account at their financial institution, or they provide payment in full with their tender. Marketable Treasury securities are issued in book-entry form and held in the commercial book-entry system operated by the Federal Reserve Banks or in other accounts maintained by the Treasury.

3. Bidding procedures are described in detail on the Bureau of the Public Debt's website at www.treasurydirect.gov/.

Primary Dealers

While the primary market is open to all investors, the *primary government securities dealers* play a special role. Primary dealers are firms with which the Federal Reserve Bank of New York interacts directly in the course of its open market operations. Among their responsibilities, primary dealers are expected to participate consistently as counterparty to the New York Fed in its execution of open market operations, provide the New York Fed's trading desk with market commentary and market information, participate in all auctions of U.S. government debt, and make reasonable markets for the New York Fed when it transacts on behalf of its foreign official account holders. The dealers must also meet certain minimum capital requirements. The 18 primary dealers as of December 31, 2010 are listed in Exhibit 9–1.

Historically, Treasury auction rules tended to facilitate bidding by the primary dealers. In August 1991, however, Salomon Brothers Inc. admitted deliberate and repeated violations of auction rules. While the rules preclude any bidder from being awarded more than 35% of any issue, Salomon amassed significantly larger positions by making unauthorized bids on behalf of their customers. For the five-year note auctioned on February 21, 1991, for example, Salomon bid for 105% of the issue (including two unauthorized customer bids) and was awarded 57% of the issue. Rule changes enacted later that year allowed any government securities broker or dealer to submit bids on behalf of customers and facilitated competitive bidding by nonprimary dealers.[4]

EXHIBIT 9–1

Primary Government Securities Dealers as of December 31, 2010

BNP Paribas Securities Corp.	Jefferies & Company, Inc.
Barclays Capital Inc.	J.P. Morgan Securities LLC
Cantor Fitzgerald & Co.	Merrill Lynch, Pierce, Fenner & Smith Inc.
Citigroup Global Markets Inc.	Mizuho Securities USA Inc.
Credit Suisse Securities (USA) LLC	Morgan Stanley & Co. Inc.
Daiwa Capital Markets America Inc.	Nomura Securities International, Inc.
Deutsche Bank Securities Inc.	RBC Capital Markets, LLC
Goldman, Sachs & Co.	RBS Securities Inc.
HSBC Securities (USA) Inc.	UBS Securities LLC

Source: Federal Reserve Bank of New York (www.newyorkfed.org/markets/pridealers_current.html).

4. For further information on the auction violations and subsequent rule changes, see the *Joint Report on the Government Securities Market*, published by the Department of the Treasury, the Securities and Exchange Commission, and the Board of Governors of the Federal Reserve System in January 1992.

Auction Schedule

To minimize uncertainty surrounding auctions, and thereby reduce borrowing costs, the Treasury offers securities on a regular, predictable schedule as shown in Exhibit 9–2. Four-, 13-, and 26-week bills are offered weekly, and 52-week bills are offered every four weeks. Four-week bills are typically announced for auction on Monday, auctioned the following Tuesday, and issued the following Thursday. Thirteen- and 26-week bills are typically announced for auction on Thursday, auctioned the following Monday, and issued on the following Thursday (one week after they are announced for auction). Fifty-two week bills are typically announced for auction on Thursday, auctioned the following Tuesday, and issued on the following Thursday. Cash-management bills are issued when required by the Treasury's short-term cash-flow needs, and not on a regular schedule.

Two-, 3-, 5-, and 7-year notes are offered monthly. Two-, 5-, and 7-year notes are usually announced for auction in the second half of the month, auctioned a few days later, and issued on the last day of the month. Three-year notes are usually announced for auction in the first half of the month, auctioned a few days later, and issued on the 15th of the month.

Ten-year notes and 30-year bonds are issued as a part of the Treasury's *quarterly refunding* in February, May, August, and November. The Treasury holds a press conference on the first Wednesday of the refunding month (or on the last

EXHIBIT 9–2

Auction Schedule for U.S. Treasury Securities

Issue	Auction Frequency	Offering Amount
4-Week bill	Weekly	$22–36 Billion
13-Week bill	Weekly	$29–30 Billion
26-Week bill	Weekly	$28–30 Billion
52-Week bill	Every 4 weeks	$22–25 Billion
2-Year note	Monthly	$35–38 Billion
3-Year note	Monthly	$32–35 Billion
5-Year note	Monthly	$35–37 Billion
7-Year note	Monthly	$29 Billion
10-Year note	Quarterly	$24 Billion
30-Year bond	Quarterly	$16 Billion

Notes: Auction frequency and offering amount are reported for regularly issued Treasury securities as of the second half of 2010. New 10-year notes and 30-year bonds are auctioned quarterly, with additional amounts of the notes auctioned one and two months later. Offering amounts exclude amounts issued to refund maturing securities of Federal Reserve Banks. Source: Department of the Treasury.

Wednesday of the preceding month) at which it announces details of the upcoming auctions. The auctions then take place the following week, with issuance on the 15th of the refunding month.

While the Treasury seeks to maintain a regular issuance cycle, its borrowing needs change over time. Most recently, the financial crisis and the government's response increased the Treasury's borrowing needs, resulting in increased issuance and a rising stock of outstanding Treasury securities. As a consequence, the Treasury increased the issuance frequency of some securities, such as the three-year note (from quarterly to monthly), and reintroduced issuance of other securities, including the 52-week bill (in 2008) and the seven-year note (in 2009).

In addition to maintaining a regular issuance cycle, the Treasury tries to maintain a stable issue size for issues of a given maturity. Public offering amounts as of the second half of 2010 were $22 to $36 billion for bills, $24 to $38 billion for notes, and $16 billion for the 30-year bond. Issue sizes have also changed in recent years in response to the government's increased funding needs. Issue sizes for two-year notes, for example, rose from $18 billion in mid 2007 to $44 billion in late 2009.

Reopenings

While the Treasury regularly offers new securities at auction, it often offers additional amounts of outstanding securities. Such additional offerings are called *reopenings*. Current Treasury practice is to reopen 10-year notes and 30-year bonds one and two months after their initial issuance. Moreover, shorter-term bills are typically fungible with previously issued and outstanding bills, so that every 13-week bill is a reopening of a previously issued 26-week bill, and every 4-week bill is a reopening of a previously issued 13- and 26-week bill. The Treasury also reopens securities on an *ad hoc* basis from time to time.

Buybacks

To maintain the sizes of its new issues and help manage the maturity of its debt in a time of federal budget surpluses, the Treasury launched a debt buyback program in January 2000. Under the program, the Treasury redeemed outstanding unmatured Treasury securities by purchasing them in the secondary market through reverse auctions. Buyback operations were announced one day in advance. Each announcement contained details of the operation, including the operation size, the eligible securities, and some of the operation rules and procedures.

The Treasury conducted 45 buyback operations between March 2000 and April 2002 (as of December 2010, there were no operations since April 2002). Operation sizes ranged from $750 million par to $3 billion par, with all but three between $1 and $2 billion. The number of eligible securities in the operations ranged from 6 to 26, but was more typically in the 10 to 13 range. Eligible securities were limited to those with original maturities of 30 years, consistent with

the Treasury's goal of using buybacks to prevent an increase in the average maturity of the public debt.

THE SECONDARY MARKET

Secondary trading in Treasury securities occurs in a multiple-dealer over-the-counter market rather than through an organized exchange. Trading takes place around the clock during the week, from the three main trading centers of Tokyo, London, and New York. As shown in Exhibit 9–3, the vast majority of trading takes place during New York trading hours, roughly 7:30 a.m. to 5:00 p.m. eastern time. The primary dealers are the principal market makers, buying and selling securities from customers for their own accounts at their quoted bid and ask prices. In 2010, primary dealers reported daily trading activity in the secondary market that averaged $565 billion per day.[5]

EXHIBIT 9–3

Trading Volume of U.S. Treasury Securities by Half Hour

Notes: Mean half-hourly trading volume as a percent of mean daily trading volume is plotted for the April 4 to August 19, 1994 period. The times on the horizontal axis indicate the beginning of intervals.

Source: Chart 2 in Michael J. Fleming, "The Round-the-Clock Market for U.S. Treasury Securities," Federal Reserve Bank of New York *Economic Policy Review* (July 1997).

5. Federal Reserve Bank of New York (www.newyorkfed.org/markets/statrel.html). As the data is collected from the primary dealers but no other entities, trades between primary dealers are counted twice, and trades between nonprimary dealers are not counted at all. The figure excludes financing transactions, such as repurchase agreements and reverse repurchase agreements.

Interdealer Brokers

In addition to trading with their customers, the dealers trade among themselves through *interdealer brokers*. The brokers offer the dealers and certain other financial firms proprietary electronic screens or electronic trading platforms that post the best bid and offer prices of the participating firms, along with the associated quantities bid or offered (minimums are $5 million for bills and $1 million for notes and bonds). The firms execute trades by notifying the brokers (by phone or electronically), who then post the resulting trade price and size. Interdealer brokers thus facilitate information flows in the market while providing anonymity to the trading firms. In compensation for their services, the brokers charge a small fee.

The interdealer market has undergone significant structural change in recent years. Until 1999, nearly all trading in the IDB market for U.S. Treasury securities occurred over the phone via voice-assisted brokers. Voice-assisted brokers provide firms with proprietary electronic screens that post the best bid and offer prices, along with the associated quantities, but trades are executed over the phone. Brokers then post the resulting trade price and size on their screens.

In 1999, Cantor Fitzgerald introduced its fully automated eSpeed electronic trading platform, whereby trades are executed electronically so that buyers are matched to sellers without human intervention. In 2000, BrokerTec, a rival electronic trading platform, began operations. Over the span of a few years, nearly all trading of the most actively traded Treasury securities migrated to these electronic platforms.[6] eSpeed was subsequently spun off from Cantor in a public offering and later merged with BGC Partners, and BrokerTec was acquired by ICAP.

Federal Reserve

The Federal Reserve is another important participant in the secondary market for Treasury securities by virtue of its open market operations, security holdings, and surveillance activities. The Federal Reserve Bank of New York buys and sells Treasury securities through open market operations as one of the tools used to implement the monetary policy directives of the Federal Open Market Committee (FOMC). As of June 30, 2010, the Federal Reserve Banks held $777 billion in Treasury securities, or 9% of the publicly held stock. The New York Fed also follows and analyzes the Treasury market and communicates market developments to other government agencies, including the Federal Reserve Board and the Treasury Department.

The financial crisis had a significant effect on the Fed's participation in the Treasury market and hence on its holdings. Early in the crisis, the Fed reduced its

6. See Bruce Mizrach and Christopher Neely, "The Transition to Electronic Communications Networks in the Secondary Treasury Market," Federal Reserve Bank of St. Louis *Review* 88, November/December 2006, and Michael J. Barclay, Terrence Hendershott, and Kenneth Kotz, "Automation versus Intermediation: Evidence from Treasuries Going Off the Run," *Journal of Finance* 61 (2006), pp. 2395–2414.

holdings of Treasury securities to finance the introduction of new liquidity facilities. It thereby sold many securities, or did not reinvest the proceeds of maturing securities. As a result, the Fed's holdings of Treasury securities declined from about $790 billion in mid 2007 to about $480 billion in mid 2008.

In March 2009, the Fed announced a program to purchase up to $300 billion of longer-term Treasury securities, following an earlier announcement to purchase agency MBS and agency debt securities. The full $300 billion was ultimately purchased by the end of October 2009. In August 2010, the Fed then announced it would reinvest principal payments from its agency MBS and agency debt securities in longer-term Treasury securities, and in November 2010 it announced its intent to purchase an additional $600 billion in longer-term Treasury securities by the end of June 2011. By December 29, 2010, the Fed's holdings of Treasury securities had grown to $1.0 trillion.

Trading Activity

While the Treasury market is extremely active and liquid, much of the activity is concentrated in a small number of the roughly 300 issues outstanding. The most recently issued securities of a given maturity, called *on-the-run securities*, are particularly active. Analysis of data from GovPX, Inc., a firm that tracks interdealer trading activity, shows that on-the-run issues account for 70% of trading volume. Older issues of a given maturity are called *off-the-run securities*. While nearly all Treasury securities are off-the-run, they account for only 24% of interdealer trading.

The remaining 6% of interdealer trading occurs in *when-issued securities*. When-issued securities are securities that have been announced for auction but not yet issued. When-issued trading facilitates price discovery for new issues and can serve to reduce uncertainty about bidding levels surrounding auctions. The when-issued market also enables dealers to sell securities to their customers in advance of the auctions, and thereby bid competitively with relatively little risk. While most Treasury market trades settle the following day, trades in the when-issued market settle on the issue date of the new security.

There are also notable differences in trading activity by issue type, with trading concentrating in the intermediate-term notes. According to data reported to the Fed by the primary dealers, Treasury bills only accounted for 15% of trading activity in 2010, even though they accounted for 20% of marketable Treasury securities outstanding at the end of the year. At the long end, bonds accounted for only 6% of activity, even though they accounted for 10% of marketable securities outstanding. Data for the on-the-run Treasury notes from BrokerTec suggests that the 2-, 5-, and 10-year notes in particular are most active, with average daily trading volume in 2009 of $25, $24, and $23 billion, respectively. In contrast, average daily volume in the 3- and 7-year notes was $10 and $5 billion, respectively.[7]

7. BrokerTec accounts for a significant share of trading activity in the interdealer market, but not all activity. Total interdealer trading volume therefore exceeds the figures given in the text.

Quoting Conventions for Treasury Bills

The convention in the Treasury market is to quote bills on a discount rate basis. The rate on a discount basis is computed as:

$$Y_d = \frac{(F - P)}{F} \times \frac{360}{t}$$

where

Y_d = the rate on a discount basis,
F = the face value,
P = the price,
t = the number of days to maturity.

For example, the 26-week bill auctioned August 18, 2008 sold at a price (P) of \$98.999 per \$100 face value (F). At issue, the bill had 182 days to maturity (t). The rate on a discount basis is then calculated as:

$$Y_d = \frac{(\$100 - \$98.999)}{\$100} \times \frac{360}{182} = 1.98\%$$

Conversely, given the rate on a discount basis, the price can be computed as:

$$P = F - \left(F \times Y_d \times \frac{t}{360}\right)$$

For our example,

$$P = \$100 - \left(\$100 \times 1.98\% \times \frac{182}{360}\right) = \$98.999$$

The discount rate differs from more standard return measures for two reasons. First, the measure compares the dollar return with the face value rather than the price. Second, the return is annualized based on a 360-day year rather than a 365-day year. Nevertheless, the discount rate can be converted to a bond-equivalent yield (as discussed in Chapter 6), and such yields are often reported alongside the discount rate.

Treasury bill discount rates are typically quoted to two decimal places in the secondary market, so that a quoted discount rate might be 1.18%. For more active issues, the last digit is often split into halves, so that a quoted rate might be 1.175%.

Typical bid/ask spreads in the interdealer market for the on-the-run bills are 0.5 basis points. A basis point equals one one-hundredth of a percentage point, so that quotes for a half basis point spread might be 1.175%/1.17%. Spreads vary with market conditions, ranging from 0 to about 2 basis points most of the time. A zero spread is called a "locked market" and can persist in the

interdealer market because of the transaction fee paid to the broker who mediates a trade. Bid/ask spreads are typically wider outside of the interdealer market and for less active issues.

Quoting Conventions for Treasury Coupon Securities

In contrast to Treasury bills, Treasury notes and bonds are quoted in the secondary market on a price basis in points in which one point equals 1% of par.[8] The points are split into units of 32nds, so that a price of 97-14, for example, refers to a price of 97 and $^{14}/_{32}$ or 97.4375. The 32nds are themselves split by the addition of a plus sign or a number, with a plus sign indicating that half a 32nd (or $1/64$) is added to the price and a number indicating how many eighths of 32nds (or 256ths) are added to the price. A price of 97-14+ therefore refers to a price of 97 and $^{14.5}/_{32}$ or 97.453125, whereas a price of 97-142 refers to a price of 97 and $^{14.25}/_{32}$ or 97.4453125. The yield to maturity, discussed in Chapter 6, is typically reported alongside the price.

Typical bid/ask spreads in the interdealer market for the on-the-run notes range from $1/128$ point for the 2-year note to $1/32$ point for the 10-year note, as shown in Exhibit 9–4. A 2-year note might thus be quoted as 99-082/99-08+,

EXHIBIT 9–4

Bid/Ask Spreads for U.S. Treasury Securities

Issue	Median Spread	90% Range
4-Week bill	1.0 Basis points	0–4.5 Basis points
13-Week bill	0.5 Basis points	0–2.0 Basis points
26-Week bill	0.5 Basis points	0–1.5 Basis points
2-Year note	1/128 Point	1/128–1/64 Point
3-Year note	1/64 Point	1/128–1/64 Point
5-Year note	1/64 Point	1/128–1/64 Point
7-Year note	1/32 Point	1/64–1/32 Point
10-Year note	1/32 Point	1/64–1/32 Point
30-Year bond	1.5/32 Point	1/64–5/32 Point

Notes: Statistics for the spread between the best bid and the best offer in the interdealer market are reported for the on-the-run securities of each issue. Bill spreads are reported in discount rate terms in basis points and coupon spreads are reported in price terms in points.

Source: Authors' calculations, based on 2006 data from GovPX (for bills) and 2009 data from BrokerTec (for notes and bonds).

8. Notes and bonds are quoted in yield terms in when-issued trading because coupon rates for new notes and bonds are not set until after these securities are auctioned.

whereas a 10-year note might be quoted as 95-23/95-24. As with bills, the spreads vary with market conditions, and are usually wider outside of the interdealer market and for less active issues.

ZERO-COUPON TREASURY SECURITIES

Zero-coupon Treasury securities are created from existing Treasury notes and bonds through coupon stripping. (The Treasury does not issue them.) Coupon stripping is the process of separating the coupon payments of a security from the principal and from one another. After stripping, each piece of the original security can trade by itself, entitling its holder to a particular payment on a particular date. A newly issued 10-year Treasury note, for example, can be split into its 20 semiannual coupon payments (called *coupon strips*) and its principal payment (called the *principal strip*), resulting in 21 individual securities. As the components of stripped Treasury securities consist of single payments (with no intermediate coupon payments), they are often referred to as *zero coupons* or *zeros,* as well as strips.

As they make no intermediate payments, zeros sell at discounts to their face value, and frequently at deep discounts due to their oftentimes long maturities. On February 11, 2011, for example, the closing bid price for the November 2040 principal strip was just $22.83 (per $100 face value). As zeros have known cash values at specific future dates, they enable investors to closely match their liabilities with Treasury cash flows, and are thus popular with pension funds and insurance companies. Zeros also appeal to speculators because their prices are more sensitive to changes in interest rates than coupon securities with the same maturity date.

The Treasury introduced its *Separate Trading of Registered Interest and Principal Securities* (STRIPS) program in February 1985 to improve the liquidity of the zero-coupon market. The program allows the individual components of eligible Treasury securities to be held separately in the Federal Reserve's book-entry system. Institutions with book-entry accounts can request that a security be stripped into its separate components by sending instructions to a Federal Reserve Bank. Each stripped component receives its own CUSIP (or identification) number and can then be traded and registered separately. The components of stripped Treasury securities remain direct obligations of the U.S. government. The STRIPS program was originally limited to new coupon security issues with maturities of 10 years or longer, but was expanded to include all new coupon issues in September 1997.

Since May 1987, the Treasury has also allowed the components of a stripped Treasury security to be reassembled into their fully constituted form. An institution with a book-entry account assembles the principal component and all remaining interest components of a given security and then sends instructions to a Federal Reserve Bank requesting the reconstitution.

As of December 31, 2010, $197 billion of fixed-principal Treasury notes and bonds were held in stripped form, representing 3% of the $6.5 trillion in fixed-principal coupon securities outstanding.[9] There is wide variation across issue types and across issues of a particular type in the rate of stripping. As of December 31, 2010, 20% of bonds were stripped but only 0.3% of notes were stripped. Among the notes, one issue was 8% stripped, while 89 issues were not stripped at all. On a flow basis, securities were stripped at a rate of $36.0 billion per month in the last quarter of 2010, and reconstituted at a rate of $34.1 billion per month.

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KEY POINTS

- U.S. Treasury securities are obligations of the U.S. government issued by the Department of the Treasury.
- Marketable Treasury securities are sold in the primary market through sealed-bid, single-price (or uniform price) auctions.
- Treasury securities are issued as either discount securities (bills) or coupon securities (notes and bonds) and are issued as either fixed-principal or inflation-protected securities.
- Secondary trading in Treasury securities occurs in a multiple-dealer over-the-counter market rather than through an organized exchange.
- Treasury securities trade in a highly liquid secondary market, and are used by market participants as a pricing and hedging instrument, risk-free benchmark, reserve asset, and investment asset.
- Zero-coupon Treasury securities are created from existing Treasury notes and bonds through the Treasury's Separate Trading of Registered Interest and Principal Securities (STRIPS) program. Coupon stripping is the process of separating the coupon payments of a security from the principal and from one another.

9. Figures are from Table V of the Treasury's Monthly Statement of the Public Debt (www.treasurydirect.gov/govt/reports/pd/mspd/mspd.htm).

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CHAPTER
TEN

AGENCY DEBT SECURITIES

MARK O. CABANA
Senior Trader/Analyst
Federal Reserve Bank of New York

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

Agency debt securities are direct obligations of federal government agencies or government-sponsored enterprises. *Federal agencies* are entities of the U.S. government, such as the Tennessee Valley Authority (TVA). *Government-sponsored enterprises* (GSEs) were designed as publicly chartered but privately owned and operated entities, such as the Federal National Mortgage Association (Fannie Mae), the Federal Home Loan Mortgage Corporation (Freddie Mac), the Federal Home Loan Banks (FHLB), and the Farm Credit Banks. Technically, GSEs are instrumentalities of the government that exempt them from certain management laws and regulations that would be applicable to other direct government agencies. However, despite this difference, for the purposes of this chapter, GSEs will frequently be referred to as *agencies*.[1]

The agencies issue debt securities to finance activities supported by public policy, including home ownership and agriculture. Other government initiatives, such as the Temporary Liquidity Guarantee Program, have provided support for debt issued by other corporations and are considered by many market participants as having characteristics similar to those of agency direct obligations.

Agency debt securities typically are not backed by the full faith and credit of the U.S. government, as is the case with Treasury securities. Therefore, agency debt securities are not considered to be risk-free instruments and trade with some credit risk. Nevertheless, agency debt securities have traditionally been considered to be of strong credit quality due to the fundamentals of their underlying businesses and because of their government affiliation.

1. For more detail on the difference between instrumentalities and agencies, see Kevin R. Kosar, *Government-Sponsored Enterprises (GSEs): An Institutional Overview,* CRS Report for Congress, December 20, 2005. Available at http://www.policyarchive.org/handle/10207/bitstreams/3817_Previous_Version_2005-12-20.pdf

AGENCY DEBT MARKET OVERVIEW

The market for agency debt securities expanded rapidly during the 1990s, primarily due to increased issuance from housing-related agencies (including Fannie Mae, Freddie Mac, and the Federal Home Loan Bank) as they grew their retained portfolios and mortgage-related businesses. The agency debt market grew from $426 billion in 1990 to $2.7 trillion at the end of 2009. However, agency debt outstanding has declined in recent years, largely due to reductions in housing-related agency borrowing demand. This decline was largely driven by reduced Federal Home Loan Bank borrowings and could continue as Fannie Mae and Freddie Mac maximum retained portfolios shrink in coming years.[2] In addition, future efforts to reform the government role in mortgage finance could affect the size of the agency debt market. At the end of 2010, there was approximately $2.6 trillion in outstanding agency debt.

Credit Quality of Agency Securities

There is a perception among some market participants that the government implicitly backs agency issues and would be reluctant to let an agency default on its obligations. However, there has been no explicit government guarantee for any agency security, and the extent of government backing for agency securities is a source of uncertainty for some investors.

Agency securities are perceived to have a government backing due to their legal characteristics and affiliation with the U.S. government. Agencies are granted authority to issue debt from Congress and many have directors that are appointed by the President of the United States. In addition, most agencies have the authority to borrow directly from the Treasury and some agencies have received direct Treasury financing. Furthermore, agency securities are eligible for Federal Reserve open market operations.

Despite their relation to the government, agency securities have historically traded at a slight discount to Treasury securities. The pricing difference between agency and Treasury securities has depended partially on the strength of each agency's underlying business, the perceived strength of their government backing, and the liquidity difference between agencies and Treasuries. For example, Fannie Mae and Freddie Mac five-year debt traded at an average spread to comparable five-year Treasuries of 30 basis points during the mid 2000s. However, as the housing market deteriorated and losses on Fannie Mae and Freddie Mac retained MBS portfolios increased in 2007, their debt spreads to comparable Treasuries widened notably. This can be seen in Exhibit 10–1.

2. Fannie and Freddie retained portfolios are scheduled to decline by 10% per year from $900 billion at the end of 2009 to $250 billion in 2022. For more information see *U.S. Treasury Support for Fannie Mae and Freddie Mac, Mortgage Market Note 10-1*, January 20, 2010. Available at http://www.fhfa.gov/webfiles/15362/MMNote_10-1_revision_of_MMN_09-1A_01192010.pdf

EXHIBIT 10–1

Fannie Mae and Freddie Mac Spreads on Five-Year Issues: January 1, 2003 to January 1, 2011

Source: Constructed from data obtained from Bloomberg Financial.

Fannie Mae and Freddie Mac were placed in a conservatorship run by the Federal Housing Finance Agency (FHFA) on September 8, 2008. At the time the conservatorship was established, then-U.S. Treasury Secretary Henry Paulson noted the action was taken to provide stability to financial markets; support the availability of mortgage finance; and protect taxpayers by minimizing the near-term costs and by setting policymakers on a course to resolve the systemic risk created by the enterprises.[3] Through the conservatorship, the U.S. Treasury Department and the FHFA established Preferred Stock Purchase Agreements (PSPA) in which Treasury ensured that each enterprise would maintain a positive net worth. Although the PSPAs were modified over time, the agreements effectively guaranteed the senior and subordinated debt of each enterprise by ensuring their solvency. Specifically, if either enterprise's liabilities exceeded its assets under Generally Accepted Accounting Principles, the Treasury agreed to provide sufficient cash capital to eliminate the deficit in exchange for an increase in the liquidation preference on the Treasury's $1 billion in senior preferred stock.[4] As of January 1, 2011 Fannie Mae and Freddie Mac had drawn on a combined

3. From U.S. Treasury Secretary Henry Paulson's statement on "Treasury and Federal Housing Finance Agency Action to Protect Financial Markets and Taxpayers," September 7, 2008.

4. The PSPA was set to terminate for each enterprise when one of the following occurs: (1) Treasury provided the full commitment of the greater of $200 billion or $200 billion plus cumulative net worth deficits experienced during 2010, 2011, and 2012; (2) the enterprise liquidates its assets; or, (3) the enterprise repaid, defeased, or made other provision for its mortgage guarantee obligations and debts.

$150.8 billion of Treasury commitments and paid back to the Treasury a combined $20.2 billion through dividend payments.[5]

Even after Fannie Mae and Freddie Mac entered conservatorship in September 2008 the government did not provide an explicit guarantee covering their outstanding debentures, but rather increased direct support to each enterprise as explained in the previous paragraph. This step strengthened government backing for Fannie Mae and Freddie Mac but did not allay investor concerns sufficiently to stop their debt spreads from widening amid further disruptions in financial markets in late 2008.

The sharp spread widening in Fannie Mae and Freddie Mac debt during 2008 was conclusively reversed only after the Federal Reserve announced it would purchase certain agency direct obligations on November 25, 2008.[6] Through the program, the Federal Reserve purchased a total of $172 billion in direct obligations of Fannie Mae ($67.1 billion), Freddie Mac ($67.4 billion), and the Federal Home Loan Bank system ($37.2 billion). Although the Federal Reserve purchase program did not legally change the government commitment to the housing-related agencies, some investors interpreted the purchases as a further strengthening of official support for these institutions sufficient to reduce the large discount priced into their debt at that time.

Agency Debt Investors

A variety of market participants invest in agency debt. Many investors are attracted to the relatively high credit quality of agency debt, which offers a slightly higher return when compared with Treasury securities while offering the perception of only modestly more credit risk. In addition, agency issues are also attractive to investors because their interest income is exempt from state and local taxation for many of the issuers (albeit not for Fannie Mae or Freddie Mac issues). However, under current U.S. regulatory capital standards, most agency

5. For more information on the conservatorship, see *U.S. Treasury Support for Fannie Mae and Freddie Mac, Mortgage Market Note 10-1*.

6. On November 25, 2008, the Federal Reserve announced a program to purchase the direct obligations of housing-related GSEs, Fannie Mae, Freddie Mac, and the Federal Home Loan Bank. The debt purchases, in combination with a larger program to purchase agency MBS, were designed to "reduce the cost and increase the availability of credit for the purchase of houses." The purchases of housing-related enterprise direct obligations were intended to narrow the spreads between rates on these direct obligations and U.S. Treasury debt. Purchases were executed by the Federal Reserve Bank of New York with their primary dealers. The GSE direct obligation purchase program was initially sized at up to $100 billion and was increased up to $200 billion on March 18, 2009. On November 9, 2009 the size was revised down to "about $175 billion" due to the limited availability of agency debt for purchases. During the program, the Federal Reserve purchased fixed-rate, noncallable, senior securities offered through Fannie Mae's Benchmark Note Program, Freddie Mac's Reference Note program, and the Federal Home Loan Bank's Global program. The last Federal Reserve purchase was on March 24, 2010, which brought cumulative purchases to $172 billion.

debt securities in U.S. banking book holdings require a 20% risk weight, as opposed to a zero risk weight for Treasury securities.

The composition of agency debt investors has changed over time. Using Freddie Mac debt statistics as an example, investment managers and North American investors were traditionally the largest buyers of such agency debt from the late 1990s through the mid 2000s. During the mid 2000s, central bank and Asian investors began purchasing Freddie Mac debt in larger quantities and the share of investment managers and North American investors declined. However, in the middle of 2008, this trend reversed and investment manager and North American investors again became the largest buyers of Freddie Mac debt. There is not adequate public data to know if similar investor trends hold true for other agencies.

TYPES OF AGENCY DEBT SECURITIES

Agency debt securities are issued in a variety of maturities and types to help manage their business financing needs, mitigate interest-rate risk, and expand their respective investor bases.

Short-Dated Agency Securities

Agencies frequently issue securities with relatively short-term tenors of less than one year, often referred to as *discount notes*. Discount notes are issued at a discount from par with maturities ranging from one day to 365 days and are priced similar to Treasury bills. Some of the agencies offer regular and predictable discount note supply through established programs with standard announcement and offering dates, including Fannie Mae's *Benchmark Bill* program, Freddie Mac's *Reference Bill* program, and the Federal Home Loan Bank's discount note auctions. Other discount notes issued by the agencies are offered through reverse inquiries from investors.

Longer-Dated Agency Securities

Agencies also offer a wide variety of longer-dated securities with maturities of between 1 and 30 years. Most agency debt is U.S. dollar denominated, although some agencies have issued debt denominated in foreign currencies. Some longer-dated issues are large in size with fixed-rate coupon offerings issued through established programs, such as Fannie Mae's *Benchmark Notes* program, Freddie Mac's *Reference Notes* program, and the Federal Home Loan Bank's *Global Debt* program. These programs were established in the late 1990s to create more regular and standardized types of debt with greater liquidity. Debt issued through these programs increased from $118 billion in 2000 to $400 billion in 2010. The programs were also intended to produce a yield-curve for liquid agency securities and thereby appeal to investors that might otherwise purchase Treasury securities.

These fixed-rate coupon offerings typically have semiannual coupon payments with principal redeemed only at the security's stated final maturity date.

In addition to these programs, agencies also offer smaller longer-dated securities with a variety of characteristics that are frequently referred to as *medium term notes.* In the past, agencies have offered medium term notes with a variety of characteristics, including: senior and subordinated hierarchies; callable, putable, and fixed-tenor structures; fixed-rate, floating-rate, indexed, and zero coupons and, denominations in U.S. dollars or in other currencies. Some agencies also offer variations on fixed-rate callable securities called "step-up notes," in which the issuer will generally have the choice to call a security on a specific date and if it is not called then the investor's interest rate increases or "steps up." In addition, the FHLB Office of Finance offers a TAP issue program, in which it issues fixed-rate securities at longer-dated maturities and has the option to continually reopen a security for a three-month period based upon investor demand. Some of these longer-dated security types are discussed in greater detail later in this chapter.

Most longer-dated agency securities generally make semiannual coupon payments and are priced similar to Treasury notes, depending on their various characteristics. Some longer-dated agency securities are also eligible for stripping into principal and interest components through the Federal Reserve Book Entry System.

Callable Securities and Other Tools to Mitigate Interest-Rate Risk

Agencies issue a wide variety of longer-dated securities to better manage the interest rate and cash flow risk inherent in their businesses, especially as some relate to securitizing mortgages and purchasing mortgage-backed securities. One of the most notable risks for housing-related GSEs is the unpredictable nature of mortgage prepayment speeds, given that mortgage prepayments tend to vary with the interest rate environment. Specifically, mortgage prepayment speeds tend to increase in a declining interest rate environment and decrease in a rising rate environment.

Housing-related agencies partially mitigate this risk by issuing callable debt securities, which have somewhat similar characteristics to mortgage-backed securities. Specifically, the duration of mortgage-backed and callable debt tends to shorten as interest rates decline due to the increased likelihood that the call options inherent in these structures will be exercised by the mortgage owner or callable debt issuer. By issuing a callable debt, GSEs effectively purchase a call option from an investor and compensate the investor by issuing the security at a slightly lower price or higher yield when compared to similar noncallable securities.

Callable securities generally have three main characteristics: the maturity date, the lockout period, and the type of call feature. The maturity date is some-

what similar to a noncallable security, which is the latest date on which the security will be retired and principal redeemed assuming the security is not called. The lockout period refers to the amount of time over which a callable security cannot be called by the issuer. For example, a "3 noncall 1-year security" cannot be called for the first year but may be callable at a specific time over the remainder of the security's total 3-year life. The call feature is generally one of three types: European-style, in which the call option can only be exercised on a single day at the end of the initial lockout period; Bermudan-style, in which the call option can be exercised on coupon payment dates after the conclusion of the initial lockout period; and, American-style, in which the call option can be exercised at any point after the initial lockout period.[7]

Housing-related agencies frequently issue callable debt, as shown in Exhibit 10–2, and callable debt issuance has been between $460 and $745 billion in recent years. Callable debt has comprised at least 35% to 49% of total housing-related GSE issuance for maturities greater than 1 year since 2007.

In addition to callable securities, housing-related GSEs also utilize a variety of other tools to help mitigate interest rate risk, including interest rate derivatives such as swaps and swaptions. Callable debt and interest-rate derivatives are an

EXHIBIT 10–2

Callable Debt Issuance by Fannie Mae, Freddie Mac, and Federal Loan Home Bank: 2007–2010

Source: Fannie Mae, Freddie Mac, Federal Home Loan Bank, Federal Reserve Bank of New York.

7. Much of the callable description was taken from Fannie Mae's website "Understanding Fannie Mae Debt," http://www.fanniemae.com/markets/debt/understanding_fm_debt/debt_securities_programs.jhtml?p=Debt+Securities&s=Understanding+Fannie+Mae+Debt&t=Characteristics+of+Fannie+Mae+Debt+Securities

important part of housing-related GSE risk management strategies, which have also allowed some GSEs to expand their investor base.

THE PRIMARY MARKET

The agencies use a variety of methods to distribute their securities, including competitive dealer bidding through auctions, issuance allocation to dealers, sales to investors through dealers, and direct sales to investors. The method may differ based on the issuer and the type of debt being offered.

Agencies have a variety of ways to issue short-dated securities, although most offerings are executed through regular discount note auctions or reverse inquiry sales. Housing-related agencies offer programs that provide a regular and predictable supply of short-dated securities to the market through weekly discount note announcements and auctions. Auctions are underwritten by a predetermined group of dealers who participate in the auctions through Internet platforms specific to each of the housing-related agencies. Depending on the agency, these discount note offerings may be conducted through single- or multiple-price auctions.

Agencies also provide discount notes through reverse inquiry offers. In this process, an agency will post rates daily to the public or investor community at which they are willing to issue discount securities. These rates are sometimes referred to as *window rates*. Dealers will then assist investors in making offers to the issuing agency for a specific amount and tenor near the applicable rate. This process is attractive for both the agency issuer and investor as it allows for a broader range of participants to finance the agencies at short-dated tenors which best meet their investment objectives. However, discount notes issued through the reverse inquiry or window offering process may have nonstandard maturity dates and limited sizes outstanding, which can hinder secondary market liquidity should they be sold by the original investor.

For longer-dated securities, agencies will also use a variety of methods, including syndicated offerings, reopening auctions, or reverse inquiry sales. A common distribution mechanism for agency debt securities is to allocate them among members of a selling group or syndicate of dealers. The syndicate provides market and trading information to the issuing agency before and during the allocation and may support secondary trading in the issue after allocation. In compensation for their services, the syndicate members are offered a concession in the offering or they are able to retain a percentage of the proceeds from the sold securities.

The syndication process is used by some agencies to issue callable and standard fixed-rate coupon offerings. Syndications are most frequently used to issue large fixed-rate coupon offerings such as those issues through Fannie Mae's *Benchmark Notes* program, Freddie Mac's *Reference Notes* program, and the Federal Home Loan Bank's *Global Debt* program. To coordinate the issuance

process among these programs, the U.S. Treasury Department in coordination with the FHFA and the housing-related agencies establish a monthly issuance calendar in which each agency has one predetermined day on which it can offer large fixed-rate coupon offerings to investors. The agencies can choose to offer securities on their respective date or pass and wait until their next scheduled issuance date. This monthly calendar coordination ensures that each housing-related agency has the potential to offer coupon securities in relatively large size without interfering with the issuance plans of any other agency. Of note, on these scheduled offering dates, the agencies can also choose to reopen previously issued securities through these established programs. The agencies generally manage the reopening auctions through their internal systems and do not require a dealer syndicate for this process.

Similar to discount notes, agencies also issue medium term notes through a reverse inquiry process. Some dealers will post or send daily rates for a variety of security types to underwriting dealers, who then assist investors in making offers to the issuing agency. Agencies frequently issue callable securities through the reverse inquiry process and are able to entertain a wide variety of callable structure reverse inquiries simultaneously, including those with European, American, and Bermudan call options. Agencies will also consider a wide variety of other debt structures through the reverse inquiry process. On any given day, agencies can issue longer-term securities with a variety of different maturities, coupon types, and call features through this process.

THE SECONDARY MARKET

Like Treasury securities, agency securities trade in a multiple-dealer over-the-counter secondary market. Also like Treasury securities, trading among dealers is screen-based, through interdealer brokers. Trading volume is significantly lower than that in the Treasury market, but it is still reasonably high relative to other fixed income markets. In fact, primary dealer trading volumes in agency debt securities averaged 11% of U.S. fixed income daily trading volumes from 2000 to 2010.

Secondary market trading activity is also concentrated in agency securities in discount notes. From 2002 to 2010, discount notes averaged 78% of daily primary dealer trading volumes, versus longer-term agency securities which averaged only 22% of such volume. During 2010, daily trading by primary dealers averaged $60 billion per day, with $47 billion in discount notes and $13 billion in longer-dated coupon securities.

AGENCY DEBT ISSUANCE

The quantity of agency debt securities sold in the primary market increased throughout the 1990s and 2000s. In 1990, agencies issued only $20 billion in securities with one year or more to maturity. At the end of 2000 agencies issued

$483 billion in longer-term debt and by the end of 2009 agencies issued nearly $1.1 trillion in debt with maturities over one year. However, agency short-term issuance exceeds long-term issuance by nearly four times.

The housing-related agencies have also been the largest issuers of agency debt with maturities of over one year since the early 1990s. Since 1998, Fannie Mae, Freddie Mac, and the Federal Home Loan Bank have also issued more than 90% of total long-term agency debt securities in any year. At the end of 2009, issuance from these three entities comprised 92% of total long-term agency debt issuance.

Despite the increased agency issuance since 2000, agency debt outstanding has increased only modestly over the same time horizon, as shown in Exhibit 10–3. The outstanding debt of the agencies stood at $1.8 trillion by the end of 2000 and increased $880 billion to $2.7 trillion by the end of 2009. Much of the new agency debt issuance has gone to service outstanding debt and resulted in limited net new issuance during the period.

The vast majority of total agency debt outstanding is attributable to the three main housing-related agencies, Fannie Mae, Freddie Mac, and the Federal Home Loan Bank. Debt issued by these three entities accounted for as much as 95% of outstanding debt in 2005 and 92% percent of total outstanding debt at the end of 2009. As shown in Exhibit 10–3, at the end of 2009 outstanding Fannie Mae, Freddie Mac, and Federal Home Loan Bank debt totaled $2.5 trillion.

EXHIBIT 10–3

Agency Debt Outstanding: 2001–2009

Source: Federal Reserve Flow of Funds.

ISSUING AGENCIES

As mentioned previously, agency securities are direct obligations of federal agencies or government-sponsored enterprises. Federal agencies are entities of the federal government. They include the Export-Import Bank of the United States, the Federal Housing Administration, the Government National Mortgage Association (Ginnie Mae), the Tennessee Valley Authority (TVA), and the Small Business Administration. Historically, a number of federal agencies issued their own debt securities. In 1974, the Federal Financing Bank was set up to consolidate agency borrowing and thereby reduce borrowing costs. However, the TVA still issues its own debt securities and accounts for nearly all the outstanding debt issued directly by federal agencies.

Government-sponsored enterprises (GSEs) are privately owned and operated entities chartered by Congress to work toward public policy goals and decrease the cost of funding for certain sectors of the economy. The GSEs are granted certain privileges to help them achieve their public purposes and, in turn, are limited to certain activities. As mentioned, agency debt securities are thought to have an implicit government guarantee, and agency security interest income is exempt from state and local taxation for many issuers. The agencies themselves are exempt from state and local income taxes and are also exempt from Securities and Exchange Commission (SEC) registration fees.

The largest GSEs were chartered to provide credit to the housing sector. As previously noted, they include Fannie Mae, Freddie Mac, and the Federal Home Loan Banks. Another set of GSEs was established to provide credit to the agricultural sector, including the Farm Credit Banks, the Farm Credit System Financial Assistance Corporation, and the Federal Agricultural Mortgage Corporation (Farmer Mac).

There are also older GSEs with debt outstanding and other GSEs that have recently been privatized. The Financing Corporation and the Resolution Funding Corporation are GSEs that were established to recapitalize the savings and loan industry but have not issued new securities in years, although they both have some debt outstanding. Another older GSE, the Student Loan Marketing Association (Sallie Mae), was wholly privatized at the end of 2004.

In addition to the agencies and GSEs, there have been some government initiatives that explicitly back types of fixed income securities for public policy purposes. The Temporary Liquidity Guarantee Program (TLGP) was established during the 2008 financial crisis, through which the Federal Deposit Insurance Company (FDIC) guaranteed senior unsecured debt of insured depository institutions issued between October 14, 2008 and June 30, 2009 that matures before June 30, 2012.

The remainder of this section provides a brief overview of each of the agencies, GSEs, and government-backed initiatives that have debt securities outstanding or were recently wound-down. This information is also summarized in Exhibit 10–4.

EXHIBIT 10–4

Agency Descriptions

Agency	Purpose	Debt Outstanding (EOY 2010)
Federal National Mortgage Association (Fannie Mae)	Promote liquid secondary market for residential mortgages	$794 billion
Federal Home Loan Mortgage Corporation (Freddie Mac)	Promote liquid secondary market for residential mortgages	$729 billion
Federal Home Loan Bank System	Increase credit availability for residential mortgages	$797 billion
Farm Credit System	Supply credit for agricultural sector	$179 billion
Federal Agricultural Mortgage Corporation (Farmer Mac)	Promote liquid secondary market for agricultural and rural housing loans	$7 billion
Tennessee Valley Authority (TVA)	Promote development of Tennessee River and adjacent areas	$23 billion
Financing Corporation	Finance and recapitalization of Federal Savings and Loan Insurance Corporation	$8 billion
Resolution Funding Corporation	Finance recapitalization of savings and loan industry	$30 billion

LARGE, ACTIVE ISSUERS

The three large, active issuers include Fannie Mae, Freddie Mac, and the Federal Home Loan Bank System.

Federal National Mortgage Association (Fannie Mae)

Fannie Mae was established in 1938 to develop a secondary market for residential mortgages and was chartered by Congress in 1968 as a private stockholder-owned corporation. Fannie Mae buys home loans from banks and other mortgage lenders in the primary market and holds the mortgages until they mature or issues securities backed by pools of the mortgages.

As previously noted, on September 6, 2008 the Director of the FHFA was appointed conservator of Fannie Mae, at which time the GSE also established the PSPA with the U.S. Treasury Department to ensure the enterprise will maintain a

positive net worth. Through the end of 2010, Fannie Mae had drawn $87.6 billion from the U.S. Treasury. FHFA also regulates Fannie Mae.

To finance their businesses, Fannie Mae issues a variety of securities, including discount notes and medium-term notes. In January 1998, Fannie Mae initiated its Benchmark Notes debt issuance program, followed by the introduction of its Benchmark Bills program in November 1999. Both Benchmark programs are intended to provide for the regular and predictable issuance of large-sized securities and are meant to enhance their efficiency, liquidity, and tradability. Benchmark Bills are issued via Dutch-style auction, with three- and six-month bills offered weekly and one-year bills offered on a less frequent, ad hoc basis. Benchmark Notes are issued via an underwriting syndicate of dealers following a yearly issuance calendar.

In 2010, Fannie Mae issued $439 billion in securities with maturities less than one year and $463 billion in securities with maturities greater than one year. At the end of 2010, Fannie Mae had outstanding $152 billion in securities with maturities less than one year and $642 billion in securities with maturities greater than one year.

Federal Home Loan Mortgage Corporation (Freddie Mac)

Freddie Mac is a stockholder-owned corporation chartered in 1970 to expand opportunities for homeownership and improve the liquidity of the secondary mortgage market. Freddie Mac purchases mortgage loans from individual lenders and sells securities backed by the mortgages to investors or holds the mortgages until they mature.

Similar to Fannie Mae, Freddie Mac entered conservatorship overseen by the FHFA in September 2006 and has a PSPA with the U.S. Treasury Department. In order to remain in positive net worth, Freddie Mac drew $63.2 billion from the U.S. Treasury through the end of 2010. FHFA also regulates Freddie Mac.

Freddie Mac issues a variety of debt securities, including discount notes and medium-term notes. In April 1998, Freddie Mac established its own benchmark securities program called Reference Notes, followed by Reference Bills in November 1999. Reference Bills are issued via Dutch auction, with three- and six-month bills offered weekly and one- and 12-month bills auctions offered optionally every month. Reference Notes are issued via an underwriting syndicate of dealers following a yearly issuance calendar.

In 2010, Feddie Mac issued $482 billion in securities with maturities less than one year and $331 billion in securities with maturities greater than one year. At the end of 2010, Freddie Mac had outstanding $195 billion in securities with maturities less than one year and $534 billion in securities with maturities greater than one year.

Federal Home Loan Bank System

The Federal Home Loan Bank (FHLB) system was established as a GSE in 1932 to increase credit access for the housing sector by supporting residential mortgage

lending and related community investment through its member financial institutions. It consists of 12 federally chartered, privately owned Federal Home Loan Banks that are charged with supporting residential mortgage, small business, rural, and agricultural lending by more than 8,000 member-stockholder institutions. The FHLB system is a cooperative structure in which each member bank is a shareholder in one of the 12 regional banks. The regional banks make loans to the member institutions, which in turn make loans to homebuyers, small businesses, and others.

The FHFA regulates the FHLB system for mission, as well as safety and soundness issues. Unlike Fannie Mae and Freddie Mac, none of the 12 regional Federal Home Loan Banks are in conservatorship.

FHLB debt issuance is conducted through the system's fiscal agent, the Office of Finance. The FHLB Office of Finance sells a variety of debt securities, including discount notes and medium-term notes. The FHLB Office of Finance issues discount notes twice weekly via multiple price auctions in four standard maturities: 4-, 9-, 13-, and 26-weeks. The Office of Finance also maintains a discount note reverse inquiry window. In July 1999, the Office of Finance launched a TAP Issue Program in which it offers longer-dated fixed-rate securities at common maturities that can be reopened daily over a three-month period. In July 1994, the FHLB Office of Finance established a Global Debt program in which it generally offers large-sized, fixed-rate securities, although it can offer smaller issues with different characteristics. FHLB globals are issued via a single dealer or an underwriting syndicate of dealers following a yearly issuance calendar.

In 2010, the FHLB Office of Finance issued $1.2 trillion in securities with maturities less than one year and $533 billion in securities with maturities greater than one year, including $31 billion in TAP issues. At the end of 2010, the FHLBs had outstanding $195 billion in securities with maturities less than one year and $602 billion in securities with maturities greater than one year, including $88 billion in TAP issues.

SMALLER, ACTIVE ISSUERS

The Farm Credit System, the Federal Agricultural Mortgage Corporation, and the Tennessee Valley Authority are three smaller, active issuers.

The Farm Credit System

The Farm Credit System (FCS) is a GSE established in 1916 to provide credit to the agricultural sector. The FCS consists of five Farm Credit Banks and approximately 88 Associations. Products and services offered by FCS institutions include real estate loans, operating loans, rural home mortgage loans, crop insurance, and various financial services. The FCS and the system's fiscal entity are regulated by the Farm Credit Administration.

The Federal Farm Credit Banks Funding Corporation is the system's fiscal entity, providing funds to system institutions through the issuance of debt securities. The FCS issues discount notes, fixed-rate callable and noncallable securities, and floating-rate notes. In addition, FCS also issues *Designated Bonds,* which are large, liquid callable and noncallable issues. These bonds are issued through a dealer syndicate and can have 2- to 10-year original maturities, with a minimum issue size of $1 billion for noncallable issues and $500 million for callable bonds. Near the end of 2010, FCS outstanding debt included $17 billion in maturities less than one year and $162 billion in long-term debt.

Federal Agricultural Mortgage Corporation (Farmer Mac)

Farmer Mac is a stockholder-owned corporation chartered in 1988 to promote a liquid secondary market for agricultural real estate and rural housing loans. It does this by buying qualified loans from lenders and grouping the loans into pools against which it issues securities. Farmer Mac thus performs a role for the agricultural mortgage market similar to that performed by Fannie Mae and Freddie Mac for the residential mortgage market. Farmer Mac issues discount notes and medium-term notes, including callable and noncallable securities. Near the end of 2010, Farmer Mac outstanding debt included $4 billion in maturities less than one year and $3 billion in long-term debt.

Tennessee Valley Authority

The Tennessee Valley Authority (TVA) is a government-owned corporation established in 1933 to promote development of the Tennessee River and adjacent areas. The TVA manages the river system for flood control, navigation, power generation, and other purposes and is the nation's largest public power company.

The TVA issues discount notes as well as longer-term coupon securities, called Power Bonds. Interest and principal on Power Bonds are paid from the proceeds of TVA's power program. Near the end of 2010, TVA outstanding debt included $219 million in discount notes and $23 billion in long-term debt.

NONACTIVE ISSUERS AND RECENTLY RETIRED GSEs

In addition to the issuers discussed above, there are issues outstanding and traded in the market from entities that were previously GSEs and those that are not currently active in the issuance market.

Financing Corporation

The Financing Corporation (FICO) was established in 1987 to finance the recapitalization of the Federal Savings and Loan Insurance Corporation (FSLIC). Between 1987 and 1989, FICO issued debt obligations with an aggregate principal

value of $8.2 billion. Towards the end of 1991, FICO's authority to issue new debt was terminated. The FHLB system provided FICO with initial capital to purchase zero-coupon Treasury securities in order to repay their principal. FICO interest payments are funded by an assessment on FDIC-insured institutions. Near the end of 2010, FICO debt outstanding totaled approximately $8 billion.

Resolution Funding Corporation

The Resolution Funding Corporation (REFCorp) was established in 1989 as the funding arm of the Resolution Trust Corporation to finance the recapitalization of the savings and loan industry. REFCorp issued $30 billion in debt securities between 1989 and 1991. Interest payments on REFCorp bonds are guaranteed by the U.S. government, and the principal is protected by the purchase of zero-coupon bonds with a face value equal to those of REFCorp bonds. The full $30 billion in issued debt securities was outstanding near the end of 2010.

Farm Credit System Financial Assistance Corporation

The Farm Credit Financial Assistance Corporation was chartered in 1988 to finance the recapitalization of FCS institutions. Between 1988 and 1990, the corporation raised $1.3 billion through the issuance of debt securities, which it provided to system institutions in return for preferred stock. Unlike most GSEs, the debt securities of this corporation were fully guaranteed by the U.S. Treasury. All debt issuance by the corporation has been called or matured, with the last bond maturing in June 2005. The Financial Assistance Corporation's charter was canceled by the FCA as of December 31, 2006.

Student Loan Marketing Association

Student Loan Marketing Association (Sallie Mae) was a stockholder-owned corporation established in 1972 to increase the availability of student loans. As a GSE, Sallie Mae purchased insured student loans from lenders and made loans to lenders secured by student loans. Sallie Mae was reorganized in 1997 in a step toward privatization and was fully privatized at the end of 2004. As a GSE, Sallie Mae issued discount notes, medium-term notes, and other debt securities, but no longer has any GSE-related debt outstanding. Sallie Mae was replaced by a publicly held, private sector financial services company named SLM Corporation, which specializes in financing education.

Treasury Liquidity Guarantee Program

The Treasury Liquidity Guarantee Program (TLGP) was announced on October 14, 2008, as an initiative to counter systemic risks in the financial sector by ensuring that financial institutions would be able to rollover maturing wholesale debt.

Through the TLGP, the Federal Deposit Insurance Corporation (FDIC) provided guarantees for a limited amount of newly issued senior unsecured debt of insured depository institutions, most U.S. bank holding companies, and one large nonbank finance company. Debt issued through the TLGP is backed by the full faith and credit of the U.S. government.

Issuers in the TLGP were required to pay a fee to the FDIC that was based on the maturity of the debt and the type of institution that was issuing it. Each participating financial institution was limited to a maximum amount of guaranteed debt that it could issue based on the amount of senior unsecured debt scheduled to expire over a set time period. Guarantees for TLGP-backed senior unsecured debt originally applied to issuance by June 30, 2009 for maturities before June 30, 2012. However, this was extended to issuance by October 31, 2009 for maturities before December 31, 2012.

Issuance through the TLGP was elevated at the start of the program when other forms of corporate debt issuance were limited. During the first 6 months of the TLGP program $346 billion in term debt was issued from applicable institutions. However, as corporate credit markets improved, credit availability increased, and the FDIC encouraged firms to return to private funding markets, TLGP issuance and amounts outstanding declined. At the end of 2010, outstanding TLGP debt totaled $267 billion.

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Mark Cabana's views expressed in this chapter are his and not necessarily those of the Federal Reserve Bank of New York or the Federal Reserve System.

KEY POINTS

- Agency securities are direct obligations of federal government agencies or government-sponsored enterprises. Agency securities have historically been viewed as having limited credit risk, although they are not risk free and have at times traded with a notable discount to Treasury securities.
- Agency security issuance and amount outstanding have grown in recent years owing to the growth of the housing GSEs—Fannie Mae, Freddie Mac, and the FHLB system. However, going forward, the supply of agency securities may decline as housing GSE retained portfolios shrink and as the government reforms its role in mortgage finance.
- Federal agencies and GSEs issue a wide variety of debt securities, including discount note securities at tenors less than one year and medium term notes with numerous structures at maturities greater than one year.

- Agencies use a variety of methods to distribute their securities, including competitive dealer bidding through auctions, issuance allocation to dealers, sales to investors through dealers, and direct sales to investors.
- The vast majority of agency debt issued (mostly concentrated in discount notes) and traded is from Fannie Mae, Freddie Mac, and the FHLB system.

CHAPTER
ELEVEN

MUNICIPAL BONDS

Sylvan G. Feldstein, Ph.D.
Director
Investment Department
Guardian Life Insurance Company of America

Frank J. Fabozzi, Ph.D., CFA, CPA
Professor of Finance
EDHEC Business School

Alexander Grant
Portfolio Manager
RS Tax-Exempt and RS High Yield Municipal Bond Funds

David Ratner, CFA
Industry Consultant

The U.S. bond market can be divided into two major sectors: the taxable bond market and the tax-exempt bond market. The former sector includes bonds issued by the U.S. government, U.S. government agencies and sponsored enterprises, and corporations. The tax-exempt bond market is one in which the interest from bonds that are issued and sold is exempt from federal income taxation. Interest may or may not be taxable at the state and local levels. The interest on U.S. Treasury securities is exempt from state and local taxes, but the distinction in classifying a bond as tax exempt is the tax treatment at the federal income tax level.

It should be noted that over the years some taxable municipal bonds have been issued. As an example of the largest issuance program, under the Federal Build America Bond (BABS) program, between 2009 and 2010, almost $190 billion of BABS were issued. Interest on these bonds was federally taxable and the federal government is to pay 35% of the interest payments.

The Federal Reserve Board estimates that the overall size of the municipal bond market as of the end of September, 2010 was $2.86 trillion. According to Barclays Capital Indices, by 2011 municipals represented 7.9% of their fixed income universe—which is made up only of the larger bond issues. The municipal sector is certainly one of the larger components of the domestic bond market, but it is clearly different from the taxable bond market.

The majority of tax-exempt securities are issued by state and local governments and by their creations, such as "authorities" and special districts. Consequently, the terms *municipal market* and *tax-exempt market* are often used

interchangeably. Although not all municipal bonds are tax-exempt securities, most are.

The major motivation for investing in tax-exempt municipal bonds is their tax advantage. The primary owners of municipal bonds are individual investors; the remainder of the investors consists of mutual funds, commercial banks, and property and casualty insurance companies. Although certain institutional investors such as pension funds have no need for tax-advantaged investments, there have been instances in which such institutional investors have crossed into the municipal bond market to take advantage of higher yields. These investors also have purchased municipal bonds when municipal bonds were expected to outperform taxable bonds. Institutional investors who are natural purchasers of taxable bonds but at times purchase municipal debt are known as *crossover buyers*.

The industry has many new buy-side participants. In addition to the traditional bank trust departments, mutual funds, property and casualty insurance companies, and high-net-worth individuals, buyers now include hedge funds, arbitrageurs, life insurance companies, crossover buyers, and foreign banks, among other relative value buyers. There are now municipal bond exchange-traded funds (ETFs) that cater to investors.

Traditionally, the household sector has owned the largest portion of the municipal bond market. Another substantial owner has been the mutual fund industry. However, examination of Federal Reserve Board data indicates that there have been three major changes among holders. First, the percentage holdings of commercial banks have dropped significantly since 1986. In general, the Tax Reform Act of 1986 reduced the benefits commercial banks received by owning municipal bonds. Commercial banks responded to this change by reducing their municipal bond holdings and investing in assets that provided greater benefits.

Households account for the next substantial ownership change. In 1990, household ownership of municipal bonds reached a peak of 49% for the 20-year period. However, by the end of September 2010, household ownership was at 41%. If commercial banks and households both decreased their holdings, then other groups had to increase their ownership. Federal Reserve Board data indicate that mutual funds, money market funds, and closed-ended funds dramatically increased their holdings. In 1979, they held only 1% of the municipal market; by the end of September, 2010, their combined share was 33%.

Insurance companies and personal bank trust accounts have had relatively stable ownership of municipal bonds. Insurance companies typically adjust their holdings of municipal bonds according to profitability and the relative value municipal bonds offer compared with taxable bonds. Trust accounts are relatively stable purchasers of municipal bonds. A typical trust account will purchase bonds near par, collect the tax-exempt income, and hold the bonds to maturity.

It should be noted that when municipal bond yields are attractive compared with taxable bonds, traditional bond buyers, hedge funds, and arbitrageurs are active and at times have become significant participants in the municipal market.

In the past, investing in municipal bonds was considered second in safety only to that of U.S. Treasury securities; however, there have now developed among investors ongoing concerns about the credit risks of municipal bonds. This is true regardless of whether or not the bonds are given investment-grade credit ratings by the commercial rating companies. There are several reasons for this: (1) the financial crisis of several major municipal issuers beginning with the City of New York billion-dollar financial crisis in 1975 and the bankruptcy filing in 1994 of Orange County, California; (2) the federal bankruptcy law (which became effective October 1979) that makes it easier for municipal bond issuers to seek protection from bondholders by filing for bankruptcy; (3) the proliferation of innovative financing techniques and legally untested security structures, highlighted by the default of the Washington Public Power Supply System (WPPSS) in the early 1980s; (4) the cutbacks in federal grant and aid programs that will affect the ability of certain municipal issuers to meet their obligations; and (5) fundamental changes in the American economy that may cause economic hardship for municipal issuers in some regions of the country and thus difficulty in meeting their obligations.

More recently, beginning in December of 2007 when the latest recession began, the well-publicized bond defaults of Vallejo, California and Harrisburg, Pennsylvania as well as the budgetary stresses of several large states and cities, highlighted credit concerns about municipal bonds. Vallejo utilized Chapter 9 of the U.S. Bankruptcy Code to avoid paying bondholders. And Harrisburg just didn't appropriate debt service.

FEATURES OF MUNICIPAL SECURITIES

In Chapter 1, the various features of fixed income securities were described. These include call and refunding provisions, sinking-fund provisions, and put provisions. Such provisions also can be included in municipal securities. In one type of municipal structure discussed below, a revenue bond, there is a special call feature wherein the issuer must call the entire issue if the facility is destroyed.

Coupon Features

The coupon rate on a municipal issue can be fixed throughout the life of the issue, or it can be reset periodically. When the coupon rate is reset periodically, the issue is referred to as a *floating-rate* or *variable-rate* issue. In general form, the coupon reset formula for a floating-rate issue is

$$\text{Percent of reference rate} \pm \text{spread}$$

Typically, when the reference rate is a municipal index, the coupon reset formula is

$$\text{Reference rate} \pm \text{spread}$$

Reference rates that have been used for municipal issues include the Securities Industry and Financial Markets Association (SIFMA), LIBOR, and Treasury bills.

The coupon rate on a floating-rate issue need not change in the same direction as the reference rate. There are derivative municipal bonds whose coupon rate changes in the opposite direction to the change in the reference rate. That is, if the reference rate increases from the previous coupon reset date, the coupon rate on the issue declines. Such issues are referred to as *inverse floating-rate issues.* Some municipal issues have a fixed coupon rate and are issued at a discount from their maturity value. Issues whose original-issue price is less than its maturity value are referred to as *original-issue discount bonds* (OIDs). The difference between the par value and the original-issue price represents tax-exempt interest that the investor realizes by holding the issue to maturity.

Two types of municipal issues do not distribute periodic interest to the investor. The first type is called a *zero-coupon bond.* The coupon rate is zero, and the original issue price is below the maturity value. Zero-coupon bonds are therefore OIDs. The other type of issue that does not distribute periodic interest is one in which a coupon rate is stated but the coupon is not distributed to the investor. Instead, the interest is accrued, and all interest is paid to the investor at the maturity date along with the maturity value. Later in this chapter we will discuss the important aspects an investor should be aware of when considering the purchase of OIDs in the secondary market.

Maturity Date

The maturity date is the date on which the issuer is obligated to pay the par value. Corporate issuers of debt generally schedule their bonds to mature in one or two different years in the future. Municipal issuers, on the other hand, frequently schedule their bonds to mature serially over many years. Such bonds are called *serial bonds.* It is common for a municipal issue to have 10 or more different maturities.

After the last of the serial maturities, some municipal issues lump together large sums of debt into one or two years—much the way corporate bonds are issued. These bonds, called *term bonds,* have become increasingly popular in the municipal market because active secondary markets for them can develop if the term issue is of sufficient size.

The Legal Opinion

Municipal bonds have legal opinions. The relationship of the legal opinion to the safety of municipal bonds for both general obligation and revenue bonds is threefold. First, bond counsel should check to determine if the issuer is indeed legally able to issue the bonds. Second, bond counsel is to see that the issuer has properly prepared for the bond sale by having enacted the various required ordinances, resolutions, and trust indentures and without violating any other laws and regulations. This preparation is particularly important in the highly technical areas of determining if the bond issue is qualified for tax exemption under federal law and if the issue has not been structured in such a way as to violate federal arbitrage regulations.

Third, bond counsel is to certify that the security safeguards and remedies provided for the bondholders and pledged either by the bond issuer or third parties, such as banks with letter-of-credit agreements, are actually supported by federal, state, and local government laws and regulations.

The popular notion is that much of the legal work done in a bond issue is boilerplate in nature, but from the bondholder's point of view, the legal opinions and document reviews should be the ultimate security provisions. The reason is that if all else fails, the bondholder may have to go to court to enforce security rights. Therefore, the integrity and competence of the lawyers who review the documents and write the legal opinions that are usually summarized and stated in the official statements are very important.

It should be noted that by 2011, there were thousands of attorneys in the business. They were located throughout the country and listed in the *The Bond Buyer's* Municipal Marketplace directory of municipal bond attorneys. They presented themselves as being experts in municipal finance law and provided various security structure and tax opinions. Sorting out quality distinctions in their work and who is well grounded in the law, and who is not, is challenging.

TYPES OF MUNICIPAL OBLIGATIONS

The number of municipal bond issuers is remarkable. One broker-dealer's estimate places the total at 60,055. Even more noteworthy is the number of different issues. As of 2011, Interactive Data Pricing and Reference Data[1] provides daily prices for over 1.4 million individual issues in its database of over 2.6 million records. The Bloomberg Financial Markets' (Bloomberg) database,[2] as of 2011, contained over 4.8 million CUSIPS (including matured bonds). Of the 1.19 million CUSIP numbers still active, Bloomberg updates them on a regular basis.

The number of different issues to choose from is staggering. Considering all the different types of issuers in the market—states, state agencies, cities, airports, colleges and universities, hospitals, continuing care retirement communities (CCRCs), school districts, toll roads and bridges, public power facilities, seaport facilities, water and sewer authorities, solid waste facilities, and other special purpose districts—the investment choices are overwhelming. Some of the issuers are extremely large and issue billions of dollars of debt. Some are extremely small and may only have $1 to $2 million in outstanding debt. Obviously, the characteristics

1. Interactive Data Pricing and Reference Data is a securities information provider that specializes in data collection and internally authored evaluations. Data are delivered electronically to financial institutions and authorized redistribution vendors. Fixed income coverage encompasses the municipal and taxable bond markets. A second pricing service is Standard & Poor's Securities Evaluation Service.
2. Bloomberg Financial Markets is a multimedia distributor of information services that combines news, data, and analysis for global financial markets and business. Company's core business is a computer network that delivers real-time financial information and links the world's financial markets and financial professionals.

of these issuers and their debt are very different, and both require independent and careful analysis. However, municipal bonds can be categorized into two broad security structures. In terms of municipal bond security structures, there are basically two different types. The first type is the general obligation bond, and the second is the revenue bond.

General Obligation Bonds

General obligation bonds are debt instruments issued by states, counties, special districts, cities, towns, and school districts. They are secured by the issuer's general taxing powers. Usually, a general obligation bond is secured by the issuer's unlimited taxing power. For smaller governmental jurisdictions, such as school districts and towns, the only available unlimited taxing power is on property. For larger general obligation bond issuers, such as states and big cities, the tax revenues are more diverse and may include corporate and individual income taxes, sales taxes, and property taxes. The security pledges for these larger issuers such as states sometimes are referred to as being *full faith and credit obligations.*

Additionally, certain general obligation bonds are secured not only by the issuer's general taxing powers to create monies accumulated in the general fund, but also from certain identified fees, grants, and special charges, which provide additional revenues from outside the general fund. Such bonds are known as being *double barreled* in security because of the dual nature of the revenue sources. Also, not all general obligation bonds are secured by unlimited taxing powers. Some have pledged taxes that are limited as to revenue sources and maximum property-tax millage amounts. Such bonds are known as *limited-tax general obligation bonds.*

Revenue Bonds

The second basic type of security structure is found in a revenue bond. Such bonds are issued for either project or enterprise financings in which the bond issuers pledge to the bondholders the revenues generated by the operating projects financed. Below are examples of the specific types of revenue bonds that have been issued over the years.

Airport Revenue Bonds

The revenues securing airport revenue bonds usually come from either traffic-generated sources—such as passenger charges, landing fees, concession fees, and airline apron-use and fueling fees—or lease revenues from one or more airlines for the use of a specific facility such as a terminal or hangar.

Charter School Bonds

These bonds are for publicly funded private schools that offer more institutional and academic flexibility than local public schools. State-aid funding usually follows the

student who goes from a traditional public school to a charter school. Bond proceeds go for capital improvements.

College and University Revenue Bonds

The revenues securing college and university revenue bonds usually include dormitory room rental fees, tuition payments, and sometimes the general assets of the college or university as well.

Continuing Care Retirement Community Bonds

Life care or continuing care retirement community (CCRC) bonds are issued to construct long-term residential facilities for older citizens. Revenues usually are derived from initial lump-sum payments made by the residents and operating revenues.

Higher Education Bonds

Debt is often issued by institutions of higher education to finance the costs of building/renovating facilities or purchasing land for expansion. These bonds are secured by revenues of the given project, student charges, and/or a general obligation of the college or university.

Hospital Revenue Bonds

The security for hospital revenue bonds is usually dependent on federal and state reimbursement programs (such as Medicaid and Medicare), third-party commercial payers (such as Blue Cross and private insurance), health maintenance organizations (HMOs), and individual patient payments.

Industrial Development and Pollution Control Revenue Bonds

Bonds have been issued for a variety of industrial and commercial activities that range from manufacturing plants to shopping centers. They usually are secured by payments to be made by the corporations or businesses that use the facilities.

Land-Secured "Dirt" Bonds

Public infrastructure costs associated with new development projects on raw land are often financed by land-secured bonds, also known as "dirt" bonds. Revenue from the additional tax or assessment placed on the properties benefitting from these improvements is the primary security for the bondholders.

Multifamily Revenue Bonds

These revenue bonds usually are issued for multifamily housing projects for senior citizens and low-income families. Some housing revenue bonds are secured by mortgages that are federally insured; others receive federal government operating subsidies, such as under Section 8, or interest-cost subsidies, such as under Section 236; and still others receive only local property-tax reductions as subsidies.

Public Power Revenue Bonds

Public power revenue bonds are secured by revenues to be produced from electrical operating plants and distribution systems. Some bonds are for a single issuer, who constructs and operates power plants and then sells the electricity. Other public power revenue bonds are issued by groups of public and private investor-owned utilities for the joint financing of the construction of one or more power plants. This last arrangement is known as a *joint power* financing structure. During the past several years, this sector started to undergo the most dramatic changes since electricity was invented. In many states the electric utility industry is transforming to a deregulated industry. In a deregulated environment, customers will have the ability to choose an electric provider; therefore, electric providers will face competition. This means that this sector will experience new and different challenges, and investors will need to analyze this sector differently.

Public-Private Partnerships (PPPs)

Privatization is a form of municipal financing where a private company pays a large payment to operate, and often build or improve, a governmental asset (e.g., usually toll roads). The purchaser issues debt to help finance this large upfront cost, and the operating revenues are pledged to repay bondholders.

Resource Recovery Revenue Bonds

A resource recovery facility converts refuse (solid waste) into commercially salable energy, recoverable products, and a residue to be landfilled. The major revenues for a resource recovery revenue bond usually are (1) the "tipping fees" per ton paid by those who deliver the garbage to the facility for disposal; (2) revenues from steam, electricity, or refuse-derived fuel sold to either an electrical power company or another energy user; and (3) revenues from the sale of recoverable materials such as aluminum and steel scrap.

Seaport Revenue Bonds

The security for seaport revenue bonds can include specific lease agreements with the benefiting companies or pledged marine terminal and cargo tonnage fees.

Sewer Revenue Bonds

Revenues for sewer revenue bonds come from hookup fees and user charges. For many older sewer bond issuers, substantial portions of their construction budgets have been financed with federal grants.

Single-Family Mortgage Revenue Bonds

Single-family mortgage revenue bonds usually are secured by the mortgages and mortgage loan repayments on single-family homes. Security features vary but can include Federal Housing Administration (FHA), Federal Veterans Administration (VA), and private mortgage insurance.

Sports Complex and Convention Center Revenue Bonds

Sports complex and convention center revenue bonds usually receive revenues from sporting or convention events held at the facilities and, in some instances, from earmarked outside revenues such as local motel and hotel room taxes.

Student Loan Revenue Bonds

Student loan revenue bonds usually are issued by state agencies or not-for-profit organizations and are used for purchasing student loans for higher education. Depending on the security structure, bondholders' payment can include student loan repayments and federal payments.

Tax-Allocation Bonds

These bonds are usually issued to finance the construction of office buildings and other new buildings in formerly blighted areas. They are secured by property taxes collected on the improved real estate.

Tobacco Revenue Bonds

Some tobacco bonds are solely secured by revenues in the Master Settlement Agreement (MSA) annually paid to states by cigarette companies.

Toll Road and Gas Tax Revenue Bonds

There are generally two types of highway revenue bonds. The bond proceeds of the first type are used to build such specific revenue-producing facilities as toll roads, bridges, and tunnels. For these pure enterprise-type revenue bonds, the pledged revenues usually are the monies collected through the tolls. The second type of highway bond is one in which the bondholders are paid by earmarked revenues outside toll collections, such as gasoline taxes, automobile registration payments, and driver's license fees.

Tribal Casino Bonds

Native American governments in general finance the construction of their casino gaming facilities by issuing debt. Tribal casino bonds derive their revenues from the gaming operations of these facilities.

Water Revenue Bonds

Water revenue bonds are issued to finance the construction of water treatment plants, pumping stations, collection facilities, and distribution systems. Revenues usually come from connection fees and charges paid by the users of the water systems.

Hybrid and Special Bond Securities

Although having certain characteristics of general obligation and revenue bonds, the following types of municipal bonds have more unique security structures as well.

Refunded Bonds

Although originally issued as either revenue or general obligation bonds, municipals are sometimes *refunded.* A refunding usually occurs when the original bonds are escrowed or collateralized either by direct obligations guaranteed by the U.S. government or other types of securities. The maturity schedules of the securities in the escrow fund are such that they pay when due the bond's maturity value, coupon, and premium payments (if any) on the refunded bonds. Once this cash-flow match is in place, the refunded bonds are no longer secured as either general obligation or revenue bonds. The bonds are now supported by the securities held in the escrow fund. Such bonds, if escrowed with securities guaranteed by the U.S. government, have little if any credit risk. They are the safest municipal bond investments available.

Usually, an escrow fund is an irrevocable trust established by the original bond issuer with a commercial bank or state treasurer's office. Government securities are deposited in an escrow fund that will be used to pay debt service on the refunded bonds. A *pure* escrow fund is one in which the deposited securities are solely direct or guaranteed obligations of the U.S. government, whereas a *mixed* escrow fund is one in which the permitted securities, as defined by the trust indenture, are not exclusively limited to direct or guaranteed U.S. government securities. Other securities that could be placed in mixed escrow funds include federal agency bonds, certificates of deposit from banks, other municipal bonds, and even annuity policies from commercial insurance companies. The escrow agreement should indicate what is in the escrow fund and if substitutions of lower-credit-quality investments are permitted.

Still another type of refunded bond is a *crossover refunded bond.* Typically, proceeds from crossover refunding bonds are used to purchase securities that are placed in an escrow account. Usually, the crossover refunding bonds are secured by maturing principal and interest from the escrowed securities *only until the crossover date,* and the bonds to be refunded continue to be secured by the issuer's own revenues until the crossover date, which is usually the first call date of the bonds to be refunded. On that date, the crossover occurs, and the bonds to be refunded are redeemed from maturing securities in the escrow fund, which could include U.S. government securities or other investments, such as certificates of deposit. In turn, the security for the refunding bonds reverts back to the issuer's own revenues.

Here we focus primarily on the pure escrow-backed bonds, not the mixed escrow or crossover bonds. The escrow fund for a refunded municipal bond can be structured so that the refunded bonds are to be called at the first possible date or a subsequent call date established in the original bond indenture. The call price usually includes a premium of from 1% to 3% above par. This type of structure usually is used for those refundings that either reduce the issuer's interest payment expenses or change the debt maturity schedule. Such bonds are known in the industry as *prerefunded* municipal bonds. Prerefunded municipal bonds usually are to be retired at their first or subsequent respective callable dates, but some

escrow funds for refunding bonds have been structured differently. In such refundings, the maturity schedules of the securities in the escrow funds match the regular debt-service requirements on the bonds as originally stated in the bond indentures. Such bonds are known as *escrowed-to-maturity,* or ETM, bonds. It should be noted that under the Tax Reform Law of 1986, such ETM refundings still can be done. In the secondary market there may be ETM refunded municipal bonds outstanding. However, we note that the investor or trader should determine whether all earlier calls have been legally defeased before purchasing an ETM bond.

Dedicated Tax-Backed and Structured Asset-Backed Bonds

More recently, states and local governments have issued increasing amounts of bonds in which the debt service is to be paid from so-called dedicated revenues such as sales taxes, tobacco settlement payments, fees, and penalty payments. Many are structured to mimic the asset-backed bonds that are common in the taxable market. The "assets" providing the security for the municipal bonds are the "dedicated" revenues instead of credit card receivables, home equity loans, and auto loan repayments that are commonly used to secure the taxable asset-backed bonds.

Insured Bonds

Insured bonds, in addition to being secured by the issuer's revenues, are also backed by insurance policies written by commercial insurance companies. The insurance, usually structured as an insurance contract, is supposed to provide prompt payment to the bondholders if a default should occur. These bonds are discussed in more detail later in this chapter.

Lease-Backed Bonds

Lease-backed bonds usually are structured as revenue-type bonds with annual payments. In some instances the payments may come only from earmarked tax revenues, student tuition payments, or patient fees. In other instances the underlying lessee governmental unit makes annual appropriations from its general fund.

Letter of Credit–Backed Bonds

Some municipal bonds, in addition to being secured by the issuer's cash-flow revenues, also are backed by commercial bank letters of credit. In some instances the letters of credit are irrevocable and, if necessary, can be used to pay the bondholders. In other instances the issuers are required to maintain investment-quality worthiness before the letters of credit can be drawn on.

Moral Obligation Bonds

A moral obligation bond is a security structure for state-issued bonds that indicates that if revenues are needed for paying bondholders, the state legislature involved is legally authorized, although not required, to make an appropriation out of general state tax revenues.

Territorial Bonds

These are bonds issued by U.S. territorial possessions such as Puerto Rico, the Virgin Islands, and Guam. The bonds are tax-exempt throughout most of the country. Also, the economies of these issuers are influenced by positive special features of the U.S. corporate tax codes that are not available to the states.

Troubled City Bailout Bonds

There are certain bonds that are structured to appear as pure revenue bonds but in essence are not. Revenues come from general-purpose taxes and revenues that otherwise would have gone to a state's or city's general fund. Their bond structures were created to bail out underlying general obligation bond issuers from severe budget deficits. Examples were the New York State Municipal Assistance Corporation for the City of New York Bonds (MAC) and the state of Illinois Chicago School Finance Authority Bonds.

Money Market Products

Tax-exempt money market products include notes, commercial paper, variable-rate demand obligations, and a hybrid of the last two products.

Notes

Municipal notes include tax anticipation notes (TANs), revenue anticipation notes (RANs), grant anticipation notes (GANs), and bond anticipation notes (BANs). These are temporary borrowings by states, local governments, and special jurisdictions. Usually, notes are issued for a period of 12 months, although it is not uncommon for notes to be issued for periods of as short as three months and for as long as three years. TANs and RANs (also known as TRANs) are issued in anticipation of the collection of taxes or other expected revenues. These are borrowings to even out the cash flows caused by the irregular flows of income into the treasuries of the states and local units of government. BANs are issued in anticipation of the sale of long-term bonds.

Tax-exempt money market products generally have some type of credit support. This may come in the form of an irrevocable letter of credit, a line of credit, municipal bond insurance policy, an escrow agreement, a bond purchase agreement, or a guaranteed investment contract. With a bond purchase agreement, a bank obligates itself to purchase the debt if the remarketing agent cannot resell the instrument or make a timely payment. In the case of a guaranteed investment contract, either an insurance company or a bank invests sufficient proceeds so that the cash-flow generated from a portfolio of supporting assets can meet the obligation of the issue.

Commercial Paper

As with commercial paper issued by corporations, tax-exempt commercial paper is used by municipalities to raise funds on a short-term basis ranging from one to

270 days. The dealer sets interest rates for various maturity dates, and the investor then selects the desired date. Thus the investor has considerable choice in selecting a maturity to satisfy investment objectives.

Variable-Rate Demand Obligations

Variable-rate demand obligations (VRDOs) are floating-rate obligations that have a nominal long-term maturity but have a coupon rate that is reset either daily or every 7 days. The investor has an option to put the issue back to the trustee at any time with 7 days' notice or the same day in the case of a daily VRDO. The put price is par plus accrued interest.

Commercial Paper Mode

The commercial paper mode is customized to meet the cash-flow needs of an investor. As with tax-exempt commercial paper, there is flexibility in structuring the maturity because the remarketing agent establishes interest rates for a range of maturities. Although the instrument may have a long nominal maturity, there is a put provision as with a VRDO. Put periods can range from one day to more than 360 days. On the put date, the investor can put back the bonds, receiving principal and interest, or the investor can elect to extend the maturity at the new interest rate and put date posted by the remarketing agent at that time. Thus the investor has two choices when initially purchasing this instrument: the interest rate and the put date. Interest generally is paid on the put date if the date is within 180 days. If the put date is more than 180 days forward, interest is paid semiannually. Some commercial paper dealers market these products under a proprietary name, but most do so simply as money market municipals.

Municipal Derivative Securities

In recent years, a number of municipal products have been created from the basic fixed-rate municipal bond. This has been done by splitting up cash flows of newly issued bonds as well as bonds existing in the secondary markets. These products have been created by dividing the coupon interest payments and principal payments into two or more bond classes, or *tranches*. The resulting bond classes may have far different yield and price volatility characteristics than the underlying fixed-rate municipal bond from which they were created. By expanding the risk/return profile available in the municipal marketplace, institutional investors have more flexibility in structuring municipal bond portfolios either to satisfy a specific asset/liability objective or to make an interest rate or yield-curve bet more efficiently.

The name *derivative securities* has been attributed to these bond classes because they derive their value from the underlying fixed-rate municipal bond. Much of the development in this market has paralleled that of the taxable and, specifically, the mortgage-backed securities market. The ability of investment bankers to create these securities has been enhanced by the development of the municipal swap market.

A common type of derivative security is one in which two classes of securities, a *floating-rate security* and an *inverse floating-rate bond,* are created from a fixed-rate bond. Two types of inverse floaters dominated the market: auction rate securities and the later-developed tender option bond (TOB) product. TOB programs, in various forms, have existed since the beginning to middle 1980s. Widespread use did not occur until the 1990s.

In 2008, when failed auctions occurred, new issuance of auction rate securities ended. Functionally, TOBs are similar to the auction rate product. Both derivatives are inverse floaters. Auction rate floaters, however, were sold primarily to corporations and individuals, whereas TOB floaters are sold to money market funds. Tax-exempt money market funds have a continuous need for tax-exempt interest. This demand provided a stable buying base for the TOB floaters. To take advantage of this money market demand, TOBs feature a liquidity facility, which makes these floating-rate derivatives putable and therefore money market eligible. These liquidity facilities typically last 364 days and are provided by highly rated banks or broker-dealers.

TOBs are created through trusts. Given this structure, certain provisions must exist for the unwinding of a TOB. For example, if the remarketing agent fails to sell out the floating-rate class or the underlying bond falls below a minimum collateral value, a mandatory tender event is triggered. When a mandatory tender event occurs, the liquidity provider pays the floater holder par plus accrued interest. The trustee simultaneously terminates the trust and liquidates the bonds. The proceeds from this sale are used to first pay par plus accrued interest to the liquidity provider and then any accrued fees. Finally, the inverse floating-rate investor receives the residual value.

Several proprietary programs have been developed to market and sell plain vanilla TOBs, which are used by mutual bond funds, insurance companies *and crossover buyers*. Additionally, at times TOBs are used in more exotic combination trades by a few Wall Street structured products areas. Citigroup's proprietary program is referred to as "ROCs & ROLs." The short-term certificates are called *ROCs* or *Residual Option Certificates*. The inverse-floaters are called the *ROLs* or *Residual Option Longs*. Barclays' certificates are called RIBS and Trust Receipts.

THE COMMERCIAL CREDIT RATING OF MUNICIPAL BONDS

Of the municipal bonds that were rated by a commercial rating company in 1929 and plunged into default in 1932, 78% had been rated double-A or better, and 48% had been rated triple-A. Since then, the ability of rating agencies to assess the creditworthiness of municipal obligations has evolved to a level of general industry acceptance and respectability. In most instances, they adequately describe the financial conditions of the issuers and identify the credit-risk factors. However, a small but significant number of relatively recent instances have caused market participants to reexamine their reliance on the opinions of the rating agencies.

As examples, the troubled bonds of the Washington Public Power Supply System (WPPSS) and Orange County, California, should be mentioned. Two major commercial rating companies, Moody's and Standard & Poor's, gave their highest ratings to the WPPSS bonds in the early 1980s. Moody's gave the WPPSS Projects 1, 2, and 3 bonds its very highest credit rating of Aaa and the Projects 4 and 5 bonds its rating of Al. This latter investment-grade rating is defined as having the strongest investment attributes within the upper medium grade of creditworthiness. Standard & Poor's also had given the WPPSS Projects 1, 2, and 3 bonds its highest rating of AAA and Projects 4 and 5 bonds its rating of A. While these high-quality ratings were in effect, WPPSS sold more than $8 billion in long-term bonds. By 1990, more than $2 billion of these bonds were in default.

Orange County, California, also had very strong credit ratings before its filing for bankruptcy protection on December 6, 1994. This would be the largest municipal bankruptcy filing in U.S. history. The Orange County debacle was unique. The county's problem was not caused by local economic problems, like Philadelphia's crisis in the early 1990s, nor was it caused by budget problems, like New York City's situation in 1975. Orange County's problem was created by the county Treasurer–Tax Collector's investment strategy for the Orange County Investment Pool. The investment pool was highly leveraged and contained a large percentage of inverse floaters. As interest rates rose in 1994, the value of the investments decreased, and the institutions that provided the financial leverage decided to terminate those financial agreements. The problem was that if the investment pool were liquidated, the amount of assets would be insufficient to cover all the loans. Since the pool did not have sufficient assets to cover its debt, the county chose to seek the safety of bankruptcy protection.

The county's voluntary bankruptcy filing was unprecedented. It was a signal to investors that the county did not necessarily intend to repay all its obligations. In most other cases of severe financial hardship, the municipalities tried to meet all their obligations and did not even suggest that they might wish not to fulfill their obligations. What troubled most investors was that Orange County was a vibrant and economically strong area and in all likelihood could fulfill its obligations. This created a different situation for investors and brought the question of an issuer's ability to pay versus its willingness to pay. This was something that municipal investors rarely, if ever, questioned before Orange County.

Another area investors rarely questioned prior to Orange County was the investment strategies that were being used to manage operating fund investments and other state and local investment funds or pools. It was a common perception that state and local government finance officials invested conservatively and followed policies that emphasized safety of principal and maintenance of liquidity. Immediately following the onset of the Orange County debacle, large investors started to question state and local officials on their investment policies and their use of financial leverage and derivative securities. Because Orange County received high-quality credit ratings prior to its problems, investors started to question the reliability of the commercial credit-rating agencies.

The Washington Public Power Supply System and Orange County, California, are the more notable issuers that had high-quality ratings prior to their problems, but they are not isolated instances. In fact, since 1975, all the major municipal defaults in the industry initially had been given investment-grade ratings by Moody's and Standard & Poor's. Of course, it should be noted that in the majority of instances, ratings of the commercial rating companies adequately reflect the condition of the credit. However, unlike 35 years ago, when the commercial rating companies would not rate many kinds of revenue bond issues, today they seem to view themselves as assisting in the capital formation process.

After criticism by some public officials on the federal and state levels, we note that in 2009 the rating agencies recalibrated their ratings upward on many general obligation and essential service revenue bonds. They argued that municipal bond issues should have higher ratings relative to corporate bonds because of historical default rates and recovery levels. This resulted in higher ratings on many municipal bonds.

Today, many large institutional investors, underwriters, and traders use the ratings of the commercial rating agencies as starting points and rely on their own in-house municipal credit analysts for determining the creditworthiness of municipal bonds. However, other investors do not perform their own credit-risk analysis but instead rely entirely on credit-risk ratings by Moody's, Standard & Poor's, and Fitch. In this section we discuss the rating categories of these three commercial rating companies.

Moody's Investors Service

The municipal bond rating system used by Moody's grades the investment quality of municipal bonds in a nine-symbol system that ranges from the highest investment quality, which is Aaa, to the lowest credit rating, which is C. The respective nine alphabetical ratings and their definitions are found in Exhibit 11–1.

Municipal bonds in the top four categories (Aaa, Aa, A, and Baa) are considered to be of investment-grade quality. Speculative or noninvestment grade ratings incorporate the five lower rating grade categories (Ba, B, Caa, Ca, and C). Additionally, bonds in the Aa through Caa categories are refined by numeric modifiers 1, 2, and 3, with 1 indicating the top third of the rating category, 2 the middle third, and 3 the bottom third.

The municipal note rating system used by Moody's is designated by investment-grade categories of Moody's Investment Grade (MIG), and one speculative grade category; SG as shown in Exhibit 11–2.

Moody's also provides credit ratings for tax-exempt commercial paper. These are promissory obligations not having an original maturity in excess of nine months. Moody's uses three designations, all considered to be of investment grade, and one speculative grade category for indicating the relative repayment capacity of the rated issuers, as shown in Exhibit 11–3.

EXHIBIT 11–1

Moody's Municipal Bond Ratings

Rating	Definition
Aaa	Highest quality, minimal credit risk
Aa	High quality, very low credit risk
A	Upper medium grade, low credit risk
Baa	Moderate credit risk
Ba	Speculative elements, substantial credit risk
B	Speculative, high credit risk
Caa	Poor standing, very high credit risk
Ca	Highly speculative, in or near default
C	In default with no recovery expected

EXHIBIT 11–2

Moody's Municipal Note Ratings*

Rating	Definition
MIG 1	Excellent Protection
MIG 2	Strong quality
MIG 3	Acceptable quality
SG	Speculative Grade

*A short issue having a demand feature (i.e., payment relying on external liquidity and usually payable on demand rather than fixed maturity dates) is differentiated by Moody's with the use of the symbols *VMIG1* through *VMIG3*, and *VSG*.

EXHIBIT 11–3

Moody's Tax-Exempt Commercial Paper Ratings

Rating	Definition
Prime 1 (P-1)	Superior capacity for repayment
Prime 2 (P-2)	Strong capacity for repayment
Prime 3 (P-3)	Acceptable capacity for repayment
NP	Not Prime Grade

Standard & Poor's

The municipal bond rating system used by Standard & Poor's grades the investment quality of municipal bonds in a 10-symbol system that ranges from the highest investment quality, which is AAA, to the lowest credit rating, which is D.[3] Bonds within the top four categories (AAA, AA, A, and BBB) are considered by Standard & Poor's as being of investment-grade quality. The respective 10 alphabetical ratings and definitions are shown in Exhibit 11–4.

Standard & Poor's also uses a plus (+) or minus (–) sign to show relative standing within the rating categories ranging from AA to CCC.

The municipal note rating system used by Standard & Poor's grades the investment quality of municipal notes in a four-symbol system that ranges from highest investment quality, SP-1, to the lowest credit rating, SP-3. Notes within the top three categories (i.e., SP-1, SP-2, and SP-3) are considered by Standard & Poor's as being of investment-grade quality. SP-3 is the speculative category. The respective ratings and summarized definitions are shown in Exhibit 11–5.

Standard & Poor's also rates tax-exempt commercial paper. The tax-exempt commercial paper rating categories are shown in Exhibit 11–6.

Fitch

The third rating company is Fitch. The alphabetical ratings and definitions used by Fitch are given in Exhibit 11–7. Plus (+) and minus (–) signs are used with a

EXHIBIT 11–4

Standard & Poor's Municipal Bond Ratings

Rating	Definition
AAA	Highest rating; extremely strong security
AA	Very strong security
A	Somewhat more susceptible to adverse economic effects than two above categories
BBB	Adequate capacity but adverse economic conditions more likely to weaken capacity
BB	Lowest degree of speculation; risk exposure
B	Speculative; risk exposure
CCC	Speculative; major risk exposure
CC	Highly vulnerable to nonpayment
C	Bankruptcy petition may be filed
D	Bonds in default with interest and/or repayment of principal in arrears

3. www.standardandpoors.com. Standard & Poor's Ratings Definitions, August 20, 2010.

EXHIBIT 11–5

Standard & Poor's Municipal Note Ratings

Rating	Definition
SP-1	Strong capacity to pay principal and interest. Those issues determined to possess overwhelming safety characteristic will be given a plus (+) designation.
SP-2	Satisfactory capacity to pay principal and interest.
SP-3	Speculative capacity to pay principal and interest.

EXHIBIT 11–6

Standard & Poor's Tax-Exempt Commercial Paper Ratings

Rating	Definition
A-1+	Extremely strong degree of safety
A-1	Strong degree of safety
A-2	Satisfactory degree of safety
A-3	Adequate degree of safety
B	Speculative capacity for timely payment
C	Doubtful capacity for payment
D	Used when principal or interest payments are not made on the due date

EXHIBIT 11–7

Fitch Municipal Bond Ratings

Rating	Definition
AAA	Highest credit quality
AA	Very high credit quality
A	High credit quality
BBB	Good
BB	Speculative
B	Highly speculative
CCC	Substantial credit risk
CC	Very high levels of credit risk
C	Exceptionally high levels of credit risk
D	Default

rating to indicate the relative position of a credit within the rating category.[4] Plus and minus signs are not used for the AAA category.

Additionally, Fitch assigns ratings for obligations that are due up to 36 months. The rating scale has three investment grade symbols, F1 (the highest), F2, and F3. There are two speculative scales, B and C. There is a rating RD for an entity that has defaulted on one or more of its financial commitments, although it is meeting other financial obligations. Lastly, D indicates a broad-based default event for an entity, or the default of a short-term obligation.

MUNICIPAL BOND INSURANCE

Using municipal bond insurance was considered for many years one way to help reduce credit risk within a portfolio. Because of this, it had great appeal to retail investors. Insurance on a municipal bond was an agreement by an insurance company to pay debt service that is not paid by the bond issuer. Municipal bond insurance contracts insure the payment of debt service on a municipal bond to the bondholder. That is, the insurance company promised to pay the issuer's obligation to the bondholder if the issuer did not do so.

The insurance usually was for the life of the issue. If the trustee or investor had not had his bond paid by the issuer on its due date, he notified the insurer and presented the defaulted bond and coupon. Under the terms of the insurance contract, the insurer generally was obligated to pay sufficient monies to cover the value of the defaulted insured principal and coupon interest when they came due.

Because it was believed that municipal bond insurance reduced the credit risk for the investor, the marketability of certain municipal bonds was greatly expanded. Municipal bonds that benefited most from the insurance would include lower-quality bonds, bonds issued by smaller governmental units not widely known in the financial community, bonds that had a sound although complex and difficult-to-understand security structure, and bonds issued by infrequent local government borrowers who do not have a general market following among investors.

Of course, a major factor for an issuer to obtain bond insurance was that its creditworthiness without the insurance was substantially lower than what it would be with the insurance. That is, the interest cost savings were only of sufficient magnitude to offset the cost of the insurance premium when the underlying creditworthiness of the issuer was lower. There were two major groups of municipal bond insurers. The first includes the "monoline" companies that were primarily in the business of insuring financial securities, including municipal bonds. Almost all the companies that insured municipal bonds could be characterized as monoline in structure. The second group of municipal bond insurers included the "multiline" property and casualty companies that usually had a wide base of business, including insurance for fires, collisions, hurricanes, and health problems.

4. www.fitchratings.com, Fitch Ratings, January 14, 2011.

While for many years until 2008, the majority of insured bonds were with the monoline insurers—most of whom had AAA ratings from all three agencies, and captured 50% of the new issue market—this dramatically changed. With massive defaults in their taxable books of insured bonds, they were rapidly downgraded and faced insolvency. In 2010, with only one monoline insurer left with a single AAA rating, the market share was down to 6%. Toward the end of 2010 Standard & Poor's downgraded that insurer to AA+ from AAA.

VALUATION METHODS

The traditional method for evaluating municipal bonds is relatively straightforward. First, an investor determines the maturity of the bond, considers the offered price (discount, par, or premium), evaluates any call features or sinking funds, and then considers credit quality. If it is a premium bond and callable, then the investor places more emphasis on the call dates. If the bond is callable and sells at a discount, then the calls are not much of a factor, and the bond is valued using its maturity date. Basically, the investor is determining the relative attractiveness of the bond based on a yield-to-worst calculation. The credit quality is quantified, and the appropriate yield premium for the specific credit quality is added to the base yield-to-worst calculation. Because investors do not perform an option-adjusted spread (OAS) analysis, the yield premium that is applied is a nominal yield premium. The benchmark yields that are used to value the bonds come from a variety of sources, such as yield levels from the primary market, trading levels of similar bonds in the secondary market, and benchmark (triple-A GO, generic sector, state-specific) interest-rate curves.

An investor interested in purchasing a municipal bond must be able to compare the promised yield on a municipal bond with that of a comparable taxable bond. Employing the yield computed with traditional approaches, the following general formula is used to determine the *equivalent taxable yield* for a tax-exempt bond:

$$\text{Equivalent taxable yield} = \frac{\text{tax} - \text{exempt yield}}{(1 - \text{marginal tax rate})}$$

For example, suppose that an investor in the 40% marginal tax bracket is considering the acquisition of a tax-exempt bond that offers a tax-exempt yield of 6%. The equivalent taxable yield is 10%, as shown below:

$$\text{Equivalent taxable yield} = \frac{0.06}{(1 - 0.40)} = 0.10 = 10\%$$

When computing the equivalent taxable yield, the traditionally computed yield-to-maturity is not the tax-exempt yield if the issue is selling below par (i.e., selling at a discount) because only the coupon interest is exempt from federal income taxes. Instead, the yield-to-maturity after an assumed capital gains tax is computed and used in the numerator of the formula.

The yield-to-maturity after an assumed capital gains tax is calculated in the same manner as the traditional yield-to-maturity. However, instead of using the redemption value in the calculation, the net proceeds after an assumed tax on any capital gain are used.

There is a major drawback in employing the equivalent taxable yield formula to compare the relative investment merits of a taxable and tax-exempt bond. Recall from the discussion in Chapter 6 that the yield-to-maturity measure assumes that the entire coupon interest can be reinvested at the computed yield. Consequently, taxable bonds with the same yield-to-maturity cannot be compared because the total dollar returns may differ from the computed yield. The same problem arises when attempting to compare taxable and tax-exempt bonds, especially because only a portion of the coupon interest on taxable bonds can be reinvested, although the entire coupon payment is available for reinvestment in the case of municipal bonds. The total return framework that should be employed to compare taxable and tax-exempt bonds is discussed in Chapter 6.

The traditional method of evaluating a municipal bond leaves much to be desired. The basic problem is that the call risk is not analyzed properly. The yield-to-worst calculation ignores the fact that interest rates can change in the future, and the actual timing of the cash flows may not be the same as what was projected. If an investor evaluates a bond to its maturity date, then this investor will be surprised if the bonds are called several years earlier. Conversely, if the investor evaluates a bond to a specific call date and the bond is not called, then this investor will realize a stream of cash flows that is different from what was anticipated. The result of the traditional methodology is that most callable municipal bonds are priced too richly, and the cost of noncallable bonds with extra convexity is cheap. This is especially true for longer-dated bonds. More information about OAS analysis can be found in Chapter 40.

TAX PROVISIONS AFFECTING MUNICIPALS

Federal tax rate levels affect municipal bond values and strategies employed by investors. There are three provisions in the Internal Revenue Code that investors in municipal securities should recognize. These provisions deal with the tax treatment of OIDs, alternative minimum tax, and the deductibility of interest expense incurred to acquire municipal securities. Moreover, there are state and local taxes about which an investor must be aware.

Tax Treatment of Original-Issue Discount Bonds

When purchasing OIDs in the secondary market, investors should analyze the bond carefully owing to the complex tax treatment of OIDs. Few investors think about tax implications when investing in municipal debt. After all, the interest earned on most municipal bonds is exempt from federal taxes. If investors do

think about taxes, they probably think about selling bonds at a higher price than the original tax cost. Most investors believe that this would create a capital gain and absent this situation there should be no tax impact. Sounds straightforward, but the municipal world isn't simplistic. Several years ago the marketplace was introduced to the Revenue Reconciliation Act of 1993, and since then investing in municipals has become more complex. Currently, profit from bonds purchased in the secondary market after April 30, 1993, could be free from any tax implications or taxed at the capital gains rate, ordinary income rate, or a combination of the two rates. To understand this situation, it is essential to understand the rule of de minimus.

In basic terms, the *rule of de minimus* states that a bond is to be discounted up to 0.25% from the face value for each remaining year of a bond's life before it is affected by ordinary income taxes. This price is commonly referred to as the "market discount cutoff price." If the bond is purchased at a market discount but the price is higher than the market discount cutoff price, then any profits will be taxed at the capital gains rate. If the purchase price is lower than the market discount cutoff price, then any profits may be taxed as ordinary income or a combination of the ordinary income rate and the capital gains rate. The exact tax burden depends on several factors.

The rule of de minimus is especially complicated for OID bonds. For these bonds, a revised issue price must be calculated, as well as the market discount cutoff price. The revised issue price does change over time because the OID must be accreted over the life of the bond. The rule of de minimus does not apply to the OID segment, but it does apply to the market discount segment. The market discount segment is equal to the purchase price (secondary market price) minus the revised issue price. If an OID bond is purchased in the secondary market at a price greater than the revised issue price, the bond is considered to have an acquisition premium, and the rule of de minimus does not apply. If the OID bond is purchased at a price below the revised issue price and above the market discount cutoff price, then the OID bond is purchased at a market discount, and any profits will be taxed at the capital gains rate. Finally, if the purchase price of the OID bond is lower than the market discount cutoff price, then any profits may be taxed as ordinary income or a combination of the ordinary income rate and the capital gains rate. The OID topic is complicated. More specific details can be found in the Internal Revenue Service (IRS) Publications.

Alternative Minimum Tax

Alternative minimum taxable income (AMTI) is a taxpayer's taxable income with certain adjustments for specified tax preferences designed to cause AMTI to approximate economic income. For both individuals and corporations, a taxpayer's liability is the greater of (1) the tax computed at regular tax rates on taxable income and (2) the tax computed at a lower rate on AMTI. This parallel tax system, the alternative minimum tax (AMT), is designed to prevent taxpayers

from avoiding significant tax liability as a result of taking advantage of exclusions from gross income, deductions, and tax credits otherwise allowed under the Internal Revenue Code.

There are different rules for determining AMTI for individuals and corporations. The latter are required to calculate their minimum tax liability using two methods. Moreover, there are special rules for property and casualty companies.

One of the tax preference items that must be included is certain tax-exempt municipal interest. As a result of the AMT, the value of the tax-exempt feature is reduced. However, the interest of some municipal issues is not subject to the AMT. Under the current tax code, tax-exempt interest earned on all private activity bonds issued after August 7, 1986 must be included in AMTI. There are two exceptions. First, interest from bonds that are issued by 501(c)(3) organizations (i.e., not-for-profit organizations) is not subject to AMTI. The second exception is interest from bonds issued for the purpose of refunding if the original bonds were issued before August 7, 1986. The AMT does not apply to interest on governmental or nonprivate activity municipal bonds. An implication is that the issues subjected to the AMT will trade at a higher yield than those exempt from AMT.

Deductibility of Interest Expense Incurred to Acquire Municipals

Some investment strategies involve the borrowing of funds to purchase or carry securities. Ordinarily, interest expense on borrowed funds to purchase or carry investment securities is tax deductible. There is one exception that is relevant to investors in municipal bonds. The IRS specifies that interest paid or accrued on "indebtedness incurred or continued to purchase or carry obligations, the interest on which is wholly exempt from taxes," is not tax deductible. It does not make any difference if any tax-exempt interest is actually received by the taxpayer in the taxable year. In other words, interest is not deductible on funds borrowed to purchase or carry tax-exempt securities.

Special rules apply to commercial banks. At one time, banks were permitted to deduct all the interest expense incurred to purchase or carry municipal securities. Tax legislation subsequently limited the deduction first to 85% of the interest expense and then to 80%. The 1986 tax law eliminated the deductibility of the interest expense for bonds acquired after August 6, 1986. The exception to this nondeductibility of interest expense rule is for *bank-qualified issues.* These are tax-exempt obligations sold by small issuers after August 6, 1986, and purchased by the bank for its investment portfolio.

An issue is bank-qualified if (1) it is a tax-exempt issue other than private activity bonds, but including any bonds issued by 501(c)(3) organizations, and (2) it is designated by the issuer as bank-qualified and the issuer or its subordinate entities reasonably do not intend to issue more than $10 million of such bonds. A nationally recognized and experienced bond attorney should include in the opinion letter for the specific bond issue that the bonds are bank-qualified.

State and Local Taxes

The tax treatment of municipal bonds varies by state. There are three types of taxes that can be imposed: (1) an income tax on coupon income, (2) a tax on realized capital gains, and (3) a personal property tax.

Many states levy an individual income tax. Coupon interest from obligations by in-state issuers is exempt from state individual income taxes in most states. A few states levy individual income taxes on coupon interest whether the issuer is in state or out of state.

State taxation of realized capital gains is often ignored by investors when making investment decisions. In many states, a tax is levied on a base that includes income from capital transactions (i.e., capital gains or losses). In many states in which coupon interest is exempt if the issuer is in state, the same exemption will not apply to capital gains involving municipal bonds.

Some states levy a personal property tax on municipal bonds. The tax resembles more of an income tax than a personal property tax. Before 1995, some state and local governments levied this tax on residents who owned municipal bonds where the issuer of the bond was located outside the investor's home state. While residents owning municipal bonds where the issuer was located within the investor's home state's boundaries were exempt from such tax, this tax was declared unconstitutional by the U.S. Supreme Court because it violated the federal commerce clause by favoring in-state businesses over out-of-state business. The determining case was *Fulton Corporation* v. *Janice H. Faulkner, Secretary of Revenue of North Carolina,* No. 94-1239 (U.S. S.C. Feb. 21, 1996). After the court ruled on this case, many state and local governments that levied a similar tax repealed the tax or chose not to collect it.

In determining the effective tax rate imposed by a particular state, an investor must consider the impact of the deductibility of state taxes on federal income taxes. Moreover, in some states, *federal* taxes are deductible in determining state income taxes.

YIELD RELATIONSHIPS WITHIN THE MUNICIPAL BOND MARKET

In this section, we briefly look at some important yield relationships within the municipal bond market.

Differences within an Assigned Credit Rating

Bond buyers primarily use the credit ratings assigned by the commercial rating companies, Standard & Poor's, Moody's, and Fitch as a starting point for pricing an issue. The final market-derived bond price is determined by the assigned credit rating and adjustments by investors to reflect their own analysis of creditworthiness and perception of marketability. For example, insured municipal

bonds—when they were a dominant factor in the market—tended to have yields that were substantially higher than noninsured superior-investment-quality municipal bonds, even though most insured bonds were given triple-A ratings by the commercial rating companies. Additionally, many investors have geographic preferences among bonds despite identical credit quality and otherwise comparable investment characteristics.

Differences between Credit Ratings

With all other factors constant, the greater the credit risk perceived by investors, the higher the return expected by investors. The spread between municipal bonds of different credit quality is not constant over time. Reasons for the change in spreads are (1) the outlook for the economy and its anticipated impact on issuers, (2) federal budget financing needs, and (3) municipal market supply-and-demand factors. During periods of relatively low interest rates, investors sometimes increase their holdings of issues of lower credit quality in order to obtain additional yield. This narrows the spread between high-grade and lower-grade credit issues. During periods in which investors anticipate a poor economic climate, there is often a "flight to quality" as investors pursue a more conservative credit-risk exposure. This widens the spread between high-grade and lower-grade credit issues.

Another factor that causes shifts in the spread between issues of different quality is the temporary oversupply of issues within a market sector. For example, a substantial new issue volume of high-grade state general obligation bonds may tend to decrease the spread between high-grade and lower-grade revenue bonds. In a weak market environment, it is easier for high-grade municipal bonds to come to market than for weaker credits. Therefore, it is not uncommon for high grades to flood weak markets at the same time that there is a relative scarcity of medium- and low-grade municipal bond issues.

Differences between In-State and General Market

Bonds of municipal issuers located in certain states (e.g., New York, New Jersey, California, Arizona, Maryland, and Pennsylvania) usually yield considerably less than issues of identical credit quality that come from other states that trade in the "general market." There are three reasons for the existence of such spreads. First, states often exempt interest from in-state issues from state and local personal income taxes. Interest from out-of-state issues is generally not exempt. Consequently, in states with high income taxes (e.g., New York and California), strong investor demand for in-state issues will reduce their yields relative to bonds of issues located in states in which state and local income taxes are not important considerations (e.g., Illinois and Wisconsin). Of course, it should be noted that bonds of Puerto Rico and other U.S. territorial governments are also exempt from state and local taxation, and enjoy these yield advantages. Second, in some states, public funds deposited in banks must be collateralized by the bank accepting the deposit.

This requirement is referred to as "pledging." Acceptable collateral for pledging typically will include issues of certain in-state issuers. For those qualifying issues, pledging tends to increase demand (particularly for the shorter maturities) and reduce yields relative to nonqualifying comparable issues. The third reason is that investors in some states exhibit extreme reluctance to purchase issues from issuers outside their state or region. In-state parochialism tends to decrease relative yields of issues from states in which investors exhibit this behavior.

Differences between Maturities

One determinant of the yield on a bond is the number of years remaining to maturity. As explained in Chapter 8, the yield-curve depicts the relationship at a given point in time between yields and maturity for bonds that are identical in every way except maturity. When yields increase with maturity, the yield-curve is said to be *normal* or *have a positive slope.* Therefore, as investors lengthen their maturity, they require a greater yield. It is also possible for the yield-curve to be *inverted,* meaning that long-term yields are less than short-term yields. If short, intermediate, and long-term yields are roughly the same, the yield-curve is said to be *flat.*

In the taxable bond market, it is not unusual to find all three shapes for the yield-curve at different points in the business cycle. However, in the municipal bond market, the yield-curve typically is normal or upward-sloping. Consequently, in the municipal bond market, long-term bonds generally offer higher yields than short- and intermediate-term bonds.

Insured Municipal Bonds

Although insured municipal bonds, when they were rated Aaa/AAA, sold at yields lower than they would without the monoline company insurance, they tended to have yields that were higher than other Aaa/AAA-rated bonds, such as deep-discount refunded bonds. Of course, supply-and-demand forces and in-state taxation factors can distort market trading patterns from time to time. Insured bonds as a generic group before their massive downgrades beginning in 2008 were not viewed in the market as having the same superior degree of safety as either refunded bonds secured with escrowed U.S. Treasuries or those general obligation bonds of states that had robust and growing economies, fiscally conservative budgetary operations, and very low debt burdens.

PRIMARY AND SECONDARY MARKETS

The municipal market can be divided into the primary market and the secondary market. The primary market is one in which all new issues of municipal bonds are sold for the first time. The secondary market is the market in which previously issued municipal securities are traded.

Primary Market

A substantial number of municipal obligations are brought to market each week. A state or local government can market its new issue by offering bonds publicly to the investing community or by placing them privately with a small group of investors. When a public offering is selected, the issue usually is underwritten by investment bankers or municipal bond departments of commercial banks. Public offerings may be marketed by either competitive bidding or direct negotiations with underwriters. When an issue is marketed via competitive bidding, the issue is awarded to the bidder submitting the best bid.

Most states mandate that general obligation issues be marketed through competitive bidding, but generally this is not required for revenue bonds. Usually state and local governments require a competitive sale to be announced in a recognized financial publication, such as *The Bond Buyer,* which is the trade publication for the municipal bond industry. *The Bond Buyer* also provides information on upcoming competitive sales and most negotiated sales, as well as the results of previous weeks.

The sale of bonds by issuers, both competitively and through negotiation, has become more efficient and software based. Two companies offer this service for competitive bond sales. One is I-Deal/Ipreo, which also provides a software platform for negotiated bond sales. The other is the Grant Street Group, which focuses on competitive sales in the municipal market.

Secondary Market

Municipal bonds are traded in the over-the-counter markets supported by municipal bond dealers across the country. Markets are maintained on smaller issuers (referred to as *local credits*) by regional brokerage firms, local banks, and some of the larger Wall Street firms. Larger issuers (referred to as *general market names*) are supported by the larger brokerage firms and banks, many of which have investment banking relationships with these issuers. There are brokers who serve as intermediaries in the sale of large blocks of municipal bonds among dealers and large institutional investors. Additionally, beginning in 2000, bonds in the secondary market, as well as some new issue competitive and negotiated bond issues, began to be auctioned and sold over the Internet by large and small broker-dealers to institutional and individual investors.

In the municipal bond markets, an odd lot of bonds is $25,000 or less in par value for retail investors. For institutions, anything below $100,000 in par value is considered an odd lot. Dealer spreads depend on several factors. For the retail investor, the spread can range from as low as one-quarter of one point ($12.50 per $5,000 of par value) on large blocks of actively traded bonds to four points ($200 per $5,000 of par value) for odd-lot sales of an inactive issue. For retail investors, the typical commission should be between $1^1/_2$ and $2^1/_2$ points. For institutional investors, the dealer spread rarely exceeds one-half of 1 point ($25 per $5,000 of par value).

The convention for both corporate and Treasury bonds is to quote prices as a percentage of par value, with 100 equal to par. Municipal bonds, however, generally are traded and quoted in terms of yield (yield-to-maturity or yield-to-call). The price of the bond in this case is called a *basis price.* Certain long-maturity revenue bonds are exceptions. A bond traded and quoted in dollar prices (actually, as a percentage of par value) is called a *dollar bond.*

It should be noted that many institutional investors, for trading and bond purchasing purposes, price bonds off the MMD scale. This is a daily index of generic AAA's prices covering the full yield-curve provided by Thomson Municipal Market Data and available to subscribers over the Internet. Also, the Municipal Securities Rulemaking Board (MSRB) in Washington, DC, reports on a daily basis for no charge actual trades and prices of specific bonds. The Internet address is www.investinginbonds.com, which is the home page of the Securities Industry and Financial Markets Association (SIFMA), the trade association for the sell side.

BOND INDEXES

The major provider of total return-based indexes to institutional investors is Barclays Capital. Investors use the Barclays Capital Municipal Bond index (formerly the Lehman Brothers Municipal Bond index) to measure relative total return performance and enhance a fund manager's ability to outperform the market. Lehman began publishing municipal indexes in January of 1980 and by 2011 Barclays Capital compiles returns and statistics on more than 2,500 benchmarks. They are broad-based performance measures for the tax-exempt bond market. Similar to all bond indexes provided by Barclays Capital, the municipal indexes are rules based and market value weighted. As of 2011, the Barclays Capital Municipal Bond Index contained more than 46,000 bonds with a market value of about $1.2 trillion. To be included in the index, bonds must have a minimum credit rating of Baa/BBB. They must have an outstanding par value of at least $7 million and be part of a transaction of $75 million or greater. The bonds must have been issued after December 31, 1990, and have a remaining maturity of at least one year.

In addition to investment-grade indexes, Barclays Capital offers total return benchmarks for the noninvestment-grade tax-exempt market. To ensure statistically significant, representative benchmarks for the lower capitalized states, Barclays Capital provides state-specific municipal benchmarks with reduced liquidity requirements.

Many investors use Barclays indexes as performance measures for a given market or market segment. The benchmarks are also employed to identify and quantify portfolio bets versus the general market and/or a given peer group.

Indexes also are used to identify relative value opportunities as well as a proxy for the outstanding market. Given the consistent methodologies, the Barclays indexes are used often when comparing tax-exempt and taxable fixed income markets.

In addition to the Barclays indexes, Bank of America Merrill Lynch publishes a number of municipal bond indexes, and *The Bond Buyer,* the trade daily newspaper, publishes weekly yield indexes.

There are also two services that in the afternoon of each trading day make available generic scales for different maturities and credit ratings. As noted, one is provided by Thomson Municipal Market Data, known in the industry as the MMD scale. The other is by Municipal Market Advisors (MMA).

OFFICIAL STATEMENT

An official statement describing the issue and issuer is prepared for new offerings. Often a preliminary official statement is issued prior to the final official statement. These statements are known as the OS and POS. These statements provide potential investors with a wealth of information. The statements contain basic information about the amount of bonds to be issued, maturity dates, coupons, the use of the bond proceeds, the credit ratings, a general statement about the issuer, and the name of the underwriter and members of the selling group. Much of this information can be found on the cover page or the first few pages of the official statement. It also contains detailed information about the security and sources of payments for the bonds, sources and uses of funds, debt-service requirements, relevant risk factors, issuer's financial statements, a summary of the bond indenture, relevant agreements, notice of any known existing or pending litigation, the bond insurance policy specimen (if insured), and the form of opinion of bond counsel. The official statement contains most of the information an investor will need to make an informed and educated investment decision.

REGULATION OF THE MUNICIPAL SECURITIES MARKET

As an outgrowth of abusive stock market practices, Congress passed the Securities Act of 1933 and the Securities Exchange Act of 1934. The 1934 act created the Securities and Exchange Commission (SEC), granting it regulatory authority over the issuance and trading of *corporate* securities. Congress specifically exempted municipal securities from both the registration requirements of the 1933 act and the periodic reporting requirements of the 1934 act. However, antifraud provisions did apply to offerings of or dealings in municipal securities.

The exemption afforded municipal securities appears to have been due to (1) the desire for governmental comity, (2) the absence of recurrent abuses in transactions involving municipal securities, (3) the greater level of sophistication of investors in this segment of the securities markets (i.e., institutional investors dominated the market), and (4) the fact that there were few defaults by municipal issuers. Consequently, from the enactment of the two federal securities acts in the early 1930s to the early 1970s, the municipal securities market can be characterized as relatively free from federal regulation.

In the early 1970s, however, circumstances changed. As incomes rose, individuals participated in the municipal securities market to a much greater extent. As a result, public outcries over selling practices occurred with greater frequency. For example, in the early 1970s, the SEC obtained seven injunctions against 72 defendants for fraudulent municipal trading practices. According to the SEC, the abusive practices involved both disregard by the defendants as to whether the particular municipal bonds offered to individuals were in fact appropriate investment vehicles for the individuals to whom they were offered, and misrepresentation—failure to disclose information necessary for individuals to assess the credit risk of the municipal issuer, especially in the case of revenue bonds. Moreover, the financial problems of some municipal issuers, notably New York City, made market participants aware that municipal issuers have the potential to experience severe and bankruptcy-type financial difficulties.

Congress passed the Securities Act Amendment of 1975 to broaden regulation in the municipals market. The legislation brought brokers and dealers in the municipal securities market, including banks that underwrite and trade municipal securities, within the regulatory scheme of the Securities Exchange Act of 1934. In addition, the legislation mandated that the SEC establish a 15-member Municipal Securities Rulemaking Board (MSRB) as an independent, self-regulatory agency whose primary responsibility is to develop rules governing the activities of banks, brokers, and dealers in municipal securities. Rules adopted by the MSRB must be approved by the SEC. The MSRB has no enforcement or inspection authority. This authority is vested with the SEC, the National Association of Securities Dealers, and certain regulatory banking agencies such as the Federal Reserve banks. The Securities Act Amendment of 1975 does *not* require that municipal issuers comply with the registration requirement of the 1933 act or the periodic-reporting requirement of the 1934 act. There have been, however, several legislative proposals to mandate financial disclosure. Although none has been passed, there is clearly pressure to improve disclosure. Even in the absence of federal legislation dealing with the regulation of financial disclosure, underwriters began insisting on greater disclosure as it became apparent that the SEC was exercising stricter application of the antifraud provisions. Moreover, underwriters recognized the need for improved disclosure to sell municipal securities to an investing public that has become much more concerned about credit risk by municipal issuers. On June 28, 1989, the SEC formally approved the first bond disclosure rule, effective January 1, 1990. The following paragraphs summarize its contents. The rule applies to all new issue municipal securities offerings of $1 million or more. Exemptions have been added for securities offered in denominations of $100,000 or more, if such securities

- Are sold to no more than 35 "sophisticated investors"
- Have a maturity of nine months or less
- Are variable-rate demand instruments

Before bidding on or purchasing an offering, underwriters must obtain and review official statements that are deemed final by the issuer, with the omission of no more than the following information:

- Offering price
- Interest rate
- Selling compensation
- Aggregate principal amount
- Principal amount per maturity
- Delivery dates
- Other terms or provisions required by an issuer of such a security to be specified in a competitive bid, ratings, other terms of the securities depending on such matters, and the identity of the underwriters

The underwriters shall contract with an issuer or its designated agent to receive copies of a final official statement within seven business days after any final agreement to purchase, offer, or sell any offering and in sufficient time to accompany any confirmation that requests payment from any customer.

Except for competitively bid offerings, the underwriters shall send, no later than the next business day, to any potential customer, on request, a single copy of the most recent preliminary official statement, if any.

Underwriters are required to distribute the final official statement to any potential customer, on request, within 90 days, or 25 days if the final official statement is available from a repository.

Most recently, the *Dodd-Frank Wall Street Reform and Consumer Protection Act*, signed into law on July 21, 2010, requires that municipal advisers be subject to SEC registration and MSRB oversight.

Material Event Disclosure under SEC Rule 15c2-12

The first phase of the implementation of amendments to Rule 15c2-12, which took effect on July 3, 1995, required dealers to determine that issuers before issuing new municipal bonds made arrangements to disclose in the future financial information *at least* annually as well as notices of the occurrence of any of 11 "material event notices" as specified in the rule. By 2011, the amended rule increased the material event notices to 14. Also by 2011, the annual report and notices of material events are filed with the Municipal Securities Rulemaking Board (MSRB), in an electronic format as prescribed by the MSRB. The MSRB designated its Electronic Municipal Market Access system (EMMA), found at http://emma.msrb.org, as the repository for such disclosure filings.

The second phase went into effect on January 1, 1996, and required dealers to have in-house procedures in place to provide reasonable assurance that they will receive prompt notice of any material event notices that are required to be disclosed by the issuers.

The Governmental Accounting Standards Board

The Governmental Accounting Standards Board (GASB) is a nonprofit organization that sets generally accepted accounting standards (GAAP) for state and local governments. Providing detailed guidelines and established in 1984, for many years it has improved financial reporting standards in reports of state and local governments that are used by analysts, auditors, and other users. By improving the transparency of state and local government accounting, it helps prevent issuers from obfuscating budget deficits and long-term liabilities that in the past had resulted in budgetary disasters and bond defaults. The Web address is http://gasb.org.

The National Federation of Municipal Analysts

The National Federation of Municipal Analysts (NMFA) was established in 1983, and by 2011 had a membership of 1,000 municipal professionals, drawing in part from the institutional investors in municipal bonds who advocated increased and timely information for investors. By 2011, its committees have developed detailed disclosure guidelines and risk factors in municipal securities ranging from specific credit sectors to swap structures. They are recommended for municipal bond issuers to use in providing ongoing financial and operating information to investors. The Web address is www.nfma.org.

KEY POINTS

- The majority of tax-exempt securities are issued by state and local governments and by their creations. Most outstanding municipal bonds are tax-exempt securities, meaning that the interest income is exempt from federal income taxes. Consequently, the major motivation for investing in tax-exempt municipal bonds is their tax advantage. The state and local income tax treatment of interest income from municipal bonds varies.
- In terms of municipal bond security structures, there are basically two different types: general obligation bonds (secured by the issuer's general taxing powers) and revenue bonds (issued for either project or enterprise financings in which the bond issuers pledge to the bondholders the revenues generated by the operating projects financed). There are bonds with security structures that have certain characteristics of general obligation and revenue bonds. These hybrid and special bond securities include refunded bonds, dedicated tax-backed and structured asset-backed bonds, insured bonds, lease-backed bonds, letter of credit–backed bonds, moral obligation bonds, territorial bonds, and troubled city bailout bonds. Municipal money market products include notes, commercial paper, variable-rate demand obligations, and commercial paper mode.

- Municipal bonds are assigned credit ratings by commercial rating agencies (Moody's, Standard & Poor's, and Fitch) just like corporate bonds. Some investors do not perform their own credit-risk analysis, but instead rely entirely on credit-risk ratings assigned. Large institutional investors, underwriters, and traders tend to use ratings as a starting point in evaluating a municipal credit and then rely on their own in-house municipal credit analysts for determining the creditworthiness of municipal bonds.
- As in other sectors of the bond market, yield measures such as yield to maturity and yield to call are computed. In comparing a tax-exempt municipal bond yield to that of a comparable taxable yield, the taxable equivalent yield is computed.
- Tax considerations in investing in tax-exempt municipal bonds include original issue discount embedded in an issue, the alternative minimum tax, deductibility of interest expense incurred to acquire a municipal bond, and treatment of interest income at the state and local tax levels.
- Barclays Capital is the major provider of total return–based municipal bond indexes that are used by institutional investors. The Barclays Capital Municipal Bond Index is used to measure relative total return performance. The Barclays indexes are available for a given market or market segment within the municipal bond market. Thomson Municipal Market Data and Municipal Market Advisors are two services that in the afternoon of each trading day make available generic scales for different maturities and different credit ratings in the municipal bond market.
- An official statement (OS) describing the issue and the issuer is prepared for new offerings. Typically a preliminary official statement (POS) is issued prior to the final official statement.

CHAPTER
TWELVE

CORPORATE BONDS

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

STEVEN V. MANN, PH.D.
Professor of Finance
Moore School of Business
University of South Carolina

ADAM B. COHEN, J.D.
Founder
Covenant Review

In its simplest form, a corporate bond is a debt instrument that obligates the issuer to pay a specified percentage of the bond's par value on designated dates (the coupon payments) and to repay the bond's par or principal value at maturity. Failure to pay the interest and/or principal when due (and to meet other of the debt's provisions) in accordance with the instrument's terms constitutes legal default, and court proceedings can be instituted to enforce the contract. Bondholders as creditors have a prior legal claim over common and preferred shareholders as to both the corporation's income and assets for cash flows due them and may have a prior claim over other creditors if liens and mortgages are involved. This legal priority does not insulate bondholders from financial loss. Indeed, bondholders are fully exposed to the firm's prospects as to the ability to generate cash-flow sufficient to pay its obligations.

Corporate bonds usually are issued in denominations of $1,000 and multiples thereof. In common usage, a corporate bond is assumed to have a par value of $1,000 unless otherwise explicitly specified. A security dealer who says that she has five bonds to sell means five bonds each of $1,000 principal amount. If the promised rate of interest (coupon rate) is 6%, the annual amount of interest on each bond is $60, and the semiannual interest is $30.

Although there are technical differences between bonds, notes, and debentures, we will use Wall Street convention and call fixed income debt by the general term—*bonds.*

THE CORPORATE TRUSTEE

The promises of corporate bond issuers and the rights of investors who buy them are set forth in great detail in contracts generally called *indentures*. If bondholders were handed the complete indenture, some may have trouble understanding the legalese and have even greater difficulty in determining from time to time if the corporate issuer is keeping all the promises made. Further, it may be practically difficult and expensive for any one bondholder to try to enforce the indenture if those promises are not being kept. These problems are solved in part by bringing in a *corporate trustee* as a third party to the contract. The indenture is made out to the corporate trustee as a representative of the interests of bondholders; that is, the trustee acts in a fiduciary capacity for investors who own the bond issue.

A corporate trustee is a bank or trust company with a corporate trust department and officers who are experts in performing the functions of a trustee. The corporate trustee must, at the time of issue, authenticate the bonds issued; that is, keep track of all the bonds sold, and make sure that they do not exceed the principal amount authorized by the indenture. It must obtain and address various certifications and requests from issuers, attorneys, and bondholders about compliance with the covenants of the indenture. These covenants are many and technical, and they must be watched during the entire period that a bond issue is outstanding. We will describe some of these covenants in subsequent pages.

It is very important that corporate trustees be competent and financially responsible. To this end, there is a federal statute known as the Trust Indenture Act that generally requires a corporate trustee for corporate bond offerings in the amount of more than $5 million sold in interstate commerce. The indenture must include adequate requirements for performance of the trustee's duties on behalf of bondholders; there must be no conflict between the trustee's interest as a trustee and any other interest it may have, especially if it is also a creditor of the issuer; and there must be provision for reports by the trustee to bondholders. If a corporate issuer has breached an indenture promise, such as not to borrow additional secured debt, or fails to pay interest or principal, the trustee may declare a default and take such action as may be necessary to protect the rights of bondholders.

However, it must be emphasized that the trustee is paid by the debt issuer and can only do what the indenture provides. The indenture may contain a clause stating that the trustee undertakes to perform such duties and only such duties as are specifically set forth in the indenture, and no implied covenants or obligations shall be read into the indenture against the trustee. Trustees often are not required to take actions such as monitoring corporate balance sheets to determine issuer covenant compliance, and in fact, indentures often expressly allow a trustee to rely upon certifications and opinions from the issuer and its attorneys. The trustee is generally not bound to make investigations into the facts surrounding documents delivered to it, but it may do so if it sees fit. Also, the trustee is usually under no obligation to exercise the rights or powers under the indenture at the request of bondholders unless it has been offered reasonable security or indemnity.

The terms of bond issues set forth in bond indentures are always a compromise between the interests of the bond issuer and those of investors who buy bonds. The issuer always wants to pay the lowest possible rate of interest and wants its actions bound as little as possible with legal covenants. Bondholders want the highest possible interest rate, the best security, and a variety of covenants to restrict the issuer in one way or another. As we discuss the provisions of bond indentures, keep this opposition of interests in mind and see how compromises are worked out in practice. A more detailed description of covenants is provided in Chapter 43 where credit analysis is covered.

SOME BOND FUNDAMENTALS

Bonds can be classified by a number of characteristics, which we will use for ease of organizing this section.

Bonds Classified by Issuer Type

The five broad categories of corporate bonds sold in the United States based on the type of issuer are public utilities, transportations, industrials, banks and finance companies, and international or Yankee issues. Finer breakdowns are often made by market participants to create homogeneous groupings. For example, public utilities are subdivided into telephone or communications, electric companies, gas distribution and transmission companies, and water companies. The transportation industry can be subdivided into airlines, railroads, and trucking companies. Like public utilities, transportation companies often have various degrees of regulation or control by state and/or federal government agencies. Industrials are a catchall class, but even here, finer degrees of distinction may be needed by analysts. The industrial grouping includes manufacturing and mining concerns, retailers, and service-related companies. Even the Yankee or international borrower sector can be more finely tuned. For example, one might classify the issuers into categories such as supranational borrowers (International Bank for Reconstruction and Development and the European Investment Bank), sovereign issuers (Canada, Australia, and the United Kingdom), and foreign municipalities and agencies.

Corporate Debt Maturity

A bond's maturity is the date on which the issuer's obligation to satisfy the terms of the indenture is fulfilled. On that date, the principal is repaid with any premium and accrued interest that may be due. However, as we shall see later when discussing debt redemption, the final maturity date as stated in the issue's title may or may not be the date when the contract terminates. Many issues can be retired prior to maturity. The maturity structure of a particular corporation can be accessed using the Bloomberg function DDIS.

Interest Payment Characteristics

The three main interest payment classifications of domestically issued corporate bonds are straight-coupon bonds, zero-coupon bonds, and floating-rate, or variable-rate, bonds. Floating-rate issues are discussed in Chapter 17, and the other two types are examined below.

However, before we get into interest-rate characteristics, let us briefly discuss bond types. We refer to the interest rate on a bond as the *coupon*. This is technically wrong because bonds issued today do not have coupons attached. Instead, bonds are represented by a certificate, similar to a stock certificate, with a brief description of the terms printed on both sides. These are called *registered bonds*. The principal amount of the bond is noted on the certificate, and the interest-paying agent or trustee has the responsibility of making payment by check to the registered holder on the due date. Years ago bonds were issued in *bearer* or coupon form, with coupons attached for each interest payment. However, the registered form is considered safer and entails less paperwork. As a matter of fact, the registered bond certificate is on its way out as more and more issues are sold in *book-entry* form. This means that only one master or global certificate is issued. It is held by a central securities depository that issues receipts denoting interests in this global certificate.

Straight-coupon bonds have an interest rate set for the life of the issue, however long or short that may be; they are also called *fixed-rate bonds*. Most fixed-rate bonds in the United States pay interest semiannually and at maturity. For example, consider the 4.75% Notes due 2013 issued by Goldman Sachs Group in July 2003. This bond carries a coupon rate of 4.75% and has a par amount of $1,000. Accordingly, this bond requires payments of $23.75 each January 15 and July 15, including the maturity date of July 15, 2013. On the maturity date, the bond's par amount is also paid. Bonds with annual coupon payments are uncommon in the U.S. capital markets but are the norm in continental Europe.

Interest on corporate bonds is based on a year of 360 days made up of twelve 30-day months. The corporate calendar day-count convention is referred to as 30/360.

Most fixed-rate corporate bonds pay interest in a standard fashion. However, there are some variations of which one should be aware. Most domestic bonds pay interest in U.S. dollars. However, starting in the early 1980s, issues were marketed with principal and interest payable in other currencies, such as the Australian, New Zealand, or Canadian dollar or the British pound. Generally, interest and principal payments are converted from the foreign currency to U.S. dollars by the paying agent unless it is otherwise notified. The bondholders bear any costs associated with the dollar conversion. Foreign currency issues provide investors with another way of diversifying a portfolio, but not without risk. The holder bears the currency, or exchange-rate, risk in addition to all the other risks associated with debt instruments.

There are a few issues of bonds that can participate in the fortunes of the issuer over and above the stated coupon rate. These are called *participating bonds* because they share in the profits of the issuer or the rise in certain assets over and

above certain minimum levels. Another type of bond rarely encountered today is the *income bond.* These bonds promise to pay a stipulated interest rate, but the payment is contingent on sufficient earnings and is in accordance with the definition of available income for interest payments contained in the indenture. Repayment of principal is not contingent. Interest may be cumulative or noncumulative. If payments are cumulative, unpaid interest payments must be made up at some future date. If noncumulative, once the interest payment is past, it does not have to be repaid. Failure to pay interest on income bonds is not an act of default and is not a cause for bankruptcy. Income bonds have been issued by some financially troubled corporations emerging from reorganization proceedings.

Zero-coupon bonds are, just as the name implies, bonds without coupons or an interest rate. Essentially, zero-coupon bonds pay only the principal portion at some future date. These bonds are issued at discounts to par; the difference constitutes the return to the bondholder. The difference between the face amount and the offering price when first issued is called the *original-issue discount* (OID). The rate of return depends on the amount of the discount and the period over which it accretes to par. For example, consider a zero-coupon bond issued by Xerox that matures September 30, 2023 and is priced at 55.835 as of mid-May 2011. In addition, this bond is putable starting on September 30, 2011 at 41.77. These embedded option features will be discussed in more detail shortly.

Zeros were first publicly issued in the corporate market in the spring of 1981 and were an immediate hit with investors. The rapture lasted only a couple of years because of changes in the income tax laws that made ownership more costly on an after-tax basis. Also, these changes reduced the tax advantages to issuers. However, tax-deferred investors, such as pension funds, could still take advantage of zero-coupon issues. One important risk is eliminated in a zero-coupon investment—the reinvestment risk. Because there is no coupon to reinvest, there isn't any reinvestment risk. Of course, although this is beneficial in declining-interest-rate markets, the reverse is true when interest rates are rising. The investor will not be able to reinvest an income stream at rising reinvestment rates. Investors tend to find zeros less attractive in lower-interest-rate markets because compounding is not as meaningful as when rates are higher. Also, the lower the rates are, the more likely it is that they will rise again, making a zero-coupon investment worth less in the eyes of potential holders.

In bankruptcy, a zero-coupon bond creditor can claim the original offering price plus the accretion that represents accrued and unpaid interest to the date of the bankruptcy filing, but not the principal amount of $1,000. Zero-coupon bonds have been sold at deep discounts, and the liability of the issuer at maturity may be substantial. The accretion of the discount on the corporation's books is not put away in a special fund for debt retirement purposes. There are no sinking funds on most of these issues. One hopes that corporate managers invest the proceeds properly and run the corporation for the benefit of all investors so that there will not be a cash crisis at maturity. The potentially large balloon repayment creates a cause for concern among investors. Thus it is most important to invest in higher-quality issues so as to reduce the risk of a potential problem.

If one wants to speculate in lower-rated bonds, then that investment should throw off some cash return.

Finally, a variation of the zero-coupon bond is the *deferred-interest bond* (DIB), also known as a *zero-coupon bond.* These bonds generally have been subordinated issues of speculative-grade issuers, also known as *junk issuers*. Most of the issues are structured so that they do not pay cash interest for the first five years. At the end of the deferred-interest period, cash interest accrues and is paid semiannually until maturity, unless the bonds are redeemed earlier. The deferred-interest feature allows newly restructured, highly leveraged companies and others with less-than-satisfactory cash flows to defer the payment of cash interest over the early life of the bond. Barring anything untoward, when cash interest payments start, the company will be able to service the debt. If it has made excellent progress in restoring its financial health, the company may be able to redeem or refinance the debt rather than have high interest outlays.

An offshoot of the deferred-interest bond is the pay-in-kind (PIK) debenture. With PIKs, cash interest payments are deferred at the issuer's option until some future date. Instead of just accreting the original-issue discount as with DIBs or zeros, the issuer pays out the interest in additional pieces of the same security. The option to pay cash or in-kind interest payments rests with the issuer, but in many cases the issuer has little choice because provisions of other debt instruments often prohibit cash interest payments until certain indenture or loan tests are satisfied. The holder just gets more pieces of paper, but these at least can be sold in the market without giving up one's original investment; PIKs, DIBs, and zeros do not have provisions for the resale of the interest portion of the instrument. An investment in this type of bond, because it is issued by speculative-grade companies, requires careful analysis of the issuer's cash-flow prospects and ability to survive.

SECURITY FOR BONDS

Investors who buy corporate bonds prefer some kind of security underlying the issue. Either real property (using a mortgage) or personal property may be pledged to offer security beyond that of the general credit standing of the issuer. In fact, the kind of security or the absence of a specific pledge of security is usually indicated by the title of a bond issue. However, the best security is a strong general credit that can repay the debt from earnings.

Mortgage Bond

A mortgage bond grants the bondholders a first-mortgage lien on substantially all its properties. This lien provides additional security for the bondholder. As a result, the issuer is able to borrow at a lower rate of interest than if the debt were unsecured. A debenture issue (i.e., unsecured debt) of the same issuer almost surely would carry a higher coupon rate, other things equal. A *lien* is a legal right

to sell mortgaged property to satisfy unpaid obligations to bondholders. In practice, foreclosure of a mortgage and sale of mortgaged property are unusual. If a default occurs, there is usually a financial reorganization on the part of the issuer, in which provision is made for settlement of the debt to bondholders. The mortgage lien is important, though, because it gives the mortgage bondholders a very strong bargaining position relative to other creditors in determining the terms of a reorganization.

Often first-mortgage bonds are issued in series with bonds of each series secured equally by the same first mortgage. Many companies, particularly public utilities, have a policy of financing part of their capital requirements continuously by long-term debt. They want some part of their total capitalization in the form of bonds because the cost of such capital is ordinarily less than that of capital raised by sale of stock. Thus, as a principal amount of debt is paid off, they issue another series of bonds under the same mortgage. As they expand and need a greater amount of debt capital, they can add new series of bonds. It is a lot easier and more advantageous to issue a series of bonds under one mortgage and one indenture than it is to create entirely new bond issues with different arrangements for security. This arrangement is called a *blanket mortgage*. When property is sold or released from the lien of the mortgage, additional property or cash may be substituted or bonds may be retired in order to provide adequate security for the debtholders.

When a bond indenture authorizes the issue of additional series of bonds with the same mortgage lien as those already issued, the indenture imposes certain conditions that must be met before an additional series may be issued. Bondholders do not want their security impaired; these conditions are for their benefit. It is common for a first-mortgage bond indenture to specify that property acquired by the issuer subsequent to the granting of the first-mortgage lien shall be subject to the first-mortgage lien. This is termed the *after-acquired clause.* Then the indenture usually permits the issue of additional bonds up to some specified percentage of the value of the after-acquired property, such as 60%. The other 40%, or whatever the percentage may be, must be financed in some other way. This is intended to ensure that there will be additional assets with a value significantly greater than the amount of additional bonds secured by the mortgage. Another customary kind of restriction on the issue of additional series is a requirement that earnings in an immediately preceding period must be equal to some number of times the amount of annual interest on all outstanding mortgage bonds including the new or proposed series (1.5, 2, or some other number). For this purpose, *earnings* usually are defined as earnings before income tax. Still another common provision is that additional bonds may be issued to the extent that earlier series of bonds have been paid off.

One seldom sees a bond issue with the term *second mortgage* in its title. The reason is that this term has a connotation of weakness. Sometimes companies get around that difficulty by using such words as *first and consolidated, first and refunding,* or *general and refunding mortgage bonds.* Usually this language means

that a bond issue is secured by a first mortgage on some part of the issuer's property but by a second or even third lien on other parts of its assets. A general and refunding mortgage bond is generally secured by a lien on all the company's property *subject* to the prior lien of first-mortgage bonds, if any are still outstanding.

Collateral Trust Bonds

Some companies do not own fixed assets or other real property and so have nothing on which they can give a mortgage lien to secure bondholders. Instead, they own securities of other companies; they are *holding companies,* and the other companies are *subsidiaries*. To satisfy the desire of bondholders for security, they pledge stocks, notes, bonds, or whatever other kinds of obligations they own. These assets are termed *collateral* (or personal property), and bonds secured by such assets are *collateral trust bonds*. Some companies own both real property and securities. They may use real property to secure mortgage bonds and use securities for collateral trust bonds. As an example, consider the 10.375% Collateral Trust Bonds due 2018 issued by National Rural Utilities. According to the bond's prospectus, the securities deposited with the trustee include mortgage notes, cash, and other permitted investments.

The legal arrangement for collateral trust bonds is much the same as that for mortgage bonds. The issuer delivers to a corporate trustee under a bond indenture the securities pledged, and the trustee holds them for the benefit of the bondholders. When voting common stocks are included in the collateral, the indenture permits the issuer to vote the stocks so long as there is no default on its bonds. This is important to issuers of such bonds because usually the stocks are those of subsidiaries, and the issuer depends on the exercise of voting rights to control the subsidiaries.

Indentures usually provide that, in event of default, the rights to vote stocks included in the collateral are transferred to the trustee. Loss of the voting right would be a serious disadvantage to the issuer because it would mean loss of control of subsidiaries. The trustee also may sell the securities pledged for whatever prices they will bring in the market and apply the proceeds to payment of the claims of collateral trust bondholders. These rather drastic actions, however, usually are not taken immediately on an event of default. The corporate trustee's primary responsibility is to act in the best interests of bondholders, and their interests may be served for a time at least by giving the defaulting issuer a proxy to vote stocks held as collateral and thus preserve the holding company structure. It also may defer the sale of collateral when it seems likely that bondholders would fare better in a financial reorganization than they would by sale of collateral.

Collateral trust indentures contain a number of provisions designed to protect bondholders. Generally, the market or appraised value of the collateral must be maintained at some percentage of the amount of bonds outstanding. The percentage is greater than 100 so that there will be a margin of safety. If collateral value declines below the minimum percentage, additional collateral must be

provided by the issuer. There is almost always provision for withdrawal of some collateral, provided other acceptable collateral is substituted.

Collateral trust bonds may be issued in series in much the same way that mortgage bonds are issued in series. The rules governing additional series of bonds require that adequate collateral must be pledged, and there may be restrictions on the use to which the proceeds of an additional series may be put. All series of bonds are issued under the same indenture and have the same claim on collateral.

Since 2005, an increasing percentage of high yield bond issues have been secured by some mix of mortgages and other collateral on a first, second, or even third lien basis. These secured high yield bonds have very customized provisions for issuing additional secured debt and there is some debate about whether the purported collateral for these kinds of bonds will provide greater recoveries in bankruptcy than traditional unsecured capital structures over an economic cycle.

Equipment Trust Certificates

The desire of borrowers to pay the lowest possible rate of interest on their obligations generally leads them to offer their best security and to grant lenders the strongest claim on it. Many years ago, the railway companies developed a way of financing purchase of cars and locomotives, called *rolling stock,* that enabled them to borrow at just about the lowest rates in the corporate bond market.

Railway rolling stock has for a long time been regarded by investors as excellent security for debt. This equipment is sufficiently standardized that it can be used by one railway as well as another. And it can be readily moved from the tracks of one railroad to those of another. There is generally a good market for lease or sale of cars and locomotives. The railroads have capitalized on these characteristics of rolling stock by developing a legal arrangement for giving investors a legal claim on it that is different from, and generally better than, a mortgage lien.

The legal arrangement is one that vests legal title to railway equipment in a trustee, which is better from the standpoint of investors than a first-mortgage lien on property. A railway company orders some cars and locomotives from a manufacturer. When the job is finished, the manufacturer transfers the legal title to the equipment to a trustee. The trustee leases it to the railroad that ordered it and at the same time sells *equipment trust certificates* (ETCs) in an amount equal to a large percentage of the purchase price, normally 80%. Money from the sale of certificates is paid to the manufacturer. The railway company makes an initial payment of rent equal to the balance of the purchase price, and the trustee gives that money to the manufacturer. Thus the manufacturer is paid off. The trustee collects lease rental money periodically from the railroad and uses it to pay interest and principal on the certificates. These interest payments are known as dividends. The amounts of lease rental payments are worked out carefully so that they are enough to pay the equipment trust certificates. At the end of some period of

time, such as 15 years, the certificates are paid off, the trustee sells the equipment to the railroad for some nominal price, and the lease is terminated.

Railroad ETCs usually are structured in serial form; that is, a certain amount becomes payable at specified dates until the final installment. For example, a $60 million ETC might mature $4 million on each June 15 from 2000 through 2014. Each of the 15 maturities may be priced separately to reflect the shape of the yield curve, investor preference for specific maturities, and supply-and-demand considerations. The advantage of a serial issue from the investor's point of view is that the repayment schedule matches the decline in the value of the equipment used as collateral. Hence principal repayment risk is reduced. From the issuer's side, serial maturities allow for the repayment of the debt periodically over the life of the issue, making less likely a crisis at maturity due to a large repayment coming due at one time.

The beauty of this arrangement from the viewpoint of investors is that the railroad does not legally own the rolling stock until all the certificates are paid. In case the railroad does not make the lease rental payments, there is no big legal hassle about foreclosing a lien. The trustee owns the property and can take it back because failure to pay the rent breaks the lease. The trustee can lease the equipment to another railroad and continue to make payments on the certificates from new lease rentals.

This description emphasizes the legal nature of the arrangement for securing the certificates. In practice, these certificates are regarded as obligations of the railway company that leased the equipment and are shown as liabilities on its balance sheet. In fact, the name of the railway appears in the title of the certificates. In the ordinary course of events, the trustee is just an intermediary who performs the function of holding title, acting as lessor, and collecting the money to pay the certificates. It is significant that even in the worst years of a depression, railways have paid their equipment trust certificates, although they did not pay bonds secured by mortgages. Although railroads have issued the largest amount of equipment trust certificates, airlines also have used this form of financing.

Debenture Bonds

While bondholders prefer to have security underlying their bonds, all else equal, most bonds issued are unsecured. These unsecured bonds are called *debentures.* With the exception of the utilities and structured products, nearly all other corporate bonds issued are unsecured.

Debentures are not secured by a specific pledge of designated property, but this does not mean that they have no claim on the property of issuers or on their earnings. Debenture bondholders have the claim of general creditors on all assets of the issuer not pledged specifically to secure other debt. And they even have a claim on pledged assets to the extent that these assets have value greater than necessary to satisfy secured creditors. In fact, if there are no pledged assets and

no secured creditors, debenture bondholders have first claim on all assets along with other general creditors.

These unsecured bonds are sometimes issued by companies that are so strong financially and have such a high credit rating that to offer security would be superfluous. Such companies simply can turn a deaf ear to investors who want security and still sell their debentures at relatively low interest rates. But debentures sometimes are issued by companies that have already sold mortgage bonds and given liens on most of their property. These debentures rank below the mortgage bonds or collateral trust bonds in their claim on assets, and investors may regard them as relatively weak. This is the kind that bears the higher rates of interest.

Even though there is no pledge of security, the indentures for debenture bonds may contain a variety of provisions designed to afford some protection to investors. Sometimes the amount of a debenture bond issue is limited to the amount of the initial issue. This limit is to keep issuers from weakening the position of debenture holders by running up additional unsecured debt. Sometimes additional debentures may be issued a specified number of times in a recent accounting period, provided that the issuer has earned its bond interest on all existing debt plus the additional issue.

If a company has no secured debt, it is customary to provide that debentures will be secured equally with any secured bonds that may be issued in the future. This is known as the *negative-pledge clause.* Some provisions of debenture bond issues are intended to protect bondholders against other issuer actions when they might be too harmful to the creditworthiness of the issuer. For example, some provisions of debenture bond issues may require maintaining some level of net worth, restrict selling major assets, or limit paying dividends in some cases. However, the trend in recent years, at least with investment-grade companies, is away from indenture restrictions.

Subordinated and Convertible Debentures

Many corporations issue *subordinated debenture bonds.* The term *subordinated* means that such an issue ranks after secured debt, after debenture bonds, and often after some general creditors in its claim on assets and earnings. Owners of this kind of bond stand last in line among creditors when an issuer fails financially.

Because subordinated debentures are weaker in their claim on assets, issuers would have to offer a higher rate of interest unless they also offer some special inducement to buy the bonds. The inducement can be an option to convert bonds into stock of the issuer at the discretion of bondholders. If the issuer prospers and the market price of its stock rises substantially in the market, the bondholders can convert bonds to stock worth a great deal more than what they paid for the bonds. This conversion privilege also may be included in the provisions of debentures that are not subordinated. Convertible securities are discussed in Chapters 14 and 42.

The bonds may be convertible into the common stock of a corporation other than that of the issuer. Such issues are called *exchangeable bonds.* There are also issues indexed to a commodity's price or its cash equivalent at the time of maturity or redemption.

Guaranteed Bonds

Sometimes a corporation may guarantee the bonds of another corporation. Such bonds are referred to as *guaranteed bonds.* The guarantee, however, does not mean that these obligations are free of default risk. The safety of a guaranteed bond depends on the financial capability of the guarantor to satisfy the terms of the guarantee, as well as the financial capability of the issuer. The terms of the guarantee may call for the guarantor to guarantee the payment of interest and/or repayment of the principal. A guaranteed bond may have more than one corporate guarantor. Each guarantor may be responsible for not only its pro rata share but also the entire amount guaranteed by the other guarantors.

ALTERNATIVE MECHANISMS TO RETIRE DEBT BEFORE MATURITY

We can partition the alternative mechanisms to retire debt into two broad categories—namely, those mechanisms that must be included in the bond's indenture in order to be used and those mechanisms that can be used without being included in the bond's indenture. Among those debt retirement mechanisms included in a bond's indenture are the following: call and refunding provisions, sinking funds, maintenance and replacement funds, and redemption through sale of assets. Alternatively, some debt retirement mechanisms are not required to be included in the bond indenture (e.g., fixed-spread tender offers).

Call and Refunding Provisions

Many corporate bonds contain an embedded option that gives the issuer the right to buy the bonds back at a fixed price either in whole or in part prior to maturity. The feature is known as a *call provision.* The ability to retire debt before its scheduled maturity date is a valuable option for which bondholders will demand compensation ex-ante. All else equal, bondholders will pay a lower price for a callable bond than an otherwise identical option-free (i.e., straight) bond. The difference between the price of an option-free bond and the callable bond is the value of the embedded call option.

Conventional wisdom suggests that the most compelling reason for corporations to retire their debt prior to maturity is to take advantage of declining borrowing rates. If they are able to do so, firms will substitute new, lower-cost debt for older, higher-cost issues. However, firms retire their debt for other

reasons as well. For example, firms retire their debt to eliminate restrictive covenants, to alter their capital structure, to increase shareholder value, or to improve financial/managerial flexibility. There are two types of call provisions included in corporate bonds—a fixed-price call and a make-whole call. We will discuss each in turn.

Fixed-Price Call Provision

With a standard fixed-price call provision, the bond issuer has the option to buy back some or all of the bond issue prior to maturity at a fixed price. The fixed price is termed the *call price*. Normally, the bond's indenture contains a call-price schedule that specifies when the bonds can be called and at what prices. The call prices generally start at a substantial premium over par and decline toward par over time such that in the final years of a bond's life, the call price is usually par.

In some corporate issues, bondholders are afforded some protection against a call in the early years of a bond's life. This protection usually takes one of two forms. First, some callable bonds possess a feature that prohibits a bond call for a certain number of years. Second, some callable bonds prohibit the bond from being refunded for a certain number of years. Such a bond is said to be *nonrefundable*. Prohibition of refunding precludes the redemption of a bond issue if the funds used to repurchase the bonds come from new bonds being issued with a lower coupon than the bonds being redeemed. However, a refunding prohibition does not prevent the redemption of bonds from funds obtained from other sources (e.g., asset sales, the issuance of equity, etc.). Call prohibition provides the bondholder with more protection than a bond that has a refunding prohibition that is otherwise callable.[1]

Make-Whole Call Provision

In contrast to a standard fixed-price call, a make-whole call price is calculated as the present value of the bond's remaining cash flows subject to a floor price equal to par value. The discount rate used to determine the present value is the yield on a comparable-maturity Treasury security plus a contractually specified *make-whole call premium*. For example, in November 2010, Coca-Cola sold $1 billion of 3.15% Notes due November 15, 2020. These notes are redeemable at any time either in whole or in part at the issuer's option. The redemption price is the greater of (1) 100% of the principal amount plus accrued interest or (2) the make-whole redemption price, which is equal to the sum of the present value of the remaining coupon and principal payments discounted at the Treasury rate plus 10 basis points. The spread of 10 basis points is the aforementioned make-whole call premium. Thus the make-whole call price is essentially a floating call price that moves inversely with the level of interest rates.

1. There are, of course, exceptions to a call prohibition, such as sinking funds and redemption of the debt under certain mandatory provisions.

The Treasury rate is calculated in one of two ways. One method is to use a constant-maturity Treasury (CMT) yield as the Treasury rate. CMT yields are published weekly by the Federal Reserve in its statistical release H.15. The maturity of the CMT yield will match the bond's remaining maturity (rounded to the nearest month). If there is no CMT yield that exactly corresponds with the bond's remaining maturity, a linear interpolation is employed using the yields of the two closest available CMT maturities. Once the CMT yield is determined, the discount rate for the bond's remaining cash flows is simply the CMT yield plus the make-whole call premium specified in the indenture.

Another method of determining the Treasury rate is to select a U.S. Treasury security having a maturity comparable with the remaining maturity of the make-whole call bond in question. This selection is made by a primary U.S. Treasury dealer designated in the bond's indenture. An average price for the selected Treasury security is calculated using the price quotations of multiple primary dealers. The average price is then used to calculate a bond-equivalent yield. This yield is then used as the Treasury rate.

Make-whole call provisions were first introduced in publicly traded corporate bonds in 1995. Bonds with make-whole call provisions are now issued routinely. Moreover, the make-whole call provision is growing in popularity while bonds with fixed-price call provisions are declining. Exhibit 12–1 presents a graph that shows the total par amount outstanding of corporate bonds issued in billions of dollars by

EXHIBIT 12–1

Total Par Amount of Corporate Bonds Outstanding by Type of Call Provision

type of bond (straight, fixed-price call, make-whole call) for years 1995 to 2009.[2] This sample of bonds contains all debentures issued on and after January 1, 1995, that might have certain characteristics.[3] These data suggest that the make-whole call provision is rapidly becoming the call feature of choice for corporate bonds.

The primary advantage from the firm's perspective of a make-whole call provision relative to a fixed-price call is a lower cost. Since the make-whole call price floats inversely with the level of Treasury rates, the issuer will not exercise the call to buy back the debt merely because its borrowing rates have declined. Simply put, the pure refunding motive is virtually eliminated. This feature will reduce the upfront compensation required by bondholders to hold make-whole call bonds versus fixed-price call bonds.

Sinking-Fund Provision

Term bonds may be paid off by operation of a *sinking fund.* These last two words are often misunderstood to mean that the issuer accumulates a fund in cash, or in assets readily sold for cash, that is used to pay bonds at maturity. It had that meaning many years ago, but too often the money supposed to be in a sinking fund was not all there when it was needed. In modern practice, there is no fund, and *sinking* means that money is applied periodically to redemption of bonds before maturity. Corporate bond indentures require the issuer to retire a specified portion of an issue each year. This kind of provision for repayment of corporate debt may be designed to liquidate all of a bond issue by the maturity date, or it may be arranged to pay only a part of the total by the end of the term. As an example, consider a $150 million issue by Westvaco in June 1997. The bonds carry a 7.5% coupon and mature on June 15, 2027. The bonds' indenture provides for an annual sinking-fund payment of $7.5 million or $15 million to be determined on an annual basis.

The issuer may satisfy the sinking-fund requirement in one of two ways. A cash payment of the face amount of the bonds to be retired may be made by the corporate debtor to the trustee. The trustee then calls the bonds pro rata or by lot for redemption. Bonds have serial numbers, and numbers may be selected randomly for redemption. Owners of bonds called in this manner turn them in for redemption; *interest payments stop at the redemption date.* Alternatively, the issuer can deliver to the trustee bonds with a total face value equal to the amount that must be retired. The bonds are purchased by the *issuer* in the open market. This option is elected by the issuer when the bonds are selling below par. A few corporate bond indentures, however, prohibit the open-market purchase of the bonds by the issuer.

2. Our data source is the Fixed Income Securities Database jointly published by LJS Global Information Services and Arthur Warga at the University of Houston.

3. These characteristics include such things as the offering amount had to be at least $25 million and excluded medium-term notes and bonds with other embedded options (e.g., bonds that were putable or convertible). See Scott Brown and Eric Powers, "The Life Cycle of Make-Whole Call Provisions," Working Paper, March 2011.

Many electric utility bond issues can satisfy the sinking-fund requirement by a third method. Instead of actually retiring bonds, the company may certify to the trustee that it has used unfunded property credits in lieu of the sinking fund. That is, it has made property and plant investments that have not been used for issuing bonded debt. For example, if the sinking-fund requirement is $1 million, it may give the trustee $1 million in cash to call bonds, it may deliver to the trustee $1 million of bonds it purchased in the open market, or it may certify that it made additions to its property and plant in the required amount, normally $1,667 of plant for each $1,000 sinking-fund requirement. In this case it could satisfy the sinking fund with certified property additions of $1,667,000.

The issuer is granted a special call price to satisfy any sinking-fund requirement. Usually, the sinking-fund call price is the par value if the bonds were originally sold at par. When issued at a price in excess of par, the sinking-fund call price generally starts at the issuance price and scales down to par as the issue approaches maturity.

There are two advantages of a sinking-fund requirement from the bondholder's perspective. First, default risk is reduced because of the orderly retirement of the issue before maturity. Second, if bond prices decline as a result of an increase in interest rates, price support may be provided by the issuer or its fiscal agent because it must enter the market on the buy side in order to satisfy the sinking-fund requirement. However, the disadvantage is that the bonds may be called at the special sinking-fund call price at a time when interest rates are lower than rates prevailing at the time of issuance. In that case, the bonds will be selling above par but may be retired by the issuer at the special call price that may be equal to par value.

Usually, the periodic payments required for sinking-fund purposes will be the same for each period. Gas company issues often have increasing sinking-fund requirements. However, a few indentures might permit variable periodic payments, where the periodic payments vary based on prescribed conditions set forth in the indenture. The most common condition is the level of earnings of the issuer. In such cases, the periodic payments vary directly with earnings. An issuer prefers such flexibility; however, an investor may prefer fixed periodic payments because of the greater default risk protection provided under this arrangement.

Many corporate bond indentures include a provision that grants the issuer the option to retire more than the amount stipulated for sinking-fund retirement. This option, referred to as an *accelerated sinking-fund provision,* effectively reduces the bondholder's call protection because, when interest rates decline, the issuer may find it economically advantageous to exercise this option at the special sinking-fund call price to retire a substantial portion of an outstanding issue.

Sinking fund provisions have fallen out of favor for most companies, but they used to be fairly common for public utilities, pipeline issuers, and some industrial issues. Finance issues almost never include a sinking fund provision. There can be a mandatory sinking fund where bonds have to be retired or, as mentioned earlier, a nonmandatory sinking fund in which it may use certain property credits for the

sinking-fund requirement. If the sinking fund applies to a particular issue, it is called a *specific sinking fund.* There are also *nonspecific sinking funds* (also known as *funnel, tunnel, blanket,* or *aggregate sinking funds*), where the requirement is based on the total bonded debt outstanding of an issuer. Generally, it might require a sinking-fund payment of 1% of all bonds outstanding as of year-end. The issuer can apply the requirement to one particular issue or to any other issue or issues. Again, the blanket sinking fund may be mandatory (where bonds have to be retired) or nonmandatory (whereby it can use unfunded property additions).

Maintenance and Replacement Funds

Maintenance and replacement fund (M&R) provisions first appeared in bond indentures of electric utilities subject to regulation by the Securities and Exchange Commission (SEC) under the Public Holding Company Act of 1940. It remained in the indentures even when most of the utilities were no longer subject to regulation under the act. The original motivation for their inclusion is straightforward. Property is subject to economic depreciation, and the replacement fund ostensibly helps to maintain the integrity of the property securing the bonds. An M&R differs from a sinking fund in that the M&R only helps to maintain the value of the security backing the debt, whereas a sinking fund is designed to improve the security backing the debt. Although it is more complex, it is similar in spirit to a provision in a home mortgage requiring the homeowner to maintain the home in good repair.

An M&R requires a utility to determine annually the amounts necessary to satisfy the fund and any shortfall. The requirement is based on a formula that is usually some percentage (e.g., 15%) of adjusted gross operating revenues. The difference between what is required and the actual amount expended on maintenance is the shortfall. The shortfall is usually satisfied with unfunded property additions, but it also can be satisfied with cash. The cash can be used for the retirement of debt or withdrawn on the certification of unfunded property credits.

While the retirement of debt through M&R provisions is not as common as it once was, M&Rs are still relevant, so bond investors should be cognizant of their presence in an indenture. For example, in April 2000, PPL Electric Utilities Corporation redeemed all its outstanding 9.25% coupon series first-mortgage bonds due in 2019 using an M&R provision. The special redemption price was par. The company's stated purpose of the call was to reduce interest expense.

Redemption through the Sale of Assets and Other Means

Because mortgage bonds are secured by property, bondholders want the integrity of the collateral to be maintained. Bondholders would not want a company to sell a plant (which has been pledged as collateral) and then to use the proceeds for a distribution to shareholders. Therefore, release-of-property and substitution-of-property clauses are found in most secured bond indentures.

As an illustration, Texas–New Mexico Power Co. issued $130 million in first-mortgage bonds in January 1992 that carried a coupon rate of 11.25%. The bonds were callable beginning in January 1997 at a call price of 105. Following the sale of six of its utilities, Texas–New Mexico Power called the bonds at par in October 1995, well before the first call date. As justification for the call, Texas–New Mexico Power stated that it was forced to sell the six utilities by municipalities in northern Texas, and as a result, the bonds were callable under the eminent domain provision in the bond's indenture. The bondholders sued, stating that the bonds were redeemed in violation of the indenture. In April 1997, the court found for the bondholders, and they were awarded damages, as well as lost interest. In the judgment of the court, while the six utilities were under the threat of condemnation, no eminent domain proceedings were initiated.

Tender Offers

In addition to those methods specified in the indenture, firms have other tools for extinguishing debt prior to its stated maturity. At any time a firm may execute a tender offer and announce its desire to buy back specified debt issues. Firms employ tender offers to eliminate restrictive covenants or to refund debt. Usually the tender offer is for "any and all" of the targeted issue, but it also can be for a fixed dollar amount that is less than the outstanding face value. An offering circular is sent to the bondholders of record stating the price the firm is willing to pay and the window of time during which bondholders can sell their bonds back to the firm. If the firm perceives that participation is too low, the firm can increase the tender offer price and extend the tender offer window. When the tender offer expires, all participating bondholders tender their bonds and receive the same cash payment from the firm.

In recent years, tender offers have been executed using a fixed spread as opposed to a fixed price.[4] In a fixed-spread tender offer, the tender offer price is equal to the present value of the bond's remaining cash flows either to maturity or the next call date if the bond is callable. The present-value calculation occurs immediately after the tender offer expires. The discount rate used in the calculation is equal to the yield-to-maturity on a comparable-maturity Treasury or the associated CMT yield plus the specified fixed spread. Fixed-spread tender offers eliminate the exposure to interest-rate risk for both bondholders and the firm during the tender offer window.

CREDIT RISK

All corporate bonds are exposed to credit risk, which includes *credit default risk* and *credit-spread risk.*

4. See Steven V. Mann and Eric A. Powers, "Determinants of Bond Tender Premiums and the Percentage Tendered," *Journal of Banking and Finance*, March 2007, pp. 547–566.

Measuring Credit Default Risk

Any bond investment carries with it the uncertainty as to whether the issuer will make timely payments of interest and principal as prescribed by the bond's indenture. This risk is termed *credit default risk* and is the risk that a bond issuer will be unable to meet its financial obligations. Institutional investors have developed tools for analyzing information about both issuers and bond issues that assist them in accessing credit default risk. These techniques are discussed in later chapters. However, most individual bond investors and some institutional bond investors do not perform any elaborate credit analysis. Instead, they rely largely on bond ratings published by the major rating agencies that perform the credit analysis and publish their conclusions in the form of ratings. The three major nationally recognized statistical rating organizations (NRSROs) in the United States are Fitch Ratings, Moody's, and Standard & Poor's. These ratings are used by market participants as a factor in the valuation of securities on account of their independent and unbiased nature.

The ratings systems use similar symbols, as shown in Exhibit 12–2. In addition to the generic rating category, Moody's employs a numerical modifier of 1, 2, or 3 to indicate the relative standing of a particular issue within a rating category. This modifier is called a *notch*. Both Standard & Poor's and Fitch use a plus (+) and a minus (–) to convey the same information. Bonds rated triple B or higher are referred to as *investment-grade bonds*. Bonds rated below triple B are referred to as *non-investment-grade bonds* or, more popularly, *high-yield bonds* or *junk bonds*.

Credit ratings can and do change over time. A *rating transition table,* also called a *rating migration table,* is a table that shows how ratings change over some specified time period. Exhibit 12–3 presents a hypothetical rating transition table for a one-year time horizon. The ratings beside each of the rows are the ratings at the start of the year. The ratings at the head of each column are the ratings at the end of the year. Accordingly, the first cell in the table tells that 93.20% of the issues that were rated AAA at the beginning of the year still had that rating at the end. These tables are published periodically by the three rating agencies and can be used to access changes in credit default risk.

Measuring Credit-Spread Risk

The *credit-spread* is the difference between a corporate bond's yield and the yield on a comparable-maturity benchmark Treasury security.[5] Credit spreads are so named because the presumption is that the difference in yields is due primarily to the corporate bond's exposure to credit risk. This is misleading, however, because

5. The U.S. Treasury yield curve is a common but by no means the only choice for a benchmark to compute credit spreads. Other reasonable choices include the swap curve or the agency yield curve.

EXHIBIT 12–2

Corporate Bond Credit Ratings

Fitch	Moody's	S&P	Summary Description
			Investment Grade
AAA	Aaa	AAA	Gilt edged, prime, maximum safety, lowest risk, and when sovereign borrower considered "default-free"
AA+	Aa1	AA+	
AA	Aa2	AA	High-grade, high credit quality
AA–	Aa3	AA–	
A+	A1	A+	
A	A2	A	Upper-medium grade
A–	A3	A–	
BBB+	Baa1	BBB+	
BBB	Baa2	BBB	Lower-medium grade
BBB–	Baa3	BBB–	
			Speculative Grade
BB+	Ba1	BB+	
BB	Ba2	BB	Low grade; speculative
BB–	Ba3	BB–	
B+	B1		
B	B	B	Highly speculative
B–	B3		
			Predominantly Speculative, Substantial Risk or in Default
CCC+		CCC+	
CCC	Caa	CCC	Substantial risk, in poor standing
CC	Ca	CC	May be in default, very speculative
C	C	C	Extremely speculative
		CI	Income bonds—no interest being paid
DDD			
DD			Default
D	D		

the risk profile of corporate bonds differs from Treasuries on other dimensions; namely, corporate bonds are less liquid and often have embedded options.

Credit-spread risk is the risk of financial loss or the underperformance of a portfolio resulting from changes in the level of credit spreads used in the marking to market of a fixed income product. Credit spreads are driven by both macro-economic forces and issue-specific factors. Macro-economic forces include such

EXHIBIT 12–3

Hypothetical One-Year Rating Transition Table

Rating at Start of Year	Rating at End of Year								
	AAA	AA	A	BBB	BB	B	CCC	D	Total
AAA	93.20	6.00	0.60	0.12	0.08	0.00	0.00	0.00	100
AA	1.60	92.75	5.07	0.36	0.11	0.07	0.03	0.01	100
A	0.18	2.65	91.91	4.80	0.37	0.02	0.02	0.05	100
BBB	0.04	0.30	5.20	87.70	5.70	0.70	0.16	0.20	100
BB	0.03	0.11	0.61	6.80	81.65	7.10	2.60	1.10	100
B	0.01	0.09	0.55	0.88	7.90	75.67	8.70	6.20	100
CCC	0.00	0.01	0.31	0.84	2.30	8.10	62.54	25.90	100

things as the level and slope of the Treasury yield curve, the business cycle, and consumer confidence. Correspondingly, the issue-specific factors include such things as the corporation's financial position and the future prospects of the firm and its industry.

One method used commonly to measure credit-spread risk is *spread duration*. Spread duration is the approximate percentage change in a bond's price for a 100 basis point change in the credit-spread assuming that the Treasury rate is unchanged. For example, if a bond has a spread duration of 3, this indicates that for a 100 basis point change in the credit-spread, the bond's price should change be approximately 3%. Spread duration is discussed in Chapter 55.

EVENT RISK

In recent years, one of the more talked-about topics among corporate bond investors is *event risk*. Over the last couple of decades, corporate bond indentures have become less restrictive, and corporate managements have been given a free rein to do as they please without regard to bondholders. Management's main concern or duty is to enhance shareholder wealth. As for the bondholder, all a company is required to do is to meet the terms of the bond indenture, including the payment of principal and interest. With few restrictions and the optimization of shareholder wealth of paramount importance for corporate managers, it is no wonder that bondholders became concerned when merger mania and other events swept the nation's boardrooms. Events such as decapitalizations, restructurings, recapitalizations, mergers, acquisitions, leveraged buyouts, and share repurchases, among other things, often caused substantial changes in a corporation's capital structure, namely, greatly increased leverage and decreased equity. Bondholders' protection was sharply reduced and debt quality ratings lowered, in many cases

to speculative-grade categories. Along with greater risk came lower bond valuations. Shareholders were being enriched at the expense of bondholders. It is important to keep in mind the distinction between event risk and headline risk. Headline risk is the uncertainty engendered by the firm's media coverage that causes investors to alter their perception of the firm's prospects. Headline risk is present regardless of the veracity of the media coverage.

In reaction to the increased activity of leveraged buyouts and strategic mergers and acquisitions, some companies incorporated "poison puts" in their indentures. These are designed to thwart unfriendly takeovers by making the target company unpalatable to the acquirer. The poison put provides that the bondholder can require the company to repurchase the debt under certain circumstances arising out of specific designated events such as a change in control. Poison puts may not deter a proposed acquisition but could make it more expensive. Many times, in addition to a designated event, a rating change to below investment grade must occur within a certain period for the put to be activated. Some issues provide for a higher interest rate instead of a put as a designated event remedy.

At times, event risk has caused some companies to include other special debt-retirement features in their indentures. An example is the *maintenance of net worth clause* included in the indentures of some lower-rated bond issues. In this case, an issuer covenants to maintain its net worth above a stipulated level, and if it fails to do so, it must begin to retire its debt at par. Usually the redemptions affect only part of the issue and continue periodically until the net worth recovers to an amount above the stated figure or the debt is retired. In other cases, the company is required only to *offer to redeem* a required amount. An offer to redeem is not mandatory on the bondholders' part; only those holders who want their bonds redeemed need do so. In a number of instances in which the issuer is required to call bonds, the bondholders may elect not to have bonds redeemed. This is not much different from an offer to redeem. It may protect bondholders from the redemption of the high-coupon debt at lower interest rates. However, if a company's net worth declines to a level low enough to activate such a call, it probably would be prudent to have one's bonds redeemed.

Protecting the value of debt investments against the added risk caused by corporate management activity is not an easy job. Investors should analyze the issuer's fundamentals carefully to determine if the company may be a candidate for restructuring. Attention to news and equity investment reports can make the task easier. Also, the indenture should be reviewed to see if there are any protective covenant features. However, there may be loopholes that can be exploited by sharp legal minds. Of course, large portfolios can reduce risk with broad diversification among industry lines, but price declines do not always affect only the issue at risk; they also can spread across the board and take the innocent down with them. This happened in the fall of 1988 with the leveraged buyout of RJR Nabisco, Inc. The whole industrial bond market suffered as buyers and traders withdrew from the market, new issues were postponed, and secondary market

activity came to a standstill. The impact of the initial leveraged buyout bid announcement on yield spreads for RJR Nabisco's debt to a benchmark Treasury increased from about 100 to 350 basis points. The RJR Nabisco transaction showed that size was not an obstacle. Therefore, other large firms that investors previously thought were unlikely candidates for a leveraged buyout were fair game. The spillover effect caused yield spreads to widen for other major corporations. This phenomenon was repeated in the mid-2000s with the buyout of large, investment grade public companies such as Alltel, First Data, and Hilton Hotels.

HIGH-YIELD BONDS

As noted, high-yield bonds are those rated below investment grade by the ratings agencies. These issues are also known as *junk bonds*. Despite the negative connotation of the term *junk,* not all bonds in the high-yield sector are on the verge of default or bankruptcy. Many of these issues are on the fringe of the investment-grade sector.

Types of Issuers

Several types of issuers fall into the less-than-investment-grade high-yield category. These categories are discussed below.

Original Issuers

Original issuers include young, growing concerns lacking the stronger balance sheet and income statement profile of many established corporations but often with lots of promise. Also called *venture-capital situations* or *growth or emerging market companies,* the debt is often sold with a story projecting future financial strength. From this we get the term *story bond.* There are also the established operating firms with financials neither measuring up to the strengths of investment-grade corporations nor possessing the weaknesses of companies on the verge of bankruptcy. Subordinated debt of investment-grade issuers may be included here. A bond rated at the bottom rung of the investment-grade category (Baa and BBB) or at the top end of the speculative-grade category (Ba and BB) is referred to as a "businessman's risk."

Fallen Angels

"Fallen angels" are companies with investment-grade-rated debt that have come on hard times with deteriorating balance sheet and income statement financial parameters. They may be in default or near bankruptcy. In these cases, investors are interested in the workout value of the debt in a reorganization or liquidation, whether within or outside the bankruptcy courts. Some refer to these issues as "special situations." Over the years, they have fallen on hard times; some have recovered, and others have not.

Restructurings and Leveraged Buyouts

These are companies that have deliberately increased their debt burden with a view toward maximizing shareholder value. The shareholders may be the existing public group to which the company pays a special extraordinary dividend, with the funds coming from borrowings and the sale of assets. Cash is paid out, net worth decreased, and leverage increased, and ratings drop on existing debt. Newly issued debt gets junk-bond status because of the company's weakened financial condition.

In a leveraged buyout (LBO), a new and private shareholder group owns and manages the company. The debt issue's purpose may be to retire other debt from commercial and investment banks and institutional investors incurred to finance the LBO. The debt to be retired is called *bridge financing* because it provides a bridge between the initial LBO activity and the more permanent financing. One example is Ann Taylor, Inc.'s 1989 debt financing for bridge loan repayment. The proceeds of BCI Holding Corporation's 1986 public debt financing and bank borrowings were used to make the required payments to the common shareholders of Beatrice Companies, pay issuance expenses, and retire certain Beatrice debt and for working capital.

Unique Features of Some Issues

Often actions taken by management that result in the assignment of a non-investment-grade bond rating result in a heavy interest-payment burden. This places severe cash-flow constraints on the firm. To reduce this burden, firms involved with heavy debt burdens have issued bonds with *deferred coupon structures* that permit the issuer to avoid using cash to make interest payments for a period of three to seven years. There are three types of deferred-coupon structures: (1) deferred-interest bonds, (2) step-up bonds, and (3) payment-in-kind bonds.

Deferred-interest bonds are the most common type of deferred-coupon structure. These bonds sell at a deep discount and do not pay interest for an initial period, typically from three to seven years. (Because no interest is paid for the initial period, these bonds are sometimes referred to as "zero-coupon bonds.") *Step-up bonds* do pay coupon interest, but the coupon rate is low for an initial period and then increases ("steps up") to a higher coupon rate. Finally, *payment-in-kind (PIK) bonds* give the issuers an option to pay cash at a coupon payment date or give the bondholder a similar bond (i.e., a bond with the same coupon rate and a par value equal to the amount of the coupon payment that would have been paid). The period during which the issuer can make this choice varies from five to ten years.

Sometimes an issue will come to market with a structure allowing the issuer to reset the coupon rate so that the bond will trade at a predetermined price.[6]

6. Most of the bonds have a coupon reset formula that requires the issuer to reset the coupon so that the bond will trade at a price of $101.

The coupon rate may reset annually or even more frequently, or reset only one time over the life of the bond. Generally, the coupon rate at the reset date will be the average of rates suggested by two investment banking firms. The new rate will then reflect (1) the level of interest rates at the reset date and (2) the credit-spread the market wants on the issue at the reset date. This structure is called an *extendible reset bond.*

Notice the difference between an extendible reset bond and a typical floating-rate issue. In a floating-rate issue, the coupon rate resets according to a fixed spread over the reference rate, with the index spread specified in the indenture. The amount of the index spread reflects market conditions at the time the issue is offered. The coupon rate on an extendible reset bond, in contrast, is reset based on market conditions (as suggested by several investment banking firms) at the time of the reset date. Moreover, the new coupon rate reflects the new level of interest rates and the new spread that investors seek.

The advantage to investors of extendible reset bonds is that the coupon rate will reset to the market rate—both the level of interest rates and the credit-spread—in principle keeping the issue at par value. In fact, experience with extendible reset bonds has not been favorable during periods of difficulties in the high-yield bond market. The sudden substantial increase in default risk has meant that the rise in the rate needed to keep the issue at par value was so large that it would have insured bankruptcy of the issuer. As a result, the rise in the coupon rate has been insufficient to keep the issue at the stipulated price.

Some speculative-grade bond issues started to appear in 1992 granting the issuer a limited right to redeem a portion of the bonds during the noncall period if the proceeds are from an initial public stock offering. Called "clawback" provisions, they merit careful attention by inquiring bond investors. The provision appears in the vast majority of new speculative-grade bond issues, and sometimes allow even private sales of stock to be used for the clawback. The provision usually allows 35% of the issue to be retired during the first three years after issuance, at a price of par plus one year of coupon. Investors should be forewarned of clawbacks because they can lose bonds at the point in time just when the issuer's finances have been strengthened through access to the equity market. Also, the redemption may reduce the amount of the outstanding bonds to a level at which their liquidity in the aftermarket may suffer.

DEFAULT RATES AND RECOVERY RATES

We now turn our attention to the various aspects of the historical performance of corporate issuers with respect to fulfilling their obligations to bondholders. Specifically, we will look at two aspects of this performance. First, we will look at the default rate of corporate borrowers. From an investment perspective, default rates by themselves are not of paramount significance; it is perfectly possible for a portfolio of bonds to suffer defaults and to outperform Treasuries at the same time, provided the yield spread of the portfolio is sufficiently high to offset

the losses from default. Furthermore, because holders of defaulted bonds typically recover some percentage of the face amount of their investment, the *default loss rate* is substantially lower than the default rate. Therefore, it is important to look at default loss rates or, equivalently, *recovery rates.*

Default Rates

A default rate can be measured in different ways. A simple way to define a default rate is to use the issuer as the unit of study. A default rate is then measured as the number of issuers that default divided by the total number of issuers at the beginning of the year. This measure gives no recognition to the amount defaulted nor the total amount of issuance. Moody's, for example, uses this default-rate statistic in its study of default rates.[7] The rationale for ignoring dollar amounts is that the credit decision of an investor does not increase with the size of the issuer. The second measure is to define the default rate as the par value of all bonds that defaulted in a given calendar year divided by the total par value of all bonds outstanding during the year. Edward Altman, who has performed extensive analyses of default rates for speculative-grade bonds, measures default rates in this way. We will distinguish between the default-rate statistic below by referring to the first as the *issuer default rate* and the second as the *dollar default rate.*

With either default-rate statistic, one can measure the default for a given year or an average annual default rate over a certain number of years. Researchers who have defined dollar default rates in terms of an average annual default rate over a certain number of years have measured it as

$$\frac{\text{Cumulative \$ value of all defaulted bonds}}{\text{Cumulative \$ value of all issuance} \times \text{weighted avg. no. of years outstanding}}$$

Alternatively, some researchers report a cumulative annual default rate. This is done by not normalizing by the number of years. For example, a cumulative annual dollar default rate is calculated as

$$\frac{\text{Cumulative \$ value of all defaulted bonds}}{\text{Cumulative \$ value of all issuance}}$$

There have been several excellent studies of corporate bond default rates. We will not review each of these studies because the findings are similar. Here we will look at a study by Moody's that covers the period 1970 to 1994.[8]

7. Moody's Investors Service, "Corporate Bond Defaults and Default Rates: 1970–1994," Moody's Special Report, January 1995, p. 13. Different issuers within an affiliated group of companies are counted separately.
8. Moody's Investors Service, "Corporate Bond Defaults and Default Rates: 1970–1994."

Over this 25-year period, 640 of the 4,800 issuers in the study defaulted on more than $96 billion of publicly offered long-term debt. A *default* in the Moody's study is defined as "any missed or delayed disbursement of interest and/or principal." Issuer default rates are calculated. The Moody's study found that the lower the credit rating, the greater is the probability of a corporate issuer defaulting.

There have been extensive studies focusing on default rates for speculative-grade issuers. In their 2011 study, Altman and Kuehne find based on a sample of high-yield bonds outstanding over the period 1971–2010, default rates typically range between 2% and 5% with occasional spikes above 10% during periods of financial dislocation.[9]

Recovery Rates

There have been several studies that have focused on recovery rates or default loss rates for corporate debt. Measuring the amount recovered is not a simple task. The final distribution to claimants when a default occurs may consist of cash and securities. Often it is difficult to track what was received and then determine the present value of any noncash payments received.

While the empirical record is developing, we will state a few stylized facts about recovery rates and by implication default rates.[10]

- The average recovery rate of bonds across seniority levels is approximately 38%.
- The distribution of recovery rates is bimodal.
- Recovery rates are unrelated to the size of the bond issuance.
- Default rates and recovery rates are inversely correlated.
- Recovery rate is lower in an economic downturn and in a distressed industry.
- Tangible asset-intensive industries have higher recovery rates.

MEDIUM-TERM NOTES

Medium-term notes (MTNs) are debt instruments that differ primarily in how they are sold to investors. Akin to a commercial paper program, they are offered continuously to institutional investors by an agent of the issuer. MTNs are registered

9. Edward I. Altman and Brenda J. Kuehne, "Defaults and Returns in the High-Yield Bond and Distressed Market: The Year 2010 in Review and Outlook," Special Report, New York University Salomon Center, Leonard N. Stern School of Business, February 4, 2011.
10. Dilip B. Madan, Gurdip S. Bakshi, and Frank Xiaoling Zhang, "Understanding the Role of Recovery in Default Risk Models: Empirical Comparisons and Implied Recovery Rates," FDIC CFR Working Paper No. 06; EFA 2004 Maastricht Meetings Paper No. 3584; FEDS Working Paper; AFA 20004 Meetings (September 2006). Available at SSRN: http://ssrn.com/abstract=285940 or doi:10.2139/ssrn.285940

with the Securities and Exchange Commission under Rule 415 ("shelf registration") which gives a corporation sufficient flexibility for issuing securities on a continuous basis. MTNs are also issued by non-U.S. corporations, federal agencies, supranational institutions, and sovereign governments.

One would suspect that MTNs would describe securities with intermediate maturities. However, it is a misnomer. MTNs are issued with maturities of 9 months to 30 years or even longer. For example, in 1993, Walt Disney Corporation issued bonds through its medium-term note program with a 100-year maturity a so-called century bond. MTNs can perhaps be more accurately described as highly flexible debt instruments that can easily be designed to respond to market opportunities and investor preferences.

As noted, MTNs differ in their primary distribution process. Most MTN programs have two to four agents. Through its agents, an issuer of MTNs posts offering rates over a range of maturities: for example, nine months to one year, one year to eighteen months, eighteen months to two years, and annually thereafter. Many issuers post rates as a yield spread over a Treasury security of comparable maturity.

Relatively attractive yield spreads are posted for maturities that the issuer desires to raise funds. The investment banks disseminate this offering rate information to their investor clients. When an investor expresses interest in an MTN offering, the agent contacts the issuer to obtain a confirmation of the terms of the transaction. Within a maturity range, the investor has the option of choosing the final maturity of the note sale, subject to agreement by the issuing company. The issuer will lower its posted rates once it raises the desired amount of funds at a given maturity.

Structured medium-term notes or simply *structured notes* are debt instruments coupled with a derivative position (options, forwards, futures, swaps, caps, and floors). For example, structured notes are often created with an underlying swap transaction. This "hedging swap" allows the issuer to create structured notes with interesting risk/return features desired by a swath of fixed income investors.

KEY POINTS

- A bond's indenture includes the promises of corporate bond issuers and the rights of investors. The terms of bond issues set forth in bond indentures are always a compromise between the interests of the bond issuer and those of investors who buy bonds.
- The classification of corporate bonds by type of issuer include public utilities, transportations, industrials, banks and finance companies, and international or Yankee issues.
- The three main interest payment classifications of domestically issued corporate bonds are straight-coupon bonds (fixed-rate bonds), zero-coupon bonds, and floating-rate bonds (variable-rate bonds).

- Either real property (using a mortgage) or personal property may be pledged to offer security beyond that of the general credit standing of the issuer. In fact, the kind of security or the absence of a specific pledge of security is usually indicated by the title of a bond issue. However, the best security is a strong general credit that can repay the debt from earnings.
- A mortgage bond grants the bondholders a first-mortgage lien on substantially all its properties and as a result the issuer is able to borrow at a lower rate of interest than if the debt were unsecured.
- Some companies do not own fixed assets or other real property and so have nothing tangible on which they can give a mortgage lien to secure bondholders. To satisfy the desire of bondholders for security, they pledge stocks, notes, bonds, or whatever other kinds of obligations they own and the resulting issues are referred to as collateral trust bonds.
- Debentures not secured by a specific pledge of designated property and therefore bondholders have the claim of general creditors on all assets of the issuer not pledged specifically to secure other debt. Moreover, debenture bondholders have a claim on pledged assets to the extent that these assets have value greater than necessary to satisfy secured creditors. In fact, if there are no pledged assets and no secured creditors, debenture bondholders have first claim on all assets along with other general creditors.
- Owners of subordinated debenture bonds stand last in line among creditors when an issuer fails financially.
- For a guaranteed bond there is a third party guaranteeing the debt but that does not mean a bond issue is free of default risk. The safety of a guaranteed bond depends on the financial capability of the guarantor to satisfy the terms of the guarantee, as well as the financial capability of the issuer.
- Debt retirement mechanisms included in a bond's indenture are call and refunding provisions, sinking funds, maintenance and replacement funds, redemption through sale of assets, and tender offers.
- All corporate bonds are exposed to credit risk, which includes credit default risk and credit-spread risk.
- Credit ratings can and do change over time and this information is captured in a rating transition table, also called a rating migration table.
- Credit-spread risk is the risk of financial loss or the underperformance of a portfolio resulting from changes in the level of credit spreads used in the marking to market of a fixed income product. One method used commonly to measure credit-spread risk is spread duration which is the approximate percentage change in a bond's price for a 100 basis point change in the credit-spread assuming that the Treasury rate is unchanged.

- The three types of issuers that comprise the less-than-investment-grade high-yield corporate bond category are original issuers, fallen angels, and restructuring and leveraged buyouts.
- Often actions taken by management that result in the assignment of a noninvestment-grade bond rating result in a heavy interest payment burden. To reduce this burden, firms involved with heavy debt burdens have issued bonds with deferred coupon structures that permit the issuer to avoid using cash to make interest payments for a period of three to seven years. There are three types of deferred-coupon structures: deferred-interest bonds, step-up bonds, and payment-in-kind bonds.
- From an investment perspective, default rates by themselves are not of paramount significance because a portfolio of bonds could suffer defaults and still outperform Treasuries at the same time. This can occur if the yield spread of the portfolio is sufficiently high to offset the losses from default. Furthermore, because holders of defaulted bonds typically recover some percentage of the face amount of their investment, the default loss rate is substantially lower than the default rate. Therefore, it is important to look at default loss rates or, equivalently, recovery rates.
- A default rate can be measured in term of the issuer default rate and the dollar default rate.

CHAPTER
THIRTEEN

LEVERAGED LOANS

STEPHEN J. ANTCZAK, CFA*
Consultant

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

JUNG LEE*
Consultant

A *leveraged loan* is a loan made to a company whose credit rating is speculative grade. That is, the borrower has a below investment-grade rating (below BBB–/Baa3). When a reference is made to "loans" by market participants, typically it means (1) loans that are broadly syndicated (to 10 or more bank and nonbank investors), (2) senior secured loans that are at the top-most rank in the borrower's capital structure, and (3) large loans to large companies. In terms of total par amount outstanding, the leveraged loan market was comparably very small back in 1996 (under $15 billion of leveraged loans versus about $975 billion of corporate bonds). The market steadily grew to about $250 billion by 2005. In the next three years, however, the market more than doubled to over $550 billion par amount outstanding. While there was a downward trend in the size in 2009 and 2010 due to the financial crisis that began in 2008, the market size remains significantly greater than its long-term average.

For below investment-grade companies, leveraged loans are a key component of their capital structure. Although there are significant variations, for a typical leveraged loan borrower the debt capitalization is about 65% to 70% loans and 30% to 35% bonds. Broadly speaking, corporate borrowers utilize the proceeds from a leveraged loan for various purposes. In the first quarter of 2011, 64% of new-issue loans were used to refinance existing debt, 11% for shareholder-friendly activities away from leveraged re-capitalizations (e.g., special dividends), 10% for corporate acquisitions, and 10% to fund (at least partially) leveraged buyouts, and the remaining 5% on other activities such as working capital.

Leveraged loans have been syndicated and sold to nonbank institutional investors since the late 1980s, but institutional investors only became a significant

*This chapter was written when Antcak was head of U.S. Credit Strategy and Lee was a credit strategist at Société Générale.

factor in the market beginning in 1995. We describe various facets of the leveraged loan market in this chapter.

SYNDICATED BANK LOANS

A leveraged loan is one form of a *syndicated loan*. A syndicated loan is a single loan with a single set of terms, but multiple lenders, each providing a portion of the funds. The advantage of the syndication of a loan from a borrower's perspective is that (1) it allows a corporation to negotiate loan terms once, while at the same time having access to multiple lenders; and (2) it avoids conflicts in priority from arising that might otherwise occur if the borrower serially negotiated loans. All lenders in the syndicate share equally in rights under the credit agreement.

Typically, a syndicated loan is arranged by a commercial or investment bank—referred to as the *arranger*, also called the *mandated lead arranger*[1]—and that entity advises the borrower on the type of facility (as described later, a revolving line of credit and/or term loan), negotiates the terms of the loan, including pricing, and manages the structuring of the credit agreement. The arranger prepares an information memo or bank book. The document, which is confidential and made available to qualified banks and accredited investors only, provides information about the borrower, the borrower's industry, loan terms, and the borrower's financial projections. For administering the loan on a daily basis, an *agent* is appointed. It is the agent, which is one of the banks, that is responsible for monitoring the borrower to assure compliance with the terms of the loan.

After the credit agreement and a security agreement are finalized, the required documents are filed with the relevant legal jurisdictions. However, the credit agreement may be amended for a variety of reasons. It could be for a minor change such as a waiver of a specific covenant. Such changes may merely require a majority vote to do so. At the other extreme, it could involve more complex changes such as changes in the interest rate, term of the loan, or the security for the loan. More complex changes may require unanimous consent.

Worth noting, one amendment that has become more frequent is the "amend-and-extend." The bankruptcy process often tends to be expensive for lenders—the cost of Lehman Brothers' bankruptcy surpassed $1 billion by the end of 2010, about two years after its filing for Chapter 11 in mid-September 2008—and in part for that reason from a lender's perspective modifying the terms of a loan may be a more beneficial option than the bankruptcy process. Exhibit 13–1 shows that the number of amend-and-extend and covenant relief amendments spiked in 2008 to 100, and then more than tripled to about 350 in 2009. While the number fell by about 50% in 2010, the number of amendments still remains significantly higher than the historical average.

1. Actually, there is often more than one arranger in a transaction despite the reference to a singular party in this chapter.

EXHIBIT 13–1

Number of Covenant Relief and Amend-and-Extend Amendments

Source: S&P LCD.

Loans may be underwritten or done on a best-effort basis. In an *underwritten deal*, for any portion of the loan that is not subscribed for by other banks or investors the arranger must take onto its books (and thus fund). In contrast, in a *best-efforts deal* the arranger does not guarantee the placement of the entire amount to other banks or investors. Instead, the pricing or the size may be adjusted. A variant of the best-effort arrangement involves the use of *market flex language* wherein borrowers typically give arrangers the flexibility to adjust loan terms and loan pricing to ensure that the loan would be fully subscribed. Typically in such an arrangement there is an upper limit on what the borrower will accept and that often involves increasing the loan's spread above its reference benchmark. A *reverse market flex*, in contrast, tightens the spread in response to oversubscription or other market conditions.

LOAN STRUCTURE

In practice, there is typically not just one loan that is arranged. Instead, a credit agreement often calls for a *revolving line of credit* and one or more *term loans* with increasing maturities, term loan A, term loan B, and so on. In some credit agreements, the revolving line of credit can be drawn upon by the borrower who is then permitted to convert the amount drawn upon into a term loan.

Leveraged loans can be classified under the credit agreement as pro rata loans and institutional loans. *Pro rata loans* are distributed to banks, and usually

include the revolving line of credit and term loans that mature from three to five years. As the name suggests, *institutional loans* are distributed to nonbank institutional investors and typically include term loans maturing in five to seven years. Newly issued leveraged loans were mostly pro rata in the late 1990s (average of 81% of the new issues from 1997 to 1999, for example) but institutional loans have grown progressively and are now the significant component of new loan issues (average of 60% of new issues from 2006 to 2010).

LOAN TERMS

The loan credit agreement sets forth the loan's terms. There are three forms: (1) representations and warranties made by the borrower, (2) affirmative covenants, and (3) negative covenants.

Leveraged loans commonly contain covenants or requirements that must be satisfied by borrowers. The two most common are maintenance requirements and incurrence requirements. These requirements are specified in the form of tests. Basically, *maintenance requirements* are regular reviews of various operating performance measures, such as leverage, interest coverage, and so on. It is not necessary for there to be any particular corporate action in order to "trigger" a review of these operating measures. An *incurrence requirement* is a review of specific operating measures relative to predetermined levels after an issuer has taken an action that triggers a review. Examples of such typical actions that can trigger a review are share repurchases, divestitures, and special dividends. There are five purposes served by this process:[2]

1. *Preservation of collateral:* The borrower represents that the lenders have a legal, valid, and enforceable security interest in the pledged collateral. Typically, this means not only the borrower's existing assets at the time of the loan's closing, but also assets subsequently acquired by the borrower. There are loans where only specific assets are pledged as collateral.
2. *Appropriation of excess cash flow:* In the absence of restrictions, a borrower could take out a loan, sell its assets, distribute the proceeds from the sale of the assets and the proceeds of the loans to the equity holders, and thereby create an empty corporate shell with no assets for the lenders. To prevent this, excess cash flow from the borrower's ordinary and extraordinary business activities—defined as cash flow minus cash expenses, required dividends, debt repayments, capital expenditures, and changes in working capital—is required to be used to prepay loans.

2. For a more detailed description, see Chapter 3 in Stephen Antczak, Douglas J. Lucas, and Frank J. Fabozzi, *Leveraged Finance: Concepts, Methods, and Trading of High-Yield Bonds, Loans and Derivatives* (New York: John Wiley & Sons, 2009).

3. *Control of business risk:* Lenders become disadvantaged when a borrower's business becomes riskier and the risk that borrowers will make business decisions to benefit equity holders at the expense of lenders increases.[3] Management of the borrowing firm can increase risk by taking on riskier investment projects, taking on more debt, or acquiring other firms. Loan terms are imposed to prevent this practice. In the case of taking on more debt, this may be prohibited even if the priority of the new debt ranking is subordinate to the loan.
4. *Performance requirements:* Performance measures used by lenders include ratios such as coverage ratios, leverage ratios, and liquidity ratios, as well as dollar amounts such as tangible net worth, maximum capital expenditures, and cash flow/net worth requirements. These measures can be calculated based on financial statement items (prepared under generally accepted accounting principles) or lender-specified calculations. If these measures are violated, the loan becomes due and payable immediately.
5. *Reporting requirements*: For purposes of monitoring the borrower, the lender will require that the borrower periodically furnish specified documents and reports. These include not only documents required by government regulatory agencies but also internal reports such as budgets and projections and accounts receivable analysis, as well as third-party nonfiling reports such as appraisals for certain assets.

The pricing of a loan (i.e., the loan's spread) depends on three factors: (1) the credit quality/rating of the borrower, (2) the size of the loans, and (3) the supply of and demand for new issues.[4] Obviously, the lower the borrower's credit rating, the greater the loan's spread all other factors equal. The second factor relates to the balance or imbalance between the amount of loans that are being brought to market and the credit appetite of buyers (i.e., banks and institutional lenders). The size of the loan can result in a higher or lower spread. On the one hand, the larger the loan size, the higher the spread needed to clear the market. On the other hand, for trading purposes, a larger loan size can work to decrease the spread because investors believe that larger loans tend to trade better in the secondary market due to greater familiarity with the issuer.[5]

3. Financial economists identify this as one of the costs of financial distress.
4. For other factors influencing a loan's attractiveness, see Chapter 3 in Antczak, Lucas, and Fabozzi, *Leveraged Finance: Concepts, Methods, and Trading of High-Yield Bonds, Loans and Derivatives*.
5. Ibid., p. 63.

RECOVERY RATES

The textbook description of the position of a creditor in the case of a bankruptcy is that the priority of creditors as set forth in the original lending agreements will be respected by the courts. However, a good number of empirical studies have clearly demonstrated that in the case of a Chapter 11 bankruptcy, the absolute priority rule is typically violated. That is, senior creditors may not be paid in full before junior creditors and even equity owners receive some form of payment. There are a good number of economic reasons as to why the absolute priority rule may be violated. These reasons relate to the direct and indirect costs associated with the negotiations among the creditors and equity claimants. The bottom line, however, is that the recovery rates for the various levels of creditors is an empirical issue.

Fortunately, studies of recovery rates confirm that despite the high risk of a violation of the absolute priority rule in practice, the senior claim of bank loan lenders on the assets of the borrower, as measured by recovery rates, is higher than that for other creditors. In a comprehensive study by Moody's of about 3,500 defaulted loans and bonds issued since 1987 by 720 nonfinancial U.S. corporations, the ultimate recovery rates were higher for loans in comparison to bonds.[6] More specifically Moody's found that the average recovery rate for defaulted loans was 81% of par value; the average recovery rate for defaulted bonds was only 39% of par value. Of course, the recovery rate for bonds did vary by the seniority of bonds in the capital structure, with the most senior bonds (i.e., senior secured bonds) recovering 67% of par value. Moreover, the Moody's study reported that loan recovery rates have a right-skewed distribution, while bond recovery rates have a left-skewed distribution.

Another way to look at the recovery rates is using the post-default trading prices as a proxy for recovery rather than the ultimate recovery levels. Based on the issuer-weighted, post-default trading prices, the 1990–2009 average recovery for first lien loans is about 70% of par value. In comparison, Moody's found that the average recovery rate for the same time period is about 41% of par value for corporate bonds.

It is important to keep in mind that the previously mentioned recovery rates are all expressed in percentage terms of par value. As such, loans trading at par are exposed to greater loss than those trading under par in the event of a default. For example, Exhibit 13–2 shows that the average bid price of leveraged loans in the secondary market fell to as low as $62 in December 2008. If we assume 82% ultimate recovery rate of par value and that an investor had bought an average loan at $62 in 2008, he would not have any loss even if a default occurred. Also worth noting is that the recovery rates tend to vary meaningfully by year. For example, while the recovery rate for loans in 2004 was almost 90% of par value, it was only about 55% in 2009.

6. Moody's *Ultimate Recovery Database: Special Comment*, April 2007. The method for measuring recovering varies from study to study. Some studies use a loan's or bond's post-default trading level as a proxy for its recovery rate. In the Moody's study, the discounted actual amount received by the holder of a given piece of debt at the resolution of a credit event was used.

EXHIBIT 13–2

Average Bid Price for Leveraged Loans

Source: S&P LCD.

Note: As of March 11, 2011. Excludes the defaulted facilities.

SECONDARY MARKET

Leveraged loans are private contracts and, as a result, prior to 1987, little public information was available about leveraged loans. This stifled secondary market trading. In 1987, the Loan Pricing Corporation (LPC) began publishing information on global syndicated loans. Its flagship product, *Gold Sheets*, is a weekly publication that provides information on pricing, structure, tenor, and industry segments.

In 1995, the Loan Syndications and Trading Association (LSTA) was created as an industry association whose goal was to foster the development of a more liquid and transparent secondary market. It has done so by establishing market practices and procedures for settlement and operations. For example, the LSTA publishes model credit agreement provisions and a document covering the principles for the communications and use of confidential information by loan market participants.

LSTA and LPC started gathering mark-to-market pricing data. LoanX (now part of Markit Partners) began offering loan pricing in 1999.

LSTA and Standard & Poor's (S&P) joined forces to create secondary market indexes. Market indexes play an important role for all asset classes for several reasons, such as measuring the performance of an asset class for purposes of making asset allocation decisions and evaluating the performance of active managers. In the leveraged loan market, the S&P/LSTA U.S. Leveraged Loan 100 is the primary index.[7] This index measures the performance of the 100 largest institutional leveraged loans (on a market-weighted basis) drawn from the approximately 1,000 term loans included in the S&P/LSTA Leveraged Loan Index (LLI). To be eligible to be included in the LLI itself, the term loan must be

7. For more details about this index, see "S&P/LSTA U.S. Leveraged Loan 100" published by Standard & Poor's available at www.SPindices.com.

a senior secured first lien, have a minimum initial term of one year, have a minimum initial spread of 125 basis points over LIBOR, have a minimum par amount of U.S. $50 million, and be dominated in U.S. dollars. The loans included in the index are selected by a set of rules specified by S&P's index committee.

According to the LSTA, quarterly secondary trading volume grew from $50 billion in the first quarter of 2005 to $142 billion in second quarter 2008, falling to $107 billion in the fourth quarter of 2010. The annual secondary trade volume was slightly above $400 billion by end of 2010, a decline since peaking in 2007 at over $500 billion, yet still more than about $350 billion in 2006.

There are two methods by which loans in the secondary market change hands: by assignment or by participation. In the case of an *assignment*, the buyer becomes the lender of record with all related rights and powers. An assignment typically requires the borrower's consent for the exchange to take place. In contrast, if the exchange is accomplished via *participation*, although the buyer receives the right to repayment, the original lender remains the lender of record. It is therefore the responsibility of the lender of record to collect the amount due from the borrower and then pay that amount to the participant. The borrower's consent is usually not required in the case of a participation. However, the buyer bears a greater credit risk in the case of a participation because there is no contractual link between the borrower and the participant. As a result, if the original lender becomes insolvent, the participant may have no recourse.

In Exhibit 13–3, we see that the secondary market for leveraged loans has historically been less volatile, with the average bidding price hovering around par value and the spread (to maturity) staying in the LIBOR plus 400 basis points range, until the beginning of the financial crisis in 2007.

EXHIBIT 13–3

Spread to Maturity in the Secondary Market

Source: SG Cross Asset Research, S&P LCD.

Note: As of March 11, 2011. Excludes the defaulted facilities.

KEY POINTS

- A leveraged loan is a loan made to a company whose credit rating is below investment-grade (below BBB–/Baa3). When a reference is made to "loans" by market participants, it typically means (1) loans that are broadly syndicated (to 10 or more bank and nonbank investors) leveraged loans, (2) senior secured loans that are at the top-most rank in the borrower's capital structure, and (3) larger loans to larger companies.
- A leveraged loan is a syndicated loan with a single set of terms, but multiple lenders, each providing a portion of the funds. The advantage of the syndication of a loan from a borrower's perspective is that it (1) allows a corporation to negotiate loan terms only once yet gain access to multiple lenders, and (2) avoids possible conflicts in priority if the borrower serially negotiated loans; all lenders in the syndicate share equal rights under the credit agreement.
- Leveraged loans can be classified as (1) pro rata loans that are distributed to banks and usually include the revolving line of credit and shorter maturity term loans, and (2) institutional loans that are distributed to nonbank institutional investors and typically include longer-maturity term loans.
- Leveraged loans commonly contain covenants or requirements that must be satisfied by borrowers. The two most common are (1) maintenance requirements, or regular reviews of operating measures, and (2) incurrence requirements, a review of specific operating measures after an issuer has taken an action to trigger a review. Purposes of such loan terms include: (1) preservation of collateral, (2) appropriation of excess cash flow, (3) control of business risk, (4) performance requirements, and (5) reporting requirements.
- Studies of recovery rates confirm that the senior claim of bank loan lenders on the assets of the borrower, as measured by recovery rates as percentage of par value, is higher than that for other creditors. It is important to keep in mind that such recovery rates are expressed in percentage terms of par value so that loans trading at par are exposed to greater loss than those trading under par in the event of a default. Also worth noting is that recovery rates tend to vary meaningfully by year.
- There are two methods by which loans in the secondary market change hands: (1) by assignment, in which the buyer becomes the lender of record with all related rights and powers, and (2) by participation, in which the buyer receives the right to repayment but the original lender remains the lender of record. In the case of a participation, the buyer bears a greater credit risk since there is no contractual link between the borrower and the participant.

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CHAPTER
FOURTEEN

CONVERTIBLE SECURITIES AND THEIR INVESTMENT APPLICATION

JONATHAN L. HORNE
Executive Vice President
Pacific Investment Management Company

CHRIS P. DIALYNAS
Managing Director
Pacific Investment Management Company

A convertible bond is a debt security that allows the holder to convert to a given number of shares of a company's equity. This convertibility to equity means that the holder of a convertible bond will profit from a significant increase in the firm's stock price while being protected against lower stock prices through his debt claim. In this chapter we will first discuss some key terms and the basic features of convertible bonds, and then describe the motivations for issuing these securities and the key portfolio management considerations for investing in them, and finally give an overview of the major factors involved in their valuation.

BASIC CHARACTERISTICS OF CONVERTIBLE SECURITIES AND KEY TERMS

Conceptually, a typical convertible bond is a combination of a debt claim and a call option on the firm's equity. However, the type of performance profile and the nature of the risks that a given convertible bond will generate will be driven by the interaction among several features of the security.

Nature of the Debt Claim

The seniority of the underlying debt claim in a convertible bond is one of the most important considerations in assessing the strength of the security's "bond floor" (and by extension, determining whether the bond is likely to be positively or negative convex under a large downward move in the equity price).

Convertible bonds will often be senior unsecured claims, but they are also frequently subordinated debt or preferred stock. In the case of preferred stock, deferral of coupons is generally not an act of default for the issuer, and nonpayment of coupons is frequently not cumulative. A convertible with a senior debt claim will exhibit much more positive convexity than subordinated debt or preferred stock, and an investor will therefore demand a higher coupon (wider credit spread) for more junior securities.

In order to assess the appropriate excess credit-spread for subordinated debt or preferred stock vis-à-vis senior debt, an investor needs to consider the likely range of potential recoveries of each tranche of debt in the event of default, as well as its relative thickness as a percentage of the overall enterprise value of the firm. (For a typical company where the enterprise value is well in excess of its liabilities, an investor should demand a wider credit-spread for a thinner part of the capital structure given an equal amount of subordination.) Additionally, while the credit component of a senior unsecured convertible bond is often able to be hedged using credit default swaps (CDS), CDS referencing subordinated debt and preferred stock are generally not traded in the marketplace.

Another common type of convertible security, aside from those with an underlying claim at the senior unsecured, subordinated, or preferred part of the capital structure, are "mandatory" convertibles. These securities are not really bonds at all. In the most typical structure, the investor receives a coupon based on the par value of the security while selling an at-the-money put option and buying an out-of-the-money call option on the issuing firm's common stock. At maturity, the mandatory convertible converts into common stock, paying the investor par if the stock price is between the put and call strike, while the investor takes direct equity exposure if the stock is below the put strike or above the call strike. Mandatory convertibles are effectively thus just long positions in the issuing firm's equity, and most investors who buy these securities do so either for income enhancement or because they are not able to take direct equity positions.

Coupon Payments

Historically, one of the primary advantages of convertible bonds to issuers is their relatively low coupon payments. Investors are willing to accept a materially lower coupon than in the case of a nonconvertible debt security because of the equity call option embedded in the convertible. Coupons are generally fixed-rate as opposed to floating, and zero coupon convertibles are not uncommon. In considering how to structure a new convertible security, the issuer must weigh the tradeoff between lowering its coupon expense versus increasing the likelihood of dilution in the case that the bond is converted to equity (i.e., selling an equity option of greater value).

Equity Conversion Rights

The equity call option embedded in a convertible bond is in the form of a *conversion ratio,* giving the holder of the bond the right to a given number of equity shares per a given bond face value. This ratio implies a *conversion price* (that is, the strike price of the embedded equity call option), which is simply the face value of the bond divided by the conversion ratio; for instance, a $1,000 par convertible bond with a conversion ratio of 25 will have a conversion price of $40. Market participants often refer to the distance between the current stock price and the conversion price in terms of how far "up" the conversion price is; for instance, one might say that a new deal coming to market is "3%, up 25," meaning that it carries a 3% coupon and its conversion price is 25% above the current equity price.

Another concept related to a convertible's equity component is the security's *parity,* which is simply the conversion ratio multiplied by the market price of the common stock. Participants will often refer to the valuation of convertibles (particularly those that are deep in-the-money) in terms of their "point premium" to parity; for example, if the parity of a convertible is $80, and its price is $105, one would say that it trades at a twenty-five point premium. Alternatively, participants will refer to a convertible's *conversion premium,* which is simply the percent premium to parity of the instrument ([convertible price – parity]/parity).

Finally, the convertible's *delta* refers to the sensitivity of the bond price to an incremental change in the underlying equity. Delta is most frequently expressed relative to parity; so if the delta of the bond in the prior example were 50%, this would mean that a 1% increase in the stock would be expected to result in a $0.40 increase in the convertible's price ($1\% \times 50\% \times 80$). Alternatively, delta can also be expressed relative to the price of the convertible itself (often called outright delta), which in the previous example would be 38.1% (i.e., 0.4/105). Expressing delta relative to parity or the bond price is often referred to as "hedge delta" or "outright delta," respectively.

Call and Put Options

It is very common for convertible bonds to include a series of call options giving the issuer the right to repurchase the bonds as well as put options giving the holder the right to sell the bonds back to the issuer at specified price. These calls and puts often occur at the same or very close dates, and so effectively serve to shorten the maturity of the convertible bond. While the presence of these calls and puts greatly complicates the valuation of a given convertible bond, they are very common features as they help to optimize the tax and accounting advantages of the security to the issuer.

Dividend Protection

Dividend protection features are intended to compensate the convertible bond holder for dividends paid to common equity holders. For securities that do not carry such provisions, the payment of dividends negatively impacts the bond holder as the convertible will not receive the dividend payment yet will suffer from the drop in the stock price after the dividend is paid. To remedy this, most convertibles now feature a conversion ratio adjustment feature, which changes the conversion ratio in proportion to any dividend announced. That is, if the company announces a dividend that is 2% of its share price prior to the announcement, the conversion ratio will be changed such that the conversion price falls by 2%.

Takeover Protection

Similar to dividend protection, takeover protections are features meant to protect a convertible bond holder against corporate actions that would otherwise adversely affect the bond's value. Takeover protections can take several different forms, including an adjustment of the conversion ratio (as in the case mentioned in the preceding) or the right to convert into the acquirer's stock at a new ratio intended to be a "make whole" value. Careful consideration of a given convertible's takeover protections are very important, as the provisions can differ significantly from bond to bond.

Other Features

Net share settlement, contingent conversion (CoCo), and contingent payment (CoPa) are other common features of convertible securities, particularly those issued before 2008. Historically, the primary motivations behind each of these provisions has been to minimize a convertible's equity share dilution and interest expense for accounting purposes while maximizing its tax benefits in terms of interest deductions to taxable income (more on this point in the following section on the motivations behind issuing convertible securities).

Net share settlement, in its most basic form, allows the issuer to meet its conversion obligation by paying the par value of the bond in cash and only issue shares for the portion of the conversion value that is above par. In some cases, this provision will be stated such that the issuer has the option to settle the bond at conversion using a combination of cash and stock at its discretion. The motivation behind this provision has historically been to minimize the issuer's equity dilution for EPS accounting purposes, but accounting changes in 2008 have greatly reduced the advantage of this provision.

Contingent conversion (CoCo) features prohibit conversion until a given threshold in the equity value has been reached (commonly 130% of the conversion price). This feature has historically been used to garner both accounting and

tax benefits for the issuer, but this motivation has been greatly reduced over the past two years given tax and accounting guideline changes.

Bonds with *contingent payment* (CoPa) provisions will pay a higher rate of interest if a given trading level of the equity is reached (for example, 130% of the conversion price). This feature has traditionally been used as a way to receive favorable tax treatment from the issuance of convertible securities, allowing issuers to expense the equivalent straight debt interest cost for tax purposes while only actually paying the lower (sometimes zero) convertible coupon interest.

Convertible Bond Return Profile

While generally highly complex securities, convertible bonds can be thought of conceptually as a combination of a corporate bond and an equity warrant. For equity values that are at or above the convertible's "strike" (that is, the price at which the implicit call option gives the holder the right to purchase equity shares), they will behave a lot like an equity option (and thus like a direct equity investment when deep in-the-money) while for equity values well below strike, and thus deeply out-of-the-money, they will behave mostly like a corporate bond.

Their hybrid nature gives convertible bonds a dynamic convexity profile, as shown in the stylized example in Exhibit 14–1. As shown in the exhibit, a typical convertible bond will be a positively convex instrument for equity prices roughly 30% below its conversion price and above, but then will generally become negatively convex (as with most corporate bonds) as the equity price trends toward zero and bankruptcy risk becomes dominant. This convexity profile makes convertible bonds a very interesting asset class, and requires that investors understand both the equity and debt part of the issuer's capital structure and the likely interaction between the two.

EXHIBIT 14–1

A Typical Performance Profile of a Convertible Bond

OVERVIEW OF CONVERTIBLE BOND VALUATION AND RISK METRICS

While conceptually a convertible bond is a combination of a risky bond and a stock warrant, a convertible's valuation is not as straightforward as simply pricing these two components separately. For one, convertible securities are generally not able to be physically split into their equity warrant and bond components. In addition, calls and puts, allowing the issuer or holder to redeem the securities early, complicate valuation further. Finally, the convertible's sensitivities to both credit-spread moves and equity price moves will dynamically depend on both of these factors. For instance, a deep in-the-money convertible will have virtually no credit-spread risk, while a distressed convertible can have an equity delta approaching one. (Consider a company in which recovery on default is zero as the equity price trends toward zero.) As a result of these complications, valuation of convertible bonds does not present a closed-form solution that captures their full complexity. Instead, the primary valuation methods used by market participants center on simulating possible paths of the stock price and accordingly, the convertible bond, at different points in time, generally using either binomial trees or so-called finite difference methods, which use a partial differential equation for the convertible price as a function of the stock price and time. While not going into the technical specifics of these models, this section focuses on the major inputs to such models and the primary differences among them, then describes the major risk metrics generated by any pricing model.

Stock Price Evolution

The most basic part of any model for valuing convertibles will be projecting the future evolution of the stock price across time. Equity volatility will describe the nature of the process, either through incremental steps in the case of a binomial tree or by helping to define the diffusion process in a partial differential equation approach. Given this path of future stock prices, values of the convertible bond across time are then populated by starting with the potential values at maturity and then working backward. Upon maturity, the value of the convertible bond will be the greater of parity and the bond's principal value (plus any final coupons), while at any given point prior to maturity the bond value will be the present value of its probability weighted future cash-flows. In addition, the bond's call and put schedule, if applicable, will be featured in this process, thus affecting the potential price paths for the convertible security. This basic structure of defining a process for future equity values, then working backward from maturity to value the possible values for the convertible bond given a stock price, is common across the vast majority of convertible bond pricing models. The key areas in which these models will differ are, first, in the method used to discount future cash-flows, and, second and most importantly, in what relationship is assumed between the evolution of the stock price and credit-spreads.

Discounting Methods

There are two basic approaches to discounting the possible future values of the convertible in order to obtain a present value, namely "blended discount" and "full discount" approaches. In a blended discount approach, the convertible is separated into its equity and bond components, and the two are discounted at different discount rates; the bond component at a risky rate including the issuer's credit-spread while the equity is generally discounted using the risk free rate (as the equity price already includes a risk premium). Exactly how the convertible is decomposed into its equity and bond components can differ across models, but one typical approach is to separate out the actual cash-flows at any given point into bond (i.e., if not converted) and equity (i.e., if converted) components.

Alternatively, convertible pricing models may also use a full discount approach, where one discount rate is used for all cash-flows. The basic rationale here is that a portfolio can be constructed of a long position in the convertible bond and a short position in the equity, whereby the only risk to this portfolio is the instantaneous default of the issuer, and the risk premium for this risk is captured by the convertible bond's credit-spread. While the differences in these two discounting approaches can result in meaningful differences in a convertible's theoretical price and delta given common inputs, these differences are relatively minor compared with the impact of incorporating credit-spreads as a stochastic factor.

Incorporating Credit Risk

Most convertible bond models today will incorporate a dynamic relationship between the equity price and credit-spreads. That is, they will seek to capture the intuitively obvious phenomenon that credit risk generally increases as the equity price falls, with this relationship becoming highly nonlinear as the equity price trends toward zero. Incorporating credit-spreads as a stochastic factor that is a product of the equity price will result in a lower theoretical value for the convertible bond and a higher equity delta, lower vega, and higher implied volatility, all else being equal. This change in valuation and risk metrics is capturing the fact that the more sensitive the credit is to the equity, the less of a "bond floor" the convertible offers and hence the less valuable the equity "option" embedded in the security becomes.

The exact method of relating changes in the credit-spread to the stock price can be considered to be the key difference among various convertible bond pricing models. One common way of establishing this relationship is by using a decay factor that defines the future credit-spread given an equity price, such that $C_t = C_0(S_0/S_t)^k$, where k is the decay factor, C_t is the future credit-spread, C_0 is the current credit-spread, S_0 is the current stock price, and S_t is the future stock price. Thus, the credit-spread trends toward infinity as the stock price approaches zero, although further parameters can be added so that the minimum price of the bond is set at an assumed recovery rate. While this approach is certainly an improvement over holding credit-spreads constant in projecting future values for the convertible, for a constant value of

k, the decay factor, it will likely miss the very different credit convexity for a given move in equity price for highly leveraged firms. (Consider the different proportionate effect on credit-spreads for a 50% decline in equity value of two firms, one with debt to enterprise value of 10%, the other 90%.) Another, far more complicated, alternative is to explicitly model the future paths of the firm's enterprise value, with equity prices and credit-spreads a function of this process using a version of a Merton capital structure model. While both of these approaches are used in the market place, widely used third part pricing engines such as Bloomberg and Kynex use the decay factor approach, and users can change the value of the decay factor to reflect differences across capital structures.

Major Convertible Bond Risk Metrics

1. *Delta:* As mentioned, this captures the change in the convertible's value for a given percentage change in the equity price. All else equal, incorporating credit-spreads as a dynamic factor will increase the delta of a convertible bond, thereby compensating for the deterioration of the bond floor as equity prices fall. Delta is most frequently expressed relative to parity; so if the delta of a bond with parity of 80 and price of 105 were 50%, this would mean that a 1% increase in the stock would be expected to result in a $0.40 increase in the convertible's price (1% × 50% × 80). Alternatively, delta can also be expressed relative to the price of the convertible itself (often called outright delta), which in the previous example would be 38.1% (i.e., 0.4/105). Expressing delta relative to parity or the bond price is often referred to as "hedge delta" or "outright delta," respectively.
2. *Gamma:* As with other options, gamma captures the incremental change in delta given a change in the underlying equity price. One of the keys to successfully managing convertible bond portfolios is understanding when a given bond will switch from having positive gamma to negative gamma as the stock price falls, which will in turn be driven by the expected behavior of credit-spreads and bond recovery upon bankruptcy. A graphical illustration of this is shown below in Exhibit 14–2. (The dotted line depicts a recovery of 10, the solid line a recovery of 40.)
3. *Vega:* This refers to the change in the value of the convertible given a change in equity implied volatility. All else being equal, vega will be lower if a higher degree of credit sensitivity to equity is assumed. In fact, given a high credit to equity sensitivity, it is possible for vega to become negative given a high enough level of equity implied volatility (given that very high levels of equity volatility imply a meaningfully higher probability of distress).
4. *Rho*: The interest rate risk of the convertible, equivalent to a vanilla bond's modified duration.

EXHIBIT 14–2

Impact of Different Recovery Rates on Convertible Convexity Profile

5. *Credit-spread duration:* The convertible's sensitivity to a change in credit-spreads. In considering how to hedge both the equity and credit risk of a convertible bond, it is important to be aware of what assumptions are being used to calculate the security's delta. For example, if a dynamic model that incorporates changes in credit-spreads given changes in the equity is being used, the delta is implicitly incorporating the sensitivity of the security to incremental moves in credit quality. As a result, hedging both the full delta given by such a model as well as the full spread duration will overhedge the position for local moves in the equity and credit. If it is desired that both risks be hedged independently, it is more consistent to use an equity delta that does not incorporate the relationship between equity and credit-spreads. As a matter of practice, an equity hedge is generally the best hedge for incremental moves in the equity while credit default swaps provide an effective hedge against a downward jump in equity prices and credit quality.
6. *Bond floor:* Also sometimes referred to as "investment value," this is simply the value of the convertible if it were treated as a straight bond discounted by an appropriate risky discount curve. An investor should always be aware of how far away this measure is from the market price of the convertible, and using scenario analysis to shock the bond floor based on various adverse credit-spread assumptions can give a good sense of what the "worst case" outcome for a position is and what an appropriate hedge might be.

In addition to directly affecting the valuation of a convertible bond, each of the primary risk factors of equity price, credit-spread, and equity implied volatility also interact with one another to drive performance. Exhibit 14–3 summarizes the impact of each of these factors as well as the interaction among them.

EXHIBIT 14–3

Summary of the Impact of Major Convertible Bond Risk Factors

	Impact on Convertible Bond Price (All Else Equal)	Interaction with Other Risk Factors
Equity price	Higher equity prices lead to higher convertible bond prices, with the degree of sensitivity defined by delta.	Delta generally moves higher with equity prices, although equity sensitivity can also move higher as equity prices move lower in the case of distressed companies whose credit-spreads are highly sensitive to equity prices. Higher equity prices generally reduce credit-spread sensitivity, particularly once parity > par. As in the case of any call option, vega and gamma are highest when the equity price is at the conversion price.
Credit-spread	Higher credit-spreads lead to lower convertible bond prices, with the degree of sensitivity defined by spread duration.	Credit-spreads tend to be negatively correlated with equity prices, with spreads becoming more sensitive to equity price moves as the stock price moves toward zero. For deep out-of-the-money convertibles, a significant move higher in credit-spreads can increase the ultimate equity sensitivity of the security. Vega will generally be lower the higher the sensitivity of credit-spreads to equity prices (i.e., the weaker the bond floor).
Equity implied volatility	Higher equity implied volatility leads to higher convertible bond prices, with the degree of sensitivity defined by vega.	Equity volatility tends to be positively correlated with equity prices and credit spreads, so in cases where equity volatility rises significantly the impact of equity price and credit-spreads on the convertible's value will generally overwhelm the benefit from higher volatility. Equity volatility tends to have the highest degree of significance for longer-dated, higher-credit quality convertibles whose equity prices are near the conversion price. Higher vega will increase the delta of an at-the-money or out-of-the-money convertible, but will reduce the delta for a deeply in-the-money convertible.

PRIMARY INVESTORS IN CONVERTIBLE BONDS

Given the relative complexity of the asset class, the convertible bond market has historically been dominated by specialized investors, namely convertible arbitrage hedge funds and dedicated outright (i.e., long only) convertible bond funds. Aside from these two core constituencies, which together have represented around 75% or more of convertible bond holdings and secondary market flows over the past 10 years, other primary investors in convertible bonds include equity and high-yield mutual funds. In general, the primary motivation for investing in convertible bonds as an asset class lies in the positively convex return profile offered by the securities, allowing investors to benefit from a significant rally in equities while lessening losses in an adverse market environment. Since 2000, convertible bonds have outperformed the S&P 500, and convertible arbitrage funds have done better than an outright investment in a convertible bond index (Exhibit 14–4). However, convertible bonds saw extreme price moves during the financial crisis, with the Bank of America-Merrill Lynch index falling 32% from August 2008 to February 2009 as compared with a 43% fall in the S&P 500. During this period, convertible bonds suffered not only from a sharp decline in stocks and widening in credit-spreads, but also were directly impacted by hedge fund deleveraging given that alternative investors were the primary holders of the asset class at the time.

EXHIBIT 14–4

Total Return of Performance of Convertible Bonds versus Equities

*Constructed from data provided by Barclays, Bank of America, Bloomberg.

Convertible Arbitrageurs

Convertible arbitrage hedge funds emerged as the dominant players in convertible bonds in the late1990s, and by 2008 made up approximately 80% of the market in terms of daily trading volumes and a comparable share in terms of ownership. While that share has fallen since the credit crisis of 2008 due to less freely available leverage, these investors still represent around 40% of convertible bond ownership and 50% to 75% of daily trading volumes.

Convertible arbitrage involves purchasing a convertible bond, then attempting to hedge out the equity component by selling short the common stock; the hedge ratio is given by the bond's equity delta. This strategy is intended to provide returns that show low correlations to the equity market and a high information ratio. The rationale behind convertible "arbitrage" is that the equity option component of convertible bonds tends to be systematically undervalued, allowing the arbitrageur to purchase this option at an attractive level of implied volatility and profit by extracting the gamma presented by significant moves in the common stock (i.e., delta hedging). As such, these investors will typically focus on convertibles in relatively volatile names where the stock price is approximately 80% to 130% of the conversion price, maximizing the convexity profile of a delta hedged convertible bond position. In addition, deep in-the-money convertibles trading at low premia to parity can provide very attractive convexity profiles to such investors by offering a cheap implicit put option on the stock.

The most important risk factor in a delta hedged convertible bond position is the residual credit-spread/default exposure embedded in the position, and an investor can attempt to hedge this risk in two primary ways. First, and most directly, he can hedge the default risk by purchasing a credit default swap (CDS), presuming that such derivatives exist for the part of the capital structure corresponding to the convertible. This gives a clean hedge to a widening in credit-spreads or jump to default, but materially reduces the carry of the position. Further, if the underlying equity rallies and the convertible becomes deep in-the-money, the sensitivity to credit-spreads will become greatly reduced, and the investor will need to adjust the CDS hedge, paying additional bid/offer costs, lest he become net short spread duration. Second, the arbitrageur can seek to adjust the equity hedge ratio to compensate for the residual credit risk. Convertible bond pricing models that incorporate credit-spreads in projecting a range of possible stock prices will give a higher equity delta for issuers with wide credit-spreads; that is, the sensitivity of credit-spreads to a change in the stock price will be incorporated into calculating the convertible's delta. This approach suffers from model uncertainty, as it relies on an assumption about the correlation between credit-spreads and equity prices in order to adjust the hedge ratio. Given that the relationship between credit and equity can be highly unstable, this approach to hedging the credit risk of a convertible bond exposes the investor to shifts in this relationship, where movements between the two decouple. However, hedging the credit component with additional equity as opposed

to CDS has the advantage of offering greater carry and also makes for a simpler overall position (as opposed to having both equity and CDS hedges). In practice, outside of highly stressed companies, convertible arbitrageurs will tend to hedge primarily with equity alone, adjusting their hedge ratio upward if they wish to offset the credit-spread exposure.

Dedicated Outright Convertible Bond Funds

Other primary investors in convertible bonds aside from convertible arbitrage hedge funds are funds specializing in managing portfolios of convertible bonds on an outright (i.e., unhedged) basis, with many managing against a convertible bond index. So-called outright players (both dedicated to convertible bonds and those focused on equities) were dominant in the early to mid 1990s, but saw their share of the market reduced to only approximately 10% to –20% by 2005 as convertible bonds became predominantly a hedge fund product. However, after the financial crisis in 2008 these participants became far more important to the market as the hedge fund universe shrank and the remaining hedge funds greatly reduced their leverage. As of 2010, dedicated outright convertible bond funds make up around 15% to 20% of ownership and daily trading volumes.

These investors will consider the same sorts of issues as a convertible arbitrageur when considering which convertible bonds to buy, but unlike an arbitrageur, their views on a given company's equity valuations will be central to performance versus their peers. Along the equity sensitivity spectrum, these funds tend to focus on convertibles with a "balanced" profile, where underlying equity prices are between 80% and 120% of the conversion price, and will generally favor convertibles of more stable companies vis-à-vis convertible arbitrage funds.

At the portfolio level, an outright fund is essentially managing a book consisting of long positions in equity, credit, equity volatility, and interest rate risk, and so must consider his or her views on all these factors accordingly. In practice, the equity risk factor will be the most dominant for an outright fund's performance, although credit risk will play an extremely important role as well. Aside from extremely stable environments for risk assets, the equity volatility and interest rate risk components will tend to be of lesser importance to total returns (the latter on account of most convertible bonds having relatively short effective durations).

Equity and High-Yield Funds

Finally, convertible bonds will frequently see crossover interest from investors primarily focused on equities or corporate credit. In the case of equity investors, they may favor a convertible bond over a direct investment in the equity if there is an income advantage presented by the bond's coupon or if downside protection is desired and the convertible is seen as a cheaper way of acquiring this than buying equity puts. Not surprisingly, equity investors tend to be most involved in high delta, equity-like convertible bonds. On the opposite end of the spectrum, high-yield bond funds and other corporate credit investors will also invest in

convertible bonds, primarily focusing on "busted" issues that trade with little to no equity delta. Here, the convertible bond will be favored if it offers more attractive valuations (i.e., wider credit-spreads) than the nonconvertible bonds in a given company's capital structure.

For any investor, the most critical investment consideration specific to investing in a convertible bond lies in assessing the extent to which there really is a bond "floor," or put another way to what extent the investor is purchasing a call option on the stock as opposed to simply getting outright equity risk.

MOTIVATIONS BEHIND THE ISSUANCE OF CONVERTIBLE SECURITIES

Given that convertible bonds are simply a combination of other types of securities available as funding sources for companies, it begs the question as to why companies issue these instruments in the first place. The answer lies in market segmentation effects (making debt issuance unattractive for small, poorly understood companies), a combination of historical tax and accounting benefits, as well as unique opportunities provided to companies by convertible securities to tactically sell their equity at attractive levels. As tax and accounting benefits of convertible bonds have lessened over the past few years this has helped to make investment grade firms a much smaller share of the convertible market (down from 50% in 2001 to under 30% in 2010), while the prevalence of convertible arbitrageurs has helped to drive an increase relative issuance among small firms not followed by credit rating agencies, as shown in Exhibit 14–5.

EXHIBIT 14–5

Composition of the Convertible Market by Credit Rating

*Constructed from data provided by Bank of America.

Companies That Cannot Access the Straight Debt Market

For public companies that are relatively small, not followed by institutional fixed income investors, and who do not have a credit rating from any of the agencies, convertible bonds can be an attractive alternative to raising additional equity capital. If such a company views its stock as undervalued, it can issue a convertible bond with a conversion price at a level that it would be comfortable issuing additional equity, and pay a far lower interest expense than if it tried to bring a debut deal to the high-yield market. Further, many companies will purchase a call spread (i.e., buying a call with a strike price equal to the conversion price and selling a call that is further out-of-the-money) on their own stock as part of a convertible issuance, thereby further increasing the stock price at which actual further dilution will occur.

In addition, many companies undergoing financial distress will use the convertible market to raise capital for similar reasons as those cited above. Yields offered to such firms in the market are likely to be prohibitive, and the company will be motivated to seek alternatives to raising equity at "fire sale" prices. In the case of both these types of firms, the prevalence of convertible arbitrage hedge funds makes the convertible market a viable source of funds in that it allows companies to raise capital from investors that are generally agnostic about its future growth prospects and who are instead simply looking for securities with attractive convexity properties.

Tax and Accounting Benefits

Much of the convertible issuance by investment grade rated companies in the 2000s was motivated by accounting and tax advantages offered by the securities. In particular, the accounting treatment of net share settlement and contingent convertibility allowed the companies to suffer little to no equity dilution from the issuance of convertible bonds, making them particularly attractive versus issuing equity. Additionally, companies could often deduct a far larger interest expense for tax purposes than was required to be expensed for generally accepted accounting principle (GAAP) earnings, which combined with the lack of dilution made convertible bonds a highly attractive means of earnings per share (EPS) management for higher quality firms. However, accounting changes made in 2008 have greatly reduced the accounting advantages of convertibles using net share settlement by forcing companies to split out the accounting for the securities into their debt and equity components, thereby closing most of the asymmetry between how interest expense is recorded for earnings reporting and tax purposes. While the full details of these accounting and tax changes is beyond the scope of this chapter, they have served to greatly reduce the motivation for investment grade firms to access the convertible bond market.

Opportunistic Issuance

A final reason that a firm may issue convertible bonds is as a means of taking advantage of what it sees as an opportunity to sell its equity or equity volatility at attractive levels. Given that they can be classified as 144A private placements, convertible bonds can be brought to market much more quickly than an issuance of additional common stock. As such, if a company has seen a significant rally in its equity prices, and sees significant further increases as unlikely or as an opportunity to raise additional equity, it can issue a convertible bond with a conversion price equal to where it would willingly issue common stock. Further, depending on the equity volatility skew companies may purchase a call spread along with the issuance of a convertible, thereby granting the obligation to issue shares at a significant premium while capturing a low cost of debt.

KEY POINTS

- Convertible bonds combine components of an equity and debt security, becoming increasingly like common stock given higher equity prices and increasingly like straight debt for lower equity prices.
- As a result of this hybrid nature, convertibles can be highly convex securities, and this aspect has made them particularly attractive to hedge fund investors.
- However, in analyzing a convertible bond as a potential investment, an investor must carefully scrutinize the credit quality of the given issuer as well as its potential growth prospects and equity upside.
- Convertible bonds issued by companies with poor credit quality will have weak "bond floors" and thus will not offer positive convexity across a large range of possible stock prices. Accordingly, many convertible bonds will switch from being positively convex to negatively convex instruments as a company's stock price falls.
- Companies issue convertible bonds for a variety of reasons. The most straightforward motivation to issue convertibles is in the case of companies that cannot access the straight debt markets, but issuance can also be driven by tax and accounting advantages as well as a company's view on the potential for its stock to appreciate beyond a certain price.

CHAPTER
FIFTEEN

STRUCTURED NOTES AND CREDIT-LINKED NOTES

JOHN D. FINNERTY, PH.D.
Professor of Finance
Fordham University
Managing Principal
Finnerty Economic Consulting, LLC

RACHAEL W. PARK
Senior Associate
Finnerty Economic Consulting, LLC

Structured notes and credit-linked notes are debt instruments that provide customized interest or principal payments that depend on the performance of a specified reference asset, market price, index, interest rate, or some other market quantity. They enable investors to express a view on the future performance of the reference item as part of their investment management program or protect their other assets against adverse changes in the value of the underlying item as part of their risk management program. A structured note combines a conventional fixed-rate or floating-rate note with an embedded derivative instrument, such as an option or a swap, which links the payments on the note to the reference item. A credit-linked note (CLN) is a particular form of structured note in which the derivative instrument is a credit default swap or some other form of credit derivative.

Structured notes and CLNs provide investors with investment opportunities that they might find difficult or expensive to access in other ways, for example, because of transaction costs, regulatory restrictions, or other market frictions. Generally, any derivative instrument can be structured either as a stand-alone financial instrument, such as a swap or a forward, or it can be attached to a conventional note to form a structured note. Structured notes have been issued regularly at least since the mid 1980s. They emerged as an important instrument in the early 1990s when financial engineers regularly began crafting new forms of structured notes, including in particular CLNs, by attaching derivative instruments to medium-term notes in the United States, Europe, and Asia. According to Bloomberg L.P., the volume of structured notes issued in the U.S. market increased nearly 30-fold from $8 billion in 2000 to $230 billion in 2010.

CLNs have been very popular since the mid 1990s, soon after the credit derivatives market first began to develop. The volume of CLNs issued in the U.S. market increased more than tenfold from $0.6 billion in 2000 to $6.5 billion in 2007, according to Bloomberg L.P. However, the global financial crisis that started in late 2007 caused a significant reduction in the volume of CLN issuance to $0.4 billion in 2010. Nevertheless, the new issue volumes for CLNs and other structured notes are likely to increase as the world economy grows following the financial crisis and investors and hedgers once again seek the risk/return opportunities that these instruments can provide.

STRUCTURED NOTES

A structured note is a hybrid security that contains an embedded derivative instrument, which transforms the interest payments or the principal payments (or both) by making at least some of these payments contingent on a specified reference asset, market price, index, interest rate, or some other market quantity. The term *structured* refers to incorporating a derivative into the structure of the note to give the reconfigured note the desired financial properties. Adding the contingency feature alters the risk/return profile of the (structured) note to suit the investment preferences of investors.

Instead of making the traditional interest payments that are either fixed in amount or tied to a specified floating-rate index, a structured note pays interest in amounts that are determined by some formula tied to the movement of a stock price or index, a bond or loan price, a commodity price, a foreign exchange rate, or some other financial variable. Some structured notes are designed to have relatively conservative risk/return profiles so as to be useful in reducing portfolio risk, whereas others are designed to have more aggressive risk/return profiles, for example, by leveraging returns so as to provide the possibility for substantial gain or loss. The nature and design of the embedded derivative instrument determines the structured note's risk/return profile.

Characteristics of Structured Notes

Although a floating-rate note is not considered a structured note, the relationship between a fixed-rate note and a floating-rate note can be used to illustrate the distinguishing characteristic of a structured note, which is the packaging of a derivative with a conventional note. Start with a 10-year note that pays a 6% fixed rate annually. Add a 10-year fixed-for-floating interest-rate swap in which the note issuer pays LIBOR + 100 basis points quarterly and receives 6% annually. Exhibit 15–1 illustrates the resulting debt service stream. The package combining the 6% note and the swap is equivalent to a floating-rate note paying LIBOR + 100 basis points. A floating-rate note could thus be characterized as a structured note that combines a conventional fixed-rate note and a conventional pay-floating-receive-fixed interest-rate swap. (Similarly, this basic relationship implies that a fixed-rate note could be

EXHIBIT 15–1

A Floating-Rate Note Can Be Characterized as a Combination of a Fixed-Rate Note and an Interest-Rate Swap

characterized as a conventional floating-rate note plus a conventional pay-fixed-receive-floating interest-rate swap.) This simple intuition underlies all structured notes, which differ in their complexity owing to the nature of the derivative instrument(s) employed in structuring the note.

Most structured notes are issued as medium-term notes (MTNs). MTNs are usually issued under a firm's shelf-registration program, which permits the issuer to register an inventory of securities that may be sold for two years after the registration statement's effective date. Having registered securities available allows the issuer to design and make an offering of previously registered securities in a short period of time without the need to first file a separate registration statement with the SEC. This flexibility allows issuers to respond quickly to changes in market conditions by designing and offering structured notes opportunistically to take advantage of favorable funding opportunities.

Another advantage of MTNs is their flexibility in design, which can benefit both issuers and investors. By combining MTNs with derivatives, issuers can reduce their financing costs, while investors can satisfy their specific investment needs. Investors seek to satisfy their investment needs through reverse inquiry: They contact an investment bank to request notes with specific characteristics that may not be available currently in the market. Based on an investor's view concerning future market conditions, such as future movements in interest rates, currency exchange rates, commodity prices, or other market variables, investors and issuers can customize structured notes to reflect the investors' specific views on the market. Consequently, structured notes can be issued with a range of embedded options, including call options, put options, swaps, caps, floors, or collars.

Investors prefer to have an MTN issuer of high-investment-grade quality so as not to incur significant credit risk. Structured note investors target specific financial risks they are willing to incur, and they are willing to take on issuer credit risk only if that risk is the specific one they have targeted. CLNs, which are discussed later in this chapter, are a form of structured note that offers such an opportunity.

The structured note issuer usually is not willing to take on the added financial risk associated with the embedded derivative. When selling a structured note, the issuer typically simultaneously enters into one or more derivative transactions to hedge this risk by transforming the cash flows that the issuer is obligated to make to investors. These derivative transactions allow the issuer to eliminate its exposure to the risks arising from the customization of the structured notes. Returning to our floating-rate note example, the issuer who sells a floating-rate MTN that pays LIBOR plus a premium can simultaneously enter into an interest-rate swap transaction in which it pays a fixed rate of interest and receives LIBOR from a swap counterparty. By combining a floating-rate note and a swap transaction, the issuer is able to create a synthetic fixed-rate note and eliminate its floating-rate risk exposure because the floating-rate payments are offsetting.

Issuing structured notes can enable a firm to reduce its financing costs when the purchasers of the structured notes are willing to pay a premium (accept a reduced yield) in exchange for the investment opportunity. They may be willing to pay a premium when similar investment opportunities are not currently available, possibly due to investment restrictions. For example, suppose an institutional investor that is not permitted to purchase stand-alone non-U.S. currency options has a view that the Australian dollar is going to appreciate significantly relative to the U.S. dollar over the next five years. It cannot buy Australian dollar call options but it might be able to purchase a structured note that will pay an increased redemption amount at maturity if the Australian dollar has appreciated above some specified threshold. This contingent payment structure embeds a call option on the Australian dollar in the structured note, as illustrated in Exhibit 15–2. The institutional investor is willing to pay for the embedded call option by accepting a lower coupon rate on the structured note than it would require for a plain vanilla fixed-rate note of the same maturity for the same issuer.

Suppose the structured note issuer does not wish to be exposed to Australian dollar foreign exchange risk. It can purchase a matching call option on the Australian dollar from an options dealer (possibly the same dealer who created the structured note) and finance the option premium through the dealer, for example, by paying the dealer 90 basis points per year. If the annual option premium payment is less than the differential in yield between the structured note and an otherwise identical conventional note, then this difference in payments reduces the firm's funding cost, as illustrated in Exhibit 15–3. The issuer saves 10 basis points (6.00% to 5.90%) in this example.

EXHIBIT 15–2

Structured Note with an Embedded Foreign Exchange Call Option

EXHIBIT 15–3

Structured Note Issuer Reduces Its Funding Cost When It Enters into an Offsetting Derivative Transaction that Costs Less than the Value It Receives for Including the Embedded Call Option in the Structured MTN

Structured European Medium-Term Notes

When an MTN is issued outside the United States, particularly in the Euromarket, the product is called a Euro-MTN. Euro-MTNs are not subject to national regulations, such as SEC registration requirements. An issuer of Euro-MTNs typically maintains a standardized single document that can be tailored to suit almost any Euro-MTN issue and provides flexibility in the size, currency, and contingent structure of the offering. Similar to MTNs issued in the U.S. market, structured Euro-MTNs can provide an issuer with the opportunity to reduce its funding costs by crafting structured notes opportunistically.

The maturity of Euro-MTNs are typically less than five years, and the ratings on Euro-MTNs are typically higher than MTNs issued in the U.S. market because of the greater credit sensitivity of Euro-MTN investors. The Euro-MTN market is more diverse than the U.S. MTN market, mostly because it has a broader range of currency denominations and a more international mix of borrowers and investors.

Types of Structured Notes

Structured notes have been designed to provide exposure to a wide range of financial risks, such as changes in interest rates, foreign exchange rates, stock prices, the value of market indices, commodity prices, and credit quality. A few examples will illustrate the rich variety of structured MTNs.

Inverse Floating-Rate Notes

A floating-rate note is structured to facilitate taking a view on the future direction of interest rates. Inverse floating-rate notes (IFRNs) reverse the direction of the bet on interest rates. They can also be structured so as to leverage the bet. In particular, IFRNs have a coupon reset formula in which LIBOR is subtracted from a fixed percentage rate. As LIBOR increases (decreases), the coupon payment on an IFRN decreases (increases). By design, investors in IFRNs generally expect interest rates to fall and are therefore bullish on bond prices. For this reason, IFRNs have also become known as *bull floaters*.

If an investor expects interest rates to fall, the investor can approach an investment bank for an opportunity to purchase a structured note, issued by an investment-grade company, with coupon payments that move inversely to LIBOR. The investment bank then communicates this interest to prospective note issuers to whom it proposes an IFRN transaction. If an issuer agrees to the proposed transaction, it would then issue the IFRNs to satisfy the investor's demand.

Exhibit 15–4 provides an example of an IFRN. An IFRN can be created by adding an interest-rate swap to a fixed-rate MTN. For example, if the issuer combines a 7% fixed-rate note and a fixed-for-floating interest-rate swap that pays 7% fixed and receives LIBOR, the resulting structured note pays interest at a rate equal to 14% minus LIBOR. The coupon rate on the IFRN varies inversely with LIBOR.

EXHIBIT 15–4

An Inverse Floating-Rate Note Can Be Characterized as a Combination of a Fixed-Rate Note and an Interest-Rate Swap

IFRNs have a very long duration. When interest rates drop, the coupon rate on the notes increases and the discount rate at which the stream of debt service payments is valued decreases, which magnifies the price increase. The opposite occurs when interest rates rise. Consequently, the IFRN exhibits much greater price sensitivity in response to interest rate changes than even a conventional fixed-rate note of the same maturity. As Exhibit 15–4 suggests, an IFRN has a duration that is roughly double the duration of a comparable fixed-rate note.

The issuer's objective in issuing structured notes is to reduce its funding cost by satisfying an investor's demand for a particular structure without incurring undue additional risk. If the issuer of IFRNs does not want to pay floating-rate interest, which will fluctuate inversely to market interest rates, but rather, wants to fix its interest payments, then it must hedge this risk. To protect itself against the IFRN's heightened interest-rate risk, the IFRN issuer can simultaneously enter into an offsetting interest-rate swap transaction to pay floating and receive fixed.

Suppose it can issue three-year IFRNs that pay 13.75% minus LIBOR with a semiannual reset. The 25-basis-point saving versus the coupon in Exhibit 15–4 might reflect the reduction in yield purchasers are willing to accept in return for the IFRN investment opportunity. An interest rate floor is included in the IFRN to prevent a negative coupon rate if LIBOR rises above 13.75%. The swap does not have such a feature but the IFRN issuer can offset the IFRN floor by purchasing a cap contract. Thus, the IFRN issuer can hedge its IFRN risk exposure by entering into a swap transaction in which it receives a fixed rate of 7% semiannually for three years and pays LIBOR and simultaneously purchasing a cap contract that pays the excess above the strike rate if LIBOR rises above 13.75%. Suppose the cap contract costs 10 basis points per year. Exhibit 15–5 illustrates the effect of the

EXHIBIT 15–5

An Issuer of an Inverse Floating-Rate Note Can Offset Its Interest-Rate Risk by Entering into an Offsetting Interest-Rate Swap and Purchasing a Cap Contract

hedging transactions. As a result of issuing the IFRN and entering into the swap and purchasing the cap contract, the issuer creates a synthetic fixed-rate note paying a 6.85% coupon rate. Its cost of arranging three-year fixed-rate funding is 6.85%, which represents a saving of 15 basis points (6.85% versus 7%).

Leveraged Inverse Floating-Rate Notes

An IFRN can be leveraged by adding another interest-rate swap. This structure results in a coupon rate that is equal to some fixed rate minus some multiple of the reference rate. Exhibit 15–6 illustrates the structure of a leveraged inverse floating-rate note (leveraged IFRN). In this particular example, two interest-rate swaps are embedded in the structured note. As a result, a multiple of two is applied to LIBOR, and the coupon rate of the leveraged IFRN declines twice as fast as the coupon of the IFRN in Exhibit 15–4 as LIBOR rises. The leveraged IFRN pays interest at the rate of 21% minus two times LIBOR.

Range Floating-Rate Notes

A range floating-rate note enables the issuer and investors to take a particular view on future interest rate volatility. Range floating-rate notes make interest payments only when the specified interest rate, usually a short-term interest rate such as three-month LIBOR, stays within the stated range. For instance, suppose an issuer sells a range floating-rate note that accrues interest during the first two interest periods at a rate equal to three-month LIBOR plus 100 basis points on those days

EXHIBIT 15–6

A Leveraged Inverse Floating-Rate Note Created by Combining a Fixed-Rate Note and Two Interest-Rate Swaps

when three-month LIBOR is between 3% and 4%. The range typically steps up in subsequent periods. If three-month LIBOR is outside the specified range, no interest accrues that day. Therefore, the investor profits if short-term interest rates rise in a gradual and predictable pattern and stay within the specified range. At the same time, the investor bears the risk that LIBOR rises or falls outside of the specified range. In return, the investor is compensated for this risk by receiving a greater spread over LIBOR than a conventional floating-rate note the same issuer would provide.

An issuer of range floaters could simultaneously enter into an interest-rate swap transaction to hedge its floating interest-rate risk exposure. For example, suppose the issuer enters into an interest-rate swap that pays 6% fixed and receives floating-rate payments that mirror the coupon payments on the structured note, which is three-month LIBOR plus 100 basis points when LIBOR is within the specified range, as in the previous example. As a result of the combined transactions, the issuer of the range floater locks in a financing rate of 6%, which is beneficial if its cost of conventional fixed-rate funding for that maturity exceeds 6%.

Currency-Linked Notes

A currency-linked note is a structured note in which payments are linked to the performance of a specified foreign exchange rate or a basket of currencies. Investors are able to capitalize on their view of the likely movement of the exchange rate. One of the most popular types of currency-linked notes combines a fixed-rate note with an embedded currency call or put option. The issuer pays (receives) an option premium to (from) investors in the form of an enhanced (reduced) coupon rate if it is long (short) the embedded option. At maturity, if the currency option remains out-of-the-money, the issuer repays the par amount

to the investor. If the option is in-the-money, the principal repayment amount is enhanced or reduced according to the type of option and its moneyness.

For example, suppose a financial institution wants to issue a structured note that will provide a hedge against a possible fall in the value of the Japanese yen relative to the U.S. dollar. It can sell investors a Japanese-yen-linked U.S. dollar-denominated structured note for $10 million with an embedded long yen put option that specifies a strike rate set equal to the spot yen-dollar exchange rate of, say, ¥90/$1 at the time of issue. This put option on yen can be viewed equivalently as a call option on the U.S. dollar. The note pays the par amount in dollars at maturity if the option is out-of-the-money (Japanese yen remains above—equivalently, the U.S. dollar remains below—¥90/$1). At maturity, if the Japanese yen has weakened (equivalently, the U.S. dollar has strengthened) to ¥95/$1, then the payment is reduced by $0.53 million (= $10 million × (90 − 95)/95). Thus, the financial institution pays—and the investors receive—$9.47 million. The $0.53 million saving would offset part of the foreign exchange loss on the assets the financial institution had hedged by issuing the currency-linked note. Conversely, non-U.S. investors who believe that the Japanese yen would strengthen relative to the U.S. dollar—equivalently, that the U.S. dollar might weaken against the Japanese yen—could express that view by taking the other side of the transaction.

As with other structured notes, an issuer of a currency-linked note that is not interested in the currency option for hedging or investment purposes, but is merely acting as a conduit, can hedge itself by taking an offsetting position in the option. If the issuer of the currency-linked note in the preceding example, which is the buyer of a currency put option, were instead merely acting as a conduit, it could hedge itself by selling an identical (or substantially similar) yen put option to neutralize its risk exposure to changes in the yen-dollar exchange rate.

Equity-Linked Notes

Equity-linked notes are structured by combining a note with an equity derivative. The payments on an equity-linked note are principally determined by the return on the underlying equity derivative, which could be a single stock, a basket of stocks, or an equity index.

One structure combines a non-interest-bearing note and an equity call option. On the maturity date, an investor receives the par value of the note plus a variable return based on the percentage change in the underlying equity derivative. Specifically, the final payout is calculated as the initial investment times the gain or loss in the underlying stock or equity index times a note-specific participation rate. For instance, if the gain on the underlying stock or equity index is 30% during the investment period and the participation rate is 90%, the investor receives 1.27 times the amount she invested. If the note provides principal protection (a floor rate of return of zero) and the underlying equity declines or remains unchanged during the investment period, then the investor simply receives the original amount she invested.

Equity-linked notes can also be interest-bearing. In that case, the participation rate is reduced to reflect the income provided by the interest payments. As with other structured notes, an issuer of an equity-linked note can hedge its risk exposure, in this case by simultaneously purchasing an equity call option to hedge its exposure to a rise in the price of the specified stock or equity index. Issuers of equity-linked notes have typically been broker-dealers, who can structure these hedges relatively cheaply.

Commodity-Linked Notes

Commodity-linked notes are created by combining a note with a commodity derivative. Commodities that have served as the underlying for such securities include crude oil, natural gas, gasoline, copper, lead, or precious metals. The payments on a commodity-linked note are determined by the performance of the underlying commodity or a specified basket of commodities. Interest or principal payments or both can be commodity-linked.

One structure combines a non-interest-bearing note and a commodity call option. At maturity, an investor receives the par value of the non-interest-bearing note plus a variable return based on the percentage change in the price of the underlying commodity component. If the note provides principal protection and the price of the underlying commodity declines or remains unchanged during the investment period, then the investor simply receives the original amount she invested.

As with equity-linked notes, commodity-linked notes can also be interest-bearing, and the issuer of the notes can hedge its risk exposure by simultaneously entering into an offsetting commodity derivative transaction.

Risks of Structured Notes

Issuers of structured notes and investors face a variety of risks in addition to the risk that is specific to the embedded derivative instrument.

Credit Risk

Because a structured note combines a plain vanilla note and a derivative instrument that an investment bank creates to satisfy an investor's desire for exposure to a specific risk, an investor bears the risk that the issuer might default on the note. Investors try to control this risk by limiting their structured note purchasers to notes issued by high-grade issuers, such as the government-sponsored enterprises Freddie Mac and Fannie Mae before they encountered financial distress.

It has been very common, however, for investment banks to issue structured notes. Because of the risk of issuer default, it is possible for a structured note to become worthless even when the embedded derivative is in-the-money. This counterparty risk is well illustrated by the collapse of Lehman Brothers in September 2008, which resulted in Lehman Brothers structured notes becoming

worthless even when the underlying derivatives had positive returns. In effect, the default risk trumped the risks and returns inherent in the embedded derivative instrument and nullified the specific bet that the issuer and the investors were trying to make when the structured notes were issued.

Market Risk

By design, an investment in a structured note carries additional market risks on top of the risks that a traditional note carries because of the embedded derivative instrument. A structured note is created for investors who are seeking to profit from specific market risks. Depending on future market conditions, such as interest-rate movements, stock price movements, or commodity price movements, losses on a structured note could be magnified. Market risks can be quantified with financial models, such as an interest-rate term structure model or an option pricing model, so that the degree of market risk can be quantified and priced into the structured note price.

Liquidity Risk

The markets for structured notes are generally less liquid than those for conventional notes. Most structured notes are rarely traded after issuance. One of the reasons for the market illiquidity is that because a structured note is customized to satisfy the specific needs of an original investor, there is a smaller number of potential investors who might be willing to buy the structured note (and make the same customized bet) in the secondary market. Another reason for the market illiquidity is that the issue sizes are generally smaller and the transaction costs are usually higher than for standardized notes. Consequently, to value a structured note, one needs to take into account not only the credit risk of the issuer, but also the particular risk/return profile customized to the investor. Pricing accuracy can be another concern with structured notes. Because structured notes are rarely traded after issuance, their prices are usually calculated with a financial model. In that case, the accuracy of the valuation depends to a large extent on whether the underlying derivative is modeled correctly.

As a result, when an investor intends to sell structured notes before they mature, it may not be easy to sell them at a reasonable price within a reasonable time frame. For instance, if interest rates move in the opposite direction to an investor's expectation when he purchased a structured note, the investor may want to sell the structured note but not be able to find a market for it. As another example, when an investor's view on the direction of interest rates proves to be correct but the interest rate underlying the structured note (such as the interest rate in an inverse floater) changed earlier than expected, the investor may want to sell the structured note before the maturity date to take advantage of current market conditions and lock in her profit. Because structured notes are thinly traded securities, the spread between the market bid and ask prices may be wide; the size of the spread would reduce the profit realized on the structured note investment.

Systemic Risk

Systemic risk refers to the risk associated with a broad market disruption within the financial market system, as opposed to being limited to an individual security or a particular market segment. By design, structured notes are more exposed to systemic risk than conventional notes because the payments on structured notes are often tied to the conditions in the derivative markets for foreign exchange, equities, or commodities. Any disruptions or problems in the underlying derivative market would magnify the structured note holder's risk exposure to that market and compound her risk exposure to disruptions or problems in the fixed income market.

Why Do Investors Buy Structured Notes?

Investors buy structured notes when the risk/return profile of the security matches their investment needs and the investment opportunity is not otherwise available as cheaply (or at all) in the capital market.

Administrative Efficiency

Compared with separate transactions consisting of notes and derivative instruments, which could be complex and costly, purchasing a structured note makes the process simple and reduces administrative costs, such as the cost of maintaining margin or the cost of rolling over shorter-term derivative contracts.

Diversification and Hedging

Structured notes facilitate investors diversifying their investment portfolios into new products and new security types and possibly new markets. The embedded derivative can serve a useful hedging purpose, as in the example earlier in the chapter of a financial institution that issued a structured currency-linked note containing a Japanese yen put option to protect against a fall in the value of the Japanese yen relative to the U.S. dollar.

Customization and Managing Risk Exposure

Because structured notes are customized to conform to investors' views on the interest rate, stock price, exchange rate, or commodity price reflected in the underlying derivative instrument, investors are able to adjust the risk/return profiles of their investment portfolios. Through a reverse inquiry, an investor is able to request notes with specific characteristics, which may not be available currently in the market.

Some structured notes are created to minimize risk exposure by providing principal protection, while others are created to maximize returns with or without principal protection. In any case, the derivative components of the structured notes allow the products to be aligned with any particular investor's market view or economic forecast and to suit the investor's risk tolerance. Moreover, leverage can be built into structured notes, as with leveraged inverse floaters, which can

enhance expected returns—but also investment risk—as compared with a direct investment in the underlying assets. Therefore, investors are able to manage risks appropriate to their risk/return profiles in line with their views on the market.

Principal-Protected Structured Notes

A principal-protected structured note (PPN) is a structured note that guarantees the return of at least 100% of invested capital (a floor rate of return of zero), regardless of market conditions, as long as the notes are held to maturity. On the maturity date, barring a default by the issuer, investors receive payments consisting of the original principal amount plus any gains from the underlying assets. Because a PPN is a structured note combined with downside protection, investors in PPNs exchange more certain yet potentially lower returns for more uncertain and potentially larger returns. The return from investing in a PPN depends on the value of the embedded option at maturity. With many PPNs, there is no periodic payment of interest during the investment period, and just a single payment is made at maturity.

Its name suggests that a PPN guarantees the repayment of 100% of invested principal. However, this assurance does not mean that there is zero downside risk because the issuer might default. Typically, an investment bank serves as the issuer and is therefore responsible for paying the contingent principal amount at maturity. Therefore, evaluating the financial condition and creditworthiness of the investment bank issuer is an important step in deciding whether to purchase a PPN. Credit risk can be significant, which materializes when the investment bank issuer defaults.

The Impact of the Lehman Brothers Bankruptcy

The Lehman Brothers collapse in September 2008 has affected virtually all areas of the financial markets in some way, but particularly the structured products market, because a large number of products were linked to Lehman Brothers' credit. One of the more significant products was the Lehman Brothers PPNs.

The Lehman Brothers PPNs were issued as hybrid financial instruments, constructed from a combination of stocks, bonds, currencies, commodities, and derivatives, which were sold to retail investors as low-risk and safe investments. UBS, one of the largest sellers of structured notes, and other brokerage firms sold Lehman Brothers structured notes to retail investors with principal protection effectively guaranteed by Lehman Brothers. Following the Lehman Brothers bankruptcy in September 2008, however, the guarantee of principal protection became meaningless, and the PPNs became essentially worthless.

Before the Lehman Brothers collapse, investment banks were able to sell PPNs to investors easily because investors were convinced that the PPNs would guarantee principal repayment even when the underlying investments did not produce a positive return. However, the Lehman Brothers bankruptcy rudely awakened retail investors to the risk of possible credit loss and generated a

substantial amount of litigation in which investors asserted that the PPN guarantee had been misrepresented because the investors' principal was not truly protected in all events.

This negative experience highlights the need to warn investors properly concerning the risks of investing in structured notes. It also highlights the problem inherent in every derivatives contract: a counterparty default will undermine the upside opportunity or downside protection investors thought they were getting when they purchased the structured notes.

CREDIT-LINKED NOTES

Broadly defined, a CLN is a structured note with at least some of its payments dependent on the occurrence of a defined credit event, such as a specified entity's default, a change in a specified entity's credit rating, or a change in a specified debt instrument's credit spread. CLNs have grown in importance with the development of the market for credit default swaps (CDS) because like CDS, CLNs provide attractive opportunities for managing credit risk exposure.

Characteristics of Credit-Linked Notes

Typically, a CLN is a combination of a conventional note and a CDS. A CLN is often issued by either a very strong credit, such as a high-grade bank or a government-sponsored enterprise, or a special-purpose bankruptcy-remote trust that is a counterparty to the CDS. A total return swap or a credit forward contract can also be used in this structure. A CLN allows the issuer to transfer a particular credit risk exposure to the purchaser of the CLN. In this structure, the issuer (seller) of the CLN is the protection buyer, and the investor (purchaser) of the CLN is the protection seller, who ultimately bears the credit risk.

As shown in Exhibit 15–7, if a credit event occurs, the CLN is redeemed early. The redemption amount is reduced below the face amount according to the reduced value of the underlying reference asset, such as a bond or a bank loan that falls in value due to the credit event's occurrence. If no credit event occurs during the life of the CLN, then the full principal amount of the note is paid to the investors at maturity.

CLNs are attractive to issuers who want to hedge against a credit default or a rating downgrade, which would adversely affect the value of one of their investments. They are able to customize the terms of the credit protection contract to satisfy their credit risk protection objectives. On the other hand, investors purchase CLNs with the objective of enhancing the yield they receive on their note investment. Investors find CLNs attractive because they are able to gain access to the credit market, which might be unavailable to them otherwise.

A CLN normally adjusts the principal repayment to pay off on the credit derivative instrument embedded within the note. For example, suppose an investor purchased a five-year CLN at a credit spread of 200 basis points that would

EXHIBIT 15–7

Payoffs on a Credit-Linked Note

repay $1,000 at maturity or $1,000 minus the payoff if a credit event occurs before the CLN matures. The investor has sold a put option to the issuer of the note and in return receives a higher coupon. Suppose that the reference bond's credit spread is 100 basis points and a credit event occurs that causes the price of the reference asset to fall to 80. The issuer of the CLN pays 100 basis points per year for the put option (200 – 100 basis points). The holder of the CLN would receive $800 (80% of $1,000) per $1,000 face amount following the credit event. The single payment is equivalent to receiving $1,000 and simultaneously paying off $200 on the put option.

Funded Credit Derivative

CLNs have gained in popularity because they provide credit protection like CDS, but entail less risk of contract default. CLNs are a form of funded credit derivative. The investor in the CLN, the protection seller, pays cash to the protection buyer—the full purchase price of the CLN—to purchase the CLN. If a credit event occurs, the protection buyer's repayment obligation decreases, and the protection buyer returns less cash to the protection seller than if no credit event had occurred. In contrast, with CDS, the protection buyer must collect the cash payment from the protection seller, if there is cash settlement, or the protection seller must obtain the bond or loan obligation from the protection buyer and sell it in the market, if there is physical settlement. A CLN thus involves less contract default risk than a CDS written by the same protection seller.

SPV Structure

CLNs have been issued by large financial institutions. This unfunded structure exposes CLN investors to the financial institution's default risk. Alternatively, the CLNs can be issued through a funded structure in which a bankruptcy-remote

EXHIBIT 15–8

Structure of a Credit-Linked Note

special-purpose vehicle (SPV) is created to hold high-quality financial assets and issue the CLNs. This structure, which is illustrated in Exhibit 15–8, insulates CLN investors from the risk of issuer default because the SPV's assets are selected so as to generate sufficient cash flows to service the CLNs. The funded CLN structure thus limits the investor's default risk exposure to the reference obligation specified in the CLN, which was the purpose for creating the CLN in the first place.

Combining Credit-Linked Notes and Credit Default Swaps

An issuer can design structured products combining CLNs and CDSs to meet both the issuer's and the investors' requirements. Exhibit 15–9 illustrates the combined structure of CLN and CDS, which is designed to fund the CDS obligation and to provide higher returns for an investor who is willing to take on the corresponding credit risk. The CLNs are issued by an SPV, which holds the collateral securities

EXHIBIT 15–9

CLN and CDS Structure on a Single Reference Name

(also known as the *underlying securities*). The SPV uses the proceeds from issuing the CLNs to purchase the pre-agreed collateral securities. They are normally risk-free securities, such as Treasury bills. The SPV grants a security interest in the collateral to secure the SPV's future performance under the CLN contract. The cash flow from these high-quality securities is used to pay the interest and principal on the CLNs as long as no credit event occurs. In this structure, the SPV buys credit protection on a single reference asset or entity by entering into a CLN and paying the ongoing premium, which is included in the CLN interest rate. The CLN investors sell the credit protection and receive the premium; they have the credit risk exposure to the reference asset or entity.

At the same time, the SPV simultaneously enters into a CDS agreement with a highly rated swap counterparty. In this swap agreement, the SPV sells credit protection on the same reference asset or entity underlying the CLNs and, in return, receives the CDS premium. Through the combined CLN and CDS structure, the SPV has a neutral credit risk position with respect to the reference asset or entity.

The coupon rate on the CLN is a spread over LIBOR and is funded by the collateral securities and the fee generated by selling protection in the CDS transaction. The SPV's payment on the CLN is linked to the performance of the reference asset or entity. If a specified credit event[1] involving the reference asset or entity occurs, there are three options to settle the CLN and the CDS. First, under the recovery-linked option, a third party sells the reference assets into the market, and the SPV distributes the realized proceeds to the CLN investors to settle the CLN. At the same time, the third party sells the underlying collateral securities and distributes the proceeds to the swap counterparty to settle the CDS. Second, under the physical delivery option, the CDS swap counterparty delivers the reference assets to the SPV and the SPV delivers them to the CLN investors, and the SPV also delivers the underlying collateral securities to the CDS swap counterparty. Third, under the binary option, a specified cash payment is negotiated among the SPV, the CDS counterparty, and the CLN investors at the outset of the transactions. The SPV makes that cash payment to the CDS counterparty if a credit event occurs. It then deducts it from the principal amount owed to the CLN investors and repays the net amount to the CLN investors.

Reference Obligation Is Emerging Market Sovereign Debt

In the case of CLNs, in which the reference obligation is an emerging market debt obligation, the SPV also may need to enter into an interest-rate swap or a currency swap to reduce interest-rate risk and to tailor the required cash flows of the CLN to the cash flows of the collateral. The resulting package is a CLN that performs similarly to a sovereign bond. Such CLNs are bought by investors who seek an increase in yield as compared with what a comparable sovereign bond would offer and who do not need liquidity during the life of the CLN.

1. Credit events typically include bankruptcy, payment default, repudiation, and restructuring.

Credit-Sensitive Notes

A conventional corporate bond can be viewed as a package consisting of a long Treasury note and a short position in a CDS, with the credit event defined as an actual default with immediate payment. (Alternatively, one can assume the immediate sale of the note in the event default occurs and ignore the optionality inherent in the flexibility to time the sale of the defaulted note.) In a conventional corporate bond, part of the coupon payment (the credit spread) can be viewed as the CDS premium. The size of the coupon payment depends on the credit quality of the bond at the date of issue, but normally does not change if the credit quality of the bond subsequently changes. Credit-sensitive notes provide for variation in the size of the coupon if the issuing firm's credit quality changes.

A credit-sensitive note is a fixed- or floating-rate note on which the interest rate is adjusted in response to a change in the issuer's credit rating. The coupon rate adjusts inversely to the change in the note's credit rating. If the issuer is downgraded by a credit rating agency, the credit-sensitive note pays a higher coupon rate to compensate investors for the additional credit risk. In this structure, the investors are short a credit spread forward agreement.

Consider the following example with the indicated credit ratings and spreads:

Credit Rating	Credit Spread
AA	100 bp
A	125 bp
BBB	150 bp
BB	200 bp

An investor buys a single-A-rated note paying 125 bp over Treasuries. If the credit rating rises to AA, the investor receives 25 bp less per year in interest. If the credit rating falls to BBB, the investor receives 25 bp more per year in interest. Thus, a credit-sensitive note is a form of structured note, which provides a built-in hedge against changes in the issuer's credit quality. It thus provides protection against the moral hazard risk fixed income investors face.

First-to-Default Credit-Linked Notes

A standard CLN is issued with reference to one specific bond or loan. A basket credit-linked note is a CLN that is linked to more than one reference entity. In a first-to-default CLN, an investor sells credit protection on a basket of assets, and the payment occurs upon whichever entity in the basket is the first to default. The coupon payment on the first-to-default CLN is LIBOR plus a multiple of the average spread for the reference entities in the basket of assets. As soon as a credit event occurs on any of the reference assets, the CLN matures.

Exhibit 15–10 illustrates a typical first-to-default CLN structure. Suppose an issuer sells a first-to-default CLN at par with three years to maturity, which is

EXHIBIT 15–10

Structure of a First-to-Default Credit-Linked Note

linked to a basket of 10 reference assets with a face value of $10 million. An investor who purchases the note pays $10 million to the issuer at the closing. The issuer will pay interest during the life of the note and will repay the $10 million at maturity, subject to there being no credit event. The CLN investor takes a credit position equal to $10 million notional in each reference entity. The first time a credit event occurs on any asset in the basket, the issuer redeems the CLN by delivering to the CLN investor $10 million face amount of the reference asset that experienced the credit event. Typically, the actual redemption amount is determined by the market value, not by the recovery value, of the reference obligation at the time the credit event is verified.

A first-to-default CLN investor faces the same type of credit risk exposure on default as with a standard CLN, namely, the reduced recovery rate on the defaulted credit. Because a first-to-default CLN involves multiple assets in the basket, rather than a single asset as in a standard CLN, it can reduce the investor's default risk exposure as compared with a single-name CLN through credit risk diversification. The CLN investor obtains default risk exposure to a basket of reference entities, which can be diversified across industries and also across credit rating categories. This diversification benefit is greater the lower are the pairwise correlations among the returns on the reference entities in the basket.

Emerging Market Credit-Linked Notes

Emerging market CLNs are structured notes that are tied to the creditworthiness of a relatively lower-rated sovereign credit. Demand from investors who are seeking higher returns from emerging market CLNs has increased over the past few years, as growth prospects for the emerging economies have improved due to the world economy recovering from the 2007–2009 financial crisis. To compensate emerging market CLN investors for taking on greater counterparty credit risk as well as liquidity risk, they are typically paid more than the underlying debt yield. For example, an

investment bank issues a $10 million 10-year 9.5% note linked to Turkish government debt when Turkish government bonds of the same maturity pay 9%.

Emerging market CLNs are efficient investment instruments for investors who are not able to trade the underlying bonds of the countries for any reason, such as transaction costs, investment regulations, or other market frictions. They are attractive to emerging market fixed income investors who believe that a particular sovereign credit rating is likely to be upgraded and who want an investment opportunity that enables them to express that view.

Synthetic CDO Credit-Linked Notes

Synthetic collateralized debt obligations (SCDOs) are a form of CDO that invests in CDSs or other assets to gain exposure to a fixed income portfolio. Unlike a CDS, which typically references a single asset, an SCDO references a portfolio of assets. This portfolio is securitized by issuing notes that are divided into tranches. The SCDO notes are typically prioritized sequentially as to their default risk exposure to the underlying portfolio. They also typically have a sequential amortization structure; the most senior notes are scheduled to be fully repaid first, the next most senior notes are scheduled to be fully repaid next, and so on. Accordingly, when payments are made, they flow first to the most senior notes, thus amortizing them more quickly than the subordinated notes. Investors in the SCDO tranches are able to take on credit risk in accordance with their risk tolerances by purchasing a particular note tranche.

Sponsors may combine SCDOs and CLNs to reduce counterparty risk. Like other CLN structures, an SPV is created to provide a bankruptcy-remote depository for the high-quality assets that are purchased with the CLN proceeds. Exhibit 15–11 illustrates a hybrid structure that combines SCDOs and CLNs in a fully funded structure. The SPV sells credit protection to the sponsor; this

EXHIBIT 15–11

Funded SCDO: SCDO Combined with CLNs

credit protection is ultimately provided by the CLN investors. If a credit event occurs involving any of the reference assets, the payments to the CLN investors are reduced according to the repayment priorities of their respective notes. The first loss CLN investors suffer the initial loss up to the full amount of their principal before more senior CLNs are affected.

SCDO transactions can also be structured as a hybrid that blends the funded and unfunded structures. A single, highly rated investor purchases the most senior tranche in the form of an unfunded CDS, whereas the rest of the liability structure is divided into a series of funded CLN tranches, which are purchased by various investors according to their relative risk tolerances. The funded portion of this SCDO structure would mirror the structure illustrated in Exhibit 15–11.

KEY POINTS

- Structured notes and CLNs provide customized interest or principal payments that depend on the performance of a specified reference asset, market price, index, interest rate, foreign exchange rate, commodity price, or some other market quantity.
- A structured note combines a conventional fixed- or floating-rate note with an embedded derivative instrument.
- A CLN is a particular form of structured note in which the derivative instrument is a credit default swap or some other form of credit derivative.
- The issuer's objective in issuing structured notes is to reduce its funding cost by satisfying an investor's demand for a particular structure without incurring undue additional risk.
- Investors buy structured notes when the risk/return profile of the security matches their investment needs and the investment opportunity is not otherwise available as cheaply (or at all) in the capital market.
- The financial crisis of 2007–2009 resulted in a reduction in the issuance of structured notes and CLNs. Issuance of both began to recover as the crisis passed. Issuance of these fixed income instruments should increase as fixed income market participants take advantage of the opportunities they afford to optimize their investment portfolios.

CHAPTER
SIXTEEN

PRIVATE MONEY MARKET INSTRUMENTS

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

STEVEN V. MANN, PH.D.
Professor of Finance
Moore School of Business
University of South Carolina

Historically, the *money market* is defined as the market for assets with original maturities of one year or less. The assets traded in this market include Treasury bills, commercial paper, some medium-term notes, bankers acceptances, federal agency discount paper, short-term municipal obligations, certificates of deposit, repurchase agreements, floating-rate instruments, and federal funds. Although several of these assets have maturities greater than one year, they are still classified as part of the money market.

In Chapter 9, Treasury bills are discussed. In this chapter we will cover private money market instruments: commercial paper, bankers acceptances, certificates of deposit, repurchase agreements, and federal funds. Medium-term notes have maturities ranging from nine months to 30 years. These securities are discussed in Chapter 12.

COMMERCIAL PAPER

A corporation that needs long-term funds can raise those funds in either the equity or bond market. If, instead, a corporation needs short-term funds, it may attempt to acquire those funds via bank borrowing. An alternative to bank borrowing is commercial paper. *Commercial paper* is short-term unsecured promissory notes issued in the open market as an obligation of the issuing entity.

The commercial paper market once was limited to entities with strong credit ratings, but in recent years, some lower-credit-rated corporations have issued commercial paper by obtaining credit enhancements or other collateral to allow them to enter the market as issuers. Issuers of commercial paper are not restricted to U.S. corporations. Non-U.S. corporations and sovereign issuers also issue commercial paper.

The maturity of commercial paper is typically less than 270 days; the most common maturity is less than 45 days.[1] There are reasons for this. First, the Securities Act of 1933 requires that securities be registered with the Securities and Exchange Commission (SEC). Special provisions in the 1933 act exempt commercial paper from registration so long as the maturity does not exceed 270 days. To avoid the costs associated with registering issues with the SEC, issuers rarely issue commercial paper with a maturity exceeding 270 days. To pay off holders of maturing paper, issuers generally issue new commercial paper. Another consideration in determining the maturity is whether the paper would be eligible collateral by a bank if it wanted to borrow from the Federal Reserve Bank's discount window. In order to be eligible, the maturity of the paper may not exceed 90 days. Because eligible paper trades at a lower cost than paper that is not eligible, issuers prefer to issue paper whose maturity does not exceed 90 days.

The risk that the investor faces is that the borrower will be unable to issue new paper at maturity. As a safeguard against "rollover risk," commercial paper issuers secure backup lines of credit sometimes called *liquidity enhancements.* Most commercial issuers maintain 100% backing because the credit rating agencies that rate commercial paper (Fitch, Moody's, and Standard & Poor's) usually require a bank line of credit as a precondition for a rating.

Investors in commercial paper are institutional investors. Money market mutual funds are the biggest purchasers of commercial paper. Pension funds, commercial bank trust departments, state and local governments, and nonfinancial corporations seeking short-term investments purchase the balance. The minimum round-lot transaction is $100,000. Some issuers will sell commercial paper in denominations of $25,000.

Issuers of Commercial Paper

According to data provided by the Federal Reserve, the total amount of commercial paper outstanding (in billions) at the end of 2010 was roughly $1.058 trillion. Commercial paper can be categorized along three dimensions: (1) type of issuer; (2) issue channel; and (3) presence of collateral. Issuer classification includes financial firms, nonfinancial firms, and asset-backed securities. Financial firms are the largest issuers ($556 billion outstanding as of year end 2010), followed by asset-backed ($382 billion), and then nonfinancial firms ($120 billion).

Financial and nonfinancial firms differ in their use of the proceeds received from the issuance of commercial paper. Nonfinancial firms utilize the funds for ongoing cash flow needs (e.g., payroll and inventories), while financial firms use the funds to manage short-term liquidity needs such as the mismatch between assets and liabilities.

1. See Frank J. Fabozzi, Steven V. Mann, and Moorad Choudhry, *The Global Money Market* (Hoboken, NJ: John Wiley & Sons, 2002).

Although the typical issuers of commercial paper are those with high credit ratings, smaller and less well-known companies with lower credit ratings have been able to issue paper in recent years. They have been able to do so by means of credit support from a firm with a high credit rating (such paper is called *credit-supported commercial paper*) or by collateralizing the issue with high-quality assets (such paper is called *asset-backed commercial paper*). An example of credit-supported commercial paper is an issue supported by a letter of credit. The terms of such a letter of credit specify that the bank issuing it guarantees that the bank will pay off the paper when it comes due if the issuer fails to. Banks charge a fee for letters of credit. From the issuer's perspective, the fee enables it to enter the commercial paper market and obtain funding at a lower cost than bank borrowing. Paper issued with this credit enhancement is referred to as *LOC paper*. The credit enhancement also may take the form of a surety bond from an insurance company.[2] Asset-backed commercial paper is issued by large corporations through special-purpose vehicles that pool the assets and issue the securities. The assets underlying these securities consist of credit card receivables, auto and equipment leases, healthcare receivables, and even small business loans.

Directly Placed versus Dealer-Placed Paper

Commercial paper is classified as either direct paper or dealer paper. *Direct paper* is sold by the issuing firm directly to investors without using a securities dealer as an intermediary. A large majority of the issuers of direct paper are financial companies. Because they require a continuous source of funds in order to provide loans to customers, they find it cost-effective to establish a sales force to sell their commercial paper directly to investors.

In the case of dealer-placed commercial paper, the issuer uses the services of a securities firm to sell its paper. Commercial paper sold in this way is referred to as *dealer paper*. Competitive pressures have forced dramatic reductions in the underwriting fees charged by dealer firms.

The Secondary Market

Commercial paper is one of the largest segments of the money market. Despite this fact, secondary trading activity is much smaller. The typical investor in commercial paper is an entity that plans to hold it until maturity, given that an investor can purchase commercial paper with the specific maturity desired. Should an investor's economic circumstances change such that there is a need to sell the paper, it can be sold back to the dealer, or in the case of directly-placed paper, the issuer will repurchase it.

2. A surety bond is a policy written by an insurance company to protect another party against loss or violation of a contract.

Yields on Commercial Paper

Like Treasury bills, commercial paper is a discount instrument. That is, it is sold at a price less than its maturity value. The difference between the maturity value and the price paid is the interest earned by the investor, although some commercial paper is issued as an interest-bearing instrument. For commercial paper, a year is treated as having 360 days.

For the period January 1, 1997 to December 31, 2010, the average weekly spread between three-month commercial paper yields and three-month U.S. Treasury bill yields was about 41 basis points, the lowest spread being 4 basis points (second week of March 2010) and the highest being 325 basis points (second week of October 2008).

The commercial paper rate is higher than that on Treasury bills for three reasons. First, the investor in commercial paper is exposed to credit risk. Second, interest earned from investing in Treasury bills is exempt from state and local income taxes. As a result, commercial paper has to offer a higher yield to offset this tax advantage. Finally, commercial paper is less liquid than Treasury bills. The liquidity premium demanded is probably small, however, because investors typically follow a buy-and-hold strategy with commercial paper and so are less concerned with liquidity. The rate on commercial paper is higher by a few basis points than the rate on certificates of deposit, which we discuss later in this chapter. The higher yield available on commercial paper is attributable to the poorer liquidity relative to certificates of deposit.

BANKERS ACCEPTANCES

Simply put, a bankers acceptance is a vehicle created to facilitate commercial trade transactions. The instrument is called a *bankers acceptance* because a bank accepts the ultimate responsibility to repay a loan to its holder. The use of bankers acceptances to finance a commercial transaction is referred to as *acceptance financing*.

The transactions in which bankers acceptances are created include (1) the importing of goods into the United States, (2) the exporting of goods from the United States to foreign entities, (3) the storing and shipping of goods between two foreign countries where neither the importer nor the exporter is a U.S. firm,[3] and (4) the storing and shipping of goods between two entities in the United States.

Bankers acceptances are sold on a discounted basis just as Treasury bills and commercial paper. The major investors in bankers acceptances are money market mutual funds and municipal entities. Bankers acceptances have declined in importance in recent years in favor of other forms of financing.

3. Bankers acceptances created from these transactions are called *third-country acceptances*.

Illustration of the Creation of a Bankers Acceptance

The best way to explain the creation of a bankers acceptance is by an illustration. Several entities are involved in our transaction:

- Car Imports Corporation of America ("Car Imports"), a firm in New Jersey that sells automobiles
- Germany Autos, Inc. ("GAI"), a manufacturer of automobiles in Germany
- Hoboken Bank of New Jersey ("Hoboken Bank"), a commercial bank in Hoboken, New Jersey
- Berlin National Bank ("Berlin Bank"), a bank in Germany
- High-Caliber Money Market Fund, a mutual fund in the United States that invests in money market instruments

Car Imports and GAI are considering a commercial transaction. Car Imports wants to import 15 cars manufactured by GAI. GAI is concerned with the ability of Car Imports to make payment on the 15 cars when they are received.

Acceptance financing is suggested as a means for facilitating the transaction. Car Imports offers $300,000 for the 15 cars. The terms of the sale stipulate payment to be made to GAI 60 days after it ships the 15 cars to Car Imports. GAI determines whether it is willing to accept the $300,000. In considering the offering price, GAI must calculate the present value of the $300,000 because it will not be receiving the payment until 60 days after shipment. Suppose that GAI agrees to these terms.

Car Imports arranges with its bank, Hoboken Bank, to issue a letter of credit. The letter of credit indicates that Hoboken Bank will make good on the payment of $300,000 that Car Imports must make to GAI 60 days after shipment. The letter of credit, or time draft, will be sent by Hoboken Bank to GAI's bank, Berlin Bank. On receipt of the letter of credit, Berlin Bank will notify GAI, who will then ship the 15 cars. After the cars are shipped, GAI presents the shipping documents to Berlin Bank and receives the present value of $300,000. GAI is now out of the picture.

Berlin Bank presents the time draft and the shipping documents to Hoboken Bank. The latter will then stamp "accepted" on the time draft. By doing so, the Hoboken Bank has created a bankers acceptance. This means that Hoboken Bank agrees to pay the holder of the bankers acceptance $300,000 at the maturity date. Car Imports will receive the shipping documents so that it can procure the 15 cars once it signs a note or some other type of financing arrangement with Hoboken Bank.

At this point, the holder of the bankers acceptance is the Berlin Bank. It has two choices. It can retain the bankers acceptance as an investment in its loan portfolio, or it can request that the Hoboken Bank make a payment of the present value of $300,000. Let's assume that Berlin Bank requests payment of the present value of $300,000.

Now the holder of the bankers acceptance is Hoboken Bank. It has two choices: retain the bankers acceptance as an investment as part of its loan portfolio or sell it to an investor. Suppose that Hoboken Bank chooses the latter and that High-Caliber Money Market Fund is seeking a high-quality investment with the same maturity as that of the bankers acceptance. The Hoboken Bank sells the bankers acceptance to the money market fund at the present value of $300,000. Rather than sell the instrument directly to an investor, Hoboken Bank could sell it to a dealer who would then resell it to an investor such as a money market fund. In either case, at the maturity date, the money market fund presents the bankers acceptance to Hoboken Bank, receiving $300,000, which the bank in turn recovers from Car Imports.

Credit Risk

Investing in bankers acceptances exposes the investor to credit risk. This is the risk that neither the borrower nor the accepting bank will be able to pay the principal due at the maturity date. Accordingly, bankers acceptances will offer a higher yield than Treasury bills of the same maturity.

Eligible Bankers Acceptance

An accepting bank that has decided to retain a bankers acceptance in its portfolio may be able to use it as collateral for a loan at the discount window of the Federal Reserve. The reason we say that it *may* is that bankers acceptances must meet certain eligibility requirements established by the Federal Reserve. One requirement for eligibility is maturity, which with few exceptions cannot exceed six months. The other requirements for eligibility are too detailed to review here, but the basic principle is simple: The bankers acceptance should be financing a self-liquidating commercial transaction. Conversely, *finance bills* are acceptances that are not related to specific transactions and are generally ineligible.

Eligibility is also important because the Federal Reserve imposes a reserve requirement on funds raised via bankers acceptances that are ineligible. Bankers acceptances sold by an accepting bank are potential liabilities of the bank, but no reserve requirements are imposed for eligible bankers acceptances. Consequently, most bankers acceptances satisfy the various eligibility criteria. Finally, the Federal Reserve also imposes a limit on the amount of eligible bankers acceptances that may be issued by a bank.

Rates Banks Charge on Bankers Acceptances

To calculate the rate to be charged the customer for issuing a bankers acceptance, the bank determines the rate for which it can sell its bankers acceptance in the open market. To this rate it adds a commission. In the case of ineligible bankers acceptances, a bank will add an amount to offset the cost of the reserve requirements imposed.

LARGE-DENOMINATION NEGOTIABLE CDs

A *certificate of deposit* (CD) is a certificate issued by a bank or thrift that indicates that a specified sum of money has been deposited at the issuing depository institution. CDs are issued by banks and thrifts to raise funds for financing their business activities. A CD bears a maturity date and a specified interest rate, and it can be issued in any denomination. CDs issued by banks are insured by the Federal Deposit Insurance Corporation (FDIC) but only for amounts up to $250,000. As for maturity, there is no limit on the maximum, but by Federal Reserve regulations CDs cannot have a maturity of less than seven days.

A CD may be nonnegotiable or negotiable. In the former case, the initial depositor must wait until the maturity date of the CD to obtain the funds. If the depositor chooses to withdraw funds prior to the maturity date, an early withdrawal penalty is imposed. In contrast, a negotiable CD allows the initial depositor (or any subsequent owner of the CD) to sell the CD in the open market prior to the maturity date.

Negotiable CDs were introduced in the early sixties. At that time, the interest rate that banks could pay on various types of deposits was subject to ceilings administered by the Federal Reserve (except for demand deposits, defined as deposits of less than one month that by law could pay no interest). For complex historical reasons, these ceiling rates started very low, rose with maturity, and remained below market rates up to some fairly long maturity. Before introduction of the negotiable CD, those with money to invest for, say, one month had no incentive to deposit it with a bank because they would get a below-market rate, unless they were prepared to tie up their capital for a much longer period of time. When negotiable CDs came along, those investors could buy a three-month or longer negotiable CD yielding a market interest rate and recoup all or more than the investment (depending on market conditions) by selling it in the market.

This innovation was critical in helping banks to increase the amount of funds raised in the money market, a position that had languished in the earlier postwar period. It also motivated competition among banks, ushering in a new era. There are now two types of negotiable CDs. The first is the large-denomination CD, usually issued in denominations of $1 million or more. These are the negotiable CDs whose history we just described.

In 1982, Merrill Lynch entered the retail CD business by opening up a primary and secondary market in small-denomination (less than $100,000 at the time) CDs. While it made the CDs of its numerous banking and savings institution clients available to retail customers, Merrill Lynch also began to give these customers the negotiability enjoyed by institutional investors by standing ready to buy back CDs prior to maturity. Today, several retail-oriented brokerage firms offer CDs that are salable in a secondary market. These are the second type of negotiable CD. Our focus in this chapter, though, is on the large-denomination negotiable CD, and we refer to them simply as CDs throughout the chapter.

The largest group of CD investors consists of investment companies, and money market funds make up the bulk of them. Far behind are banks and bank trust departments, followed by municipal entities and corporations.

CD Issuers

CDs can be classified into four types, based on the issuing bank. First are CDs issued by domestic banks. Second are CDs denominated in U.S. dollars but issued outside the United States. These CDs are called *Eurodollar CDs* or *Euro CDs.* Euro CDs are U.S. dollar–denominated CDs issued primarily in London by U.S., Canadian, European, and Japanese banks. Branches of large U.S. banks once were the major issuers of Euro CDs. A third type of CD is the *Yankee CD,* which is a CD denominated in U.S. dollars and issued by a foreign bank with a branch in the United States. Finally, *thrift CDs* are those issued by savings and loan associations and savings banks.

Yields on CDs

Unlike Treasury bills, commercial paper, and bankers acceptances, yields on domestic CDs are quoted on an interest-bearing basis. CDs with a maturity of one year or less pay interest at maturity. For purposes of calculating interest, a year is treated as having 360 days. Term CDs issued in the United States normally pay interest semiannually, again with a year taken to have 360 days.

The yields posted on CDs vary depending on three factors: (1) the credit rating of the issuing bank, (2) the maturity of the CD, and (3) the supply and demand for CDs. With respect to the third factor, banks and thrifts issue CDs as part of their liability management strategy, so the supply of CDs will be driven by the demand for bank loans and the cost of alternative sources of capital to fund these loans. Moreover, bank loan demand will depend on the cost of alternative funding sources such as commercial paper. When loan demand is weak, CD rates decline. When demand is strong, the rates rise. The effect of maturity depends on the shape of the yield curve.

Credit risk has become more of an issue. At one time, domestic CDs issued by money center banks traded on a no-name basis. Recent financial crises in the banking industry, however, have caused investors to take a closer look at issuing banks. Prime CDs (those issued by high-rated domestic banks) trade at a lower yield than nonprime CDs (those issued by lower-rated domestic banks). Because of the unfamiliarity investors have with foreign banks, generally Yankee CDs trade at a higher yield than domestic CDs.

Euro CDs offer a higher yield than domestic CDs. There are three reasons for this. First, there are reserve requirements imposed by the Federal Reserve on CDs issued by U.S. banks in the United States that do not apply to issuers of Euro CDs. The reserve requirement effectively raises the cost of funds to the issuing bank because it cannot invest all the proceeds it receives from the issuance of a CD, and the amount that must be kept as reserves will not earn a return for the bank.

Because it will earn less on funds raised by selling domestic CDs, the domestic issuing bank will pay less on its domestic CD than a Euro CD. Second, the bank issuing the CD must pay an insurance premium to the FDIC, which again raises the cost of funds. Finally, Euro CDs are dollar obligations that are payable by an entity operating under a foreign jurisdiction, exposing the holders to a risk (called *sovereign risk*) that their claim may not be enforced by the foreign jurisdiction. As a result, a portion of the spread between the yield offered on Euro CDs and domestic CDs reflects what can be termed a *sovereign-risk premium.* This premium varies with the degree of confidence in the international banking system.

Since the 1990s, the liquidity of the Eurodollar CDs has increased dramatically, and the perception of higher risk has diminished considerably. For the period January 1, 2000 to December 31, 2010, the average weekly spread between three-month LIBOR and three-month CD rate was 9 basis points, the lowest spread being –7 basis points (third week of September 2010) and the highest being 106 basis points (second week of October 2008).

CD yields are higher than yields on Treasury securities of the same maturity. For the period January 1, 2000 to December 31, 2010, the average weekly spread between the three-month CD rate and the three-month Treasury bill rate was about 48 basis points, the lowest spread being 5 basis points (second week of March 2010) and the highest being 437 basis points (second week of October 2008). The spread is due mainly to the credit risk that a CD investor is exposed to and the fact that CDs offer less liquidity. The spread due to credit risk will vary with economic conditions and confidence in the banking system, increasing when there is a flight to quality or when there is a crisis in the banking system.

At one time, there were more than 30 dealers who made markets in CDs. The presence of that many dealers provided good liquidity to the market. Today, fewer dealers are interested in making markets in CDs, and the market can be characterized as an illiquid one.

REPURCHASE AGREEMENTS

A *repurchase agreement* is the sale of a security with a commitment by the seller to buy the security back from the purchaser at a specified price at a designated future date. Basically, a repurchase agreement is a collateralized loan, where the collateral is a security. The agreement is best explained with an illustration.

Suppose that on September 28, 2006 a government securities dealer purchases a 4.875% coupon on-the-run 10-year U.S. Treasury note that matures on August 15, 2016. The face amount of the position is $1 million and the note's full price (i.e., flat price plus the accrued interest) is $1,025,672.55. Further, suppose the dealer wants to hold the position until the next business day which is Friday, September 29, 2006. Where does the dealer obtain the funds to finance this position? Of course, the dealer can finance the position with its own funds or by borrowing from a bank. Typically, however, the dealer uses the repurchase agreement or "repo" market to obtain financing. In the repo market, the dealer can

use the Treasury security as collateral for a loan. The term of the loan and the interest rate that the dealer agrees to pay (called the *repo rate*) are specified. When the term of the loan is one day, it is called an *overnight repo;* a loan for more than one day is called a *term repo.* Alternatively, *open-maturity* repos give both counterparties the option to terminate the repo each day. This structure reduces the settlement costs if counterparties choose to continuously roll over overnight repos.

The transaction is referred to as a "repurchase agreement" because it calls for the sale of the security and its repurchase at a future date. Both the sale price and the purchase price are specified in the agreement. The difference between the purchase (repurchase) price and the sale price is the dollar interest cost of the loan.

Let us return to the dealer who needs to finance a long position in the Treasury note for one day. The settlement date is the day that the collateral must be delivered and the money lent to initiate the transaction which, in our example, is September 28, 2006. Likewise, the termination date of the repo agreement is September 29. At this point, we need to address who might serve as the dealer's counterparty (i.e., the lender of funds) in this transaction. Suppose that one of the dealer's customers has excess funds in the amount of $1,025,672.55 and is the amount loaned in the repo agreement. Accordingly, on September 28, 2006, the dealer would agree to deliver ("sell") $1,025,672.55 worth of 10-year U.S. Treasury notes to the customer and buy the same 10-year notes back for an amount determined by the repo rate the next business day on September 29, 2006.[4]

Suppose that the repo rate in this transaction is 5.15%. Then, as will be explained below, the dealer would agree to deliver the 10-year U.S. Treasury notes for $1,025,819.28 the next day. The $146.73 difference between the "sale" price of $1,025,672.55 and the "repurchase" price of $1,025,819.28 is the dollar interest on the financing. From the customer's perspective, the agreement is called a *reverse* repo.

The following formula is used to calculate the dollar interest on a repo transaction:

$$\text{Dollar interest} = \text{dollar principal} \times \text{repo rate} \times \left(\frac{\text{repo term}}{360}\right)$$

Notice that the interest is computed on a 360-day basis. In our illustration, using a repo rate of 5.15% and a repo term of one day, the dollar interest is $146.73, as shown below:

$$\$146.73 = \$1{,}025{,}672.55 \times 0.0515 \times (1/360)$$

The advantage to the dealer of using the repo market for borrowing on a short-term basis is that the rate is less than the cost of bank financing. We will

4. We are assuming in this example that the borrower will provide collateral that is equal in value to the money that is loaned. In practice, lenders usually require borrowers to provide collateral in excess of the value of money that is loaned. We will illustrate how this is accomplished when we discuss repo margins.

explain why later in this section. From the customer's perspective, the repo market offers an attractive yield on a short-term secured transaction that is highly liquid.

The example illustrates financing a dealer's long position in the repo market, but dealers also can use the market to cover a short position. For example, suppose a government dealer shorted $10 million of Treasury securities two weeks ago and must now cover the position—that is, deliver the securities. The dealer can do a reverse repo (agree to buy the securities and sell them back). Of course, the dealer eventually would have to buy the Treasury securities in the market in order to cover its short position.

There is a good deal of Wall Street jargon describing repo transactions. To understand it, remember that one party is lending money and accepting security as collateral for the loan; the other party is borrowing money and giving collateral to borrow money. When someone lends securities in order to receive cash (i.e., borrow money), that party is said to be *reversing out* securities. A party that lends money with the security as collateral is said to be *reversing in* securities. The expressions *to repo securities* and *to do repo* are also used. The former means that someone is going to finance securities using the security as collateral; the latter means that the party is going to invest in a repo. Finally, the expressions *selling collateral* and *buying collateral* are used to describe a party financing a security with a repo on the one hand, and lending on the basis of collateral on the other.

The collateral in a repo is not limited to government securities. Money market instruments, federal agency securities, and mortgage-backed securities are also used. Moreover, repos can include *substitution clauses* that permit the counterparty to substitute alternative securities as collateral over the repo's life.

Credit Risks

Why does credit risk occur in a repo transaction? Consider our initial example, in which the dealer used $10 million of government securities as collateral to borrow. If the dealer cannot repurchase the government securities, the customer may keep the collateral; if interest rates on government securities have increased subsequent to the repo transaction, however, the market value of the government securities will decline, and the customer will own securities with a market value less than the amount it loaned to the dealer. If the market value of the security rises instead, the dealer firm will be concerned with the return of the collateral, which then has a market value higher than the loan.

Repos are now structured more carefully to reduce credit risk exposure. The amount loaned is less than the market value of the security used as collateral, which provides the lender with some cushion should the market value of the security decline. The amount by which the market value of the security used as collateral exceeds the value of the loan is called *margin.*[5] The amount of margin is

5. Margin is also referred to as the "haircut."

generally between 1% and 3%. For borrowers of lower creditworthiness or when less liquid securities are used as collateral, the margin can be 10% or more.

Another practice to limit credit risk is to mark the collateral to market on a regular basis. When market value changes by a certain percentage, the repo position is adjusted accordingly. Suppose that a dealer firm has borrowed $20 million using collateral with a market value of $20.4 million. The margin is 2%. Suppose further that the market value of the collateral drops to $20.1 million. A repo agreement can specify either (1) a margin call or (2) repricing of the repo. In the case of a margin call, the dealer firm is required to put up additional collateral with a market value of $300,000 to bring the margin up to $400,000. If repricing is agreed on, the principal amount of the repo will be changed from $20 million to $19.7 million (the market value of $20.1 million divided by 1.02). The dealer would then send the customer $300,000.

One concern in structuring a repo is delivery of the collateral to the lender. The most obvious procedure is for the borrower to deliver the collateral to the lender. At the end of the repo term, the lender returns the collateral to the borrower in exchange for the principal and interest payment. This procedure may be too costly, though, particularly for short-term repos, because of the costs associated with delivering the collateral. The cost of delivery would be factored into the transaction by a lower repo rate offered by the borrower. The risk of the lender not taking possession of the collateral is that the borrower may sell the security or use the same security as collateral for a repo with another party.

As an alternative to delivering the collateral, the lender may agree to allow the borrower to hold the security in a segregated customer account. Of course, the lender still faces the risk that the borrower uses the collateral fraudulently by offering it as collateral for another repo transaction.

Another method is for the borrower to deliver the collateral to the lender's custodial account at the borrower's clearing bank. The custodian then has possession of the collateral that it holds on behalf of the lender. This practice reduces the cost of delivery because it is merely a transfer within the borrower's clearing bank. If, for example, a dealer enters into an overnight repo with customer A, the next day the collateral is transferred back to the dealer. The dealer can then enter into a repo with customer B for, say, five days without having to redeliver the collateral. The clearing bank simply establishes a custodian account for customer B and holds the collateral in that account.

There have been a number of well-publicized losses by nondealer institutional investors—most notably Orange County, California—that have resulted from the use of repurchase agreements. Such losses did not occur as a result of credit risk. Rather, it was the use of repos to make a leverage bet on the movement of interest rates. That is, the repo was not used as a money market instrument but as a leveraging vehicle. This can be accomplished by mismatching the maturity of repos and reverse repos. For example, if one has a view that rates will rise, one could borrow money via a term repo (say, three months) and lend money overnight. Conversely, if rates are expected to fall, one could reverse the maturity

mismatch. Leverage can be increased many times if market participants are able to borrow and lend a single piece of collateral multiple times.

Participants in the Market

Because it is used by dealer firms (investment banking firms and money center banks acting as dealers) to finance positions and cover short positions, the repo market has evolved into one of the largest sectors of the money market. Financial and nonfinancial firms participate in the markets as both sellers and buyers, depending on the circumstances they face. Thrifts and commercial banks are typically *net sellers* of collateral (i.e., net borrowers of funds); money market funds, bank trust departments, municipalities, and corporations are typically *net buyers* of collateral (i.e., providers of funds).

Although a dealer firm uses the repo market as the primary means for financing its inventory and covering short positions, it also will use the repo market to run a matched book, where it takes on repos and reverse repos with the same maturity. The firm will do so to capture the spread at which it enters into the repo and reverse repo agreement. For example, suppose that a dealer firm enters into a term repo of 10 days with a money market fund and a reverse repo rate with a thrift for 10 days in which the collateral is identical. This means that the dealer firm is borrowing funds from the money market fund and lending money to the thrift. If the rate on the repo is 0.30% and the rate on the reverse repo is 0.35%, the dealer firm is borrowing at 0.30% and lending at 0.35%, locking in a spread of 0.05% (5 basis points).

Another participant is the repo broker. To understand the role of the repo broker, suppose that a dealer firm has shorted $50 million of a security. It will then survey its regular customers to determine if it can borrow via a reverse repo the security it shorted. Suppose that it cannot find a customer willing to do a repo transaction (repo from the customer's point of view, reverse repo from the dealer's). At that point, the dealer firm will use the services of a repo broker. When the collateral is difficult to acquire, it is said to be "on special."

The Fed and the Repo Market

The Federal Reserve influences short-term interest rates through its open market operations—that is, by the outright purchase or sale of government securities. This is not the common practice followed by the Fed, however. It uses the repo market instead to implement monetary policy by purchasing or selling collateral. By buying collateral (i.e., lending funds), the Fed injects money into the financial markets, thereby exerting downward pressure on short-term interest rates. When the Fed buys collateral for its own account, this is called a *system repo.* The Fed also buys collateral on behalf of foreign central banks in repo transactions that are called *customer repos.* It is primarily through system repos that the Fed attempts to influence short-term rates. By selling securities for its own account, the Fed drains money from the financial markets, thereby exerting upward pressure on short-term interest rates. This transaction is called a *matched sale.*

Note the language that is used to describe the transactions of the Fed in the repo market. When the Fed lends funds based on collateral, we call it a *system* or *customer repo,* not a reverse repo. Borrowing funds using collateral is called a *matched sale,* not a repo. The jargon is confusing, which is why we used the terms of *buying collateral* and *selling collateral* to describe what parties in the market are doing.

Determinants of the Repo Rate

There is no one repo rate; rates vary from transaction to transaction depending on several factors:

Quality. The higher the credit quality and liquidity of the collateral, the lower is the repo rate.

Term of the repo. The effect of the term of the repo on the rate depends on the shape of the yield curve.

Delivery requirement. As noted earlier, if delivery of the collateral to the lender is required, the repo rate will be lower. If the collateral can be deposited with the bank of the borrower, a higher repo rate is paid.

Availability of collateral. The more difficult it is to obtain the collateral, the lower is the repo rate. To understand why this is so, consider the case when the borrower (or equivalently, the seller of the collateral) has a security that is a hot or special issue. The party that needs the collateral will be willing to lend funds at a lower repo rate to obtain the collateral.

These factors determine the repo rate on a particular transaction; the federal funds rate discussed below determines the general level of repo rates. The repo rate will be a rate below the federal funds rate. The reason is that a repo involves collateralized borrowing, whereas a federal funds transaction is unsecured borrowing.

FEDERAL FUNDS

The rate determined in the federal funds market is the major factor that influences the rate paid on all the other money market instruments described in this chapter. When the Federal Reserve formulates and executes monetary policy, it sets a target level for the federal funds rate. Announcements of changes in monetary policy specify the changes in the Fed's target for this rate. The Federal Reserve influences the level of the federal funds rate through open market operations.

Depository institutions (commercial banks and thrifts) are required to maintain reserves. The reserves are deposits at their district Federal Reserve Bank, which are called federal funds. The level of the reserves that a bank must maintain is based on its average daily deposits over the previous 14 days. Of all depository institutions, commercial banks are by far the largest holders of federal funds.

No interest is earned on federal funds. Consequently, a depository institution that maintains federal funds in excess of the amount required incurs an opportunity cost—the loss of interest income that could be earned on the excess reserves. At the same time, there are depository institutions whose federal funds are less than the amount required. Typically, smaller banks have excess reserves, whereas money center banks find themselves short of reserves and must make up the shortfall. Banks maintain federal funds desks whose managers are responsible for the bank's federal funds position.

One way that banks with less than the required reserves can bring reserves to the required level is to enter into a repo with a nonbank customer. An alternative is for the bank to borrow federal funds from a bank that has excess reserves. The market in which federal funds are bought (borrowed) by banks that need these funds and sold (lent) by banks that have excess federal funds is called the *federal funds market.* The equilibrium interest rate, which is determined by the supply and demand for federal funds, is the *federal funds rate.*

The federal funds rate and the repo rate are tied together because both are a means for a bank to borrow. The federal funds rate is higher because the lending of federal funds is done on an unsecured basis; this differs from the repo, in which the lender has a security as collateral. The spread between the two rates varies depending on market conditions; typically, the spread is approximately 25 basis points.

The term of most federal funds transactions is overnight, but there are longer-term transactions that range from one week to six months. Trading typically takes place directly between the buyer and seller—usually between a large bank and one of its correspondent banks. Some federal funds transactions require the use of a broker.

KEY POINTS

- The money market is comprised of debt instruments with original maturities of one year or less.
- Commercial paper is a short-term unsecured promissory note issued in the open market as an obligation of the issuing entity.
- A bankers acceptance is a debt instrument used to facilitate a commercial trade transaction.
- A certificate of deposit is issued by a financial institution that indicates that a specified sum of money has been deposited at the issuing depository institution.
- A repurchase agreement is the sale of a security with a commitment by the seller to buy the security back from the purchaser at a specified price on a designated future date.
- Federal funds are deposits held by depository institutions at their district Federal Reserve Banks.

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CHAPTER
SEVENTEEN

FLOATING-RATE SECURITIES

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

STEVEN V. MANN, PH.D.
Professor of Finance
Moore School of Business
University of South Carolina

Under the rubric of floating-rate securities or simply *floaters,* there are several different types of securities with an essential feature in common: coupon interest will vary over the instrument's life. Floaters, which were first introduced into the European debt market and issued in the United States in the early 1970s, are now issued in every sector of the bond market—government, agency, corporate, municipal, mortgage, and asset-backed—in the United States and in markets throughout the world. Although a floater's coupon formula may depend on a wide variety of economic variables (e.g., foreign exchange rates or commodity prices), a floater's coupon payments usually depend on the level of a money market interest rate (e.g., the London Interbank Offer Rate, or LIBOR, Treasury bills). A floater's coupon rate can be reset semiannually, quarterly, monthly, or weekly. The term *adjustable rate* or *variable rate* typically refers to securities with coupon rates reset not more than annually or based on a longer-term interest rate. However, this is a distinction without a difference, and we will refer to both floating-rate securities and adjustable-rate securities as "floaters."

In this chapter we will discuss the general features of floaters and present some illustrations of the major product types. Most market participants use "spread" or margin measures (e.g., adjusted simple margin or discount margin) to assess the relative value of a floater. We will briefly describe these measures and note their limitations. Finally, we discuss several popular portfolio strategies that employ floaters.

Parts of this chapter are adapted from Frank J. Fabozzi and Steven V. Mann, *Floating-Rate Securities* (New Hope, PA: Frank J. Fabozzi Associates, 2000).

GENERAL FEATURES OF FLOATERS AND MAJOR PRODUCT TYPES

A floater is a debt security whose coupon rate is reset at designated dates based on the value of some designated reference rate. The coupon formula for a pure floater (i.e., a floater with no embedded options) can be expressed as follows:

$$\text{Coupon rate} = \text{reference rate} \pm \text{quoted margin}$$

The quoted margin is the adjustment (in basis points) that the issuer agrees to make to the reference rate. For example, consider a floating-rate note issued in September 2007 by Bank of America that matured on September 11, 2011. This floater delivered cash flows quarterly and had a coupon formula equal to three-month LIBOR plus 12 basis points.

As noted, the reference rate is the interest rate or index that appears in a floater's coupon formula, and it is used to determine the coupon payment on each reset date within the boundaries designated by embedded caps and/or floors. The four most common reference rates are LIBOR, Treasury bill yields, prime rates, and domestic CD rates, and they appear in the coupon formulas of a wide variety of floating-rate products. Other reference rates are used in more specialized markets such as the markets for mortgage-backed securities and the municipal market. For example, the most common reference rates for adjustable-rate mortgages (ARMs) or collateralized mortgage obligation (CMO) floaters include (1) the one-year Constant Maturity Treasury Rate (i.e., one-year CMT), (2) the 11th District Cost of Funds (COFI), (3) the six-month LIBOR, and (4) the National Monthly Median Cost of Funds Index. In the municipal market, the reference rate for floaters is often a Treasury rate or the prime rate. Alternatively, the reference rate could be a municipal index. Three popular municipal indexes are the J. J. Kenney Index, the Bond Buyer 40 Bond Index, and the Merrill Lynch Municipal Securities Index.[1]

A floater often imposes limits on how much the coupon rate can float. Specifically, a floater may have a restriction on the maximum coupon rate that will be paid on any reset date. This is called a *cap*. Consider a floater issued by Federal Home Bank that matured on October 20, 2006. The coupon formula was three-month LIBOR plus 75 basis points with a cap of 3.75%. If the three-month LIBOR at a coupon date reset was 3.25%, then the coupon formula would suggest the new coupon rate would be 4%. However, the cap restricted the maximum coupon rate to 3.75%. Needless to say, a cap is an unattractive feature from the investor's perspective.

In contrast, a floater also may specify a minimum coupon rate called a *floor*. Suppose a floater delivers quarterly coupon payments with a coupon formula of the three-month LIBOR plus 12.5 basis points with a floor of 4.25%. Thus, if the three-month LIBOR ever fell below 4.125%, the coupon rate would remain at 4.25%.

1. For a detailed description of each of these reference rates, see Frank J. Fabozzi and Steven V. Mann, *Floating Rate Securities* (New Hope, PA: Frank J. Fabozzi Associates, 2000).

A floor is an attractive feature from the investor's perspective. When a floater possesses both a cap and a floor, this feature is referred to as a *collar*. Thus a collared floater's coupon rate has a maximum and a minimum value.

While a floater's coupon rate typically moves in the same direction as the reference rate, there are floaters whose coupon rate changes in the opposite direction from the change in the reference rate. These floaters are referred to as *inverse floaters* or *reverse floaters*. A general formula for an inverse floater is

$$K - L \times (\text{reference rate})$$

From the formula, it is easy to see that as the reference rate goes up (down), the coupon rate goes down (up). As an example, consider an inverse floater issued by a large bank. This issue delivered quarterly coupon payments according to the formula

$$18\% - 2.5 \times (\text{three-month LIBOR})$$

In addition, this inverse floater has a floor of 3% and a cap of 15.5%. Note that for this inverse floater, the value for L (called the *coupon leverage*) in the coupon reset formula is 2.5. Assuming that neither the cap rate nor the floor rate are binding, this means that for every one basis point change in the three-month LIBOR, the coupon rate changes by 2.5 basis points in the opposite direction.[2]

There is a wide variety of floaters that have special features that may appeal to certain types of investors. For example, some issues provide for a change in the quoted margin (i.e., the spread added to or subtracted from the reference in the coupon reset formula) at certain intervals over a floater's life. These issues are called *stepped-spread floaters* because the quoted margin can either step to a higher or lower level over time. Consider Abu Dhabi Commercial Bank's floater due in May 2016. From its issuance in May 2006 until May 2011, the coupon formula was 3-month LIBOR plus 60 basis points. Thereafter, until maturity, the quote margin "steps up" to 90 basis points.

A *range note* is a floater where the coupon payment depends on the number of days that the specified reference rate stays within a preestablished collar. For instance, Barclay's Bank issued a range note in November 2006 (due in November 2016). For every day during the quarter that the three-month LIBOR was between 3% and 9%, the investor earned the three-month LIBOR plus 155 basis points. Interest would accrue at 0% for each day that the three-month LIBOR was outside this collar.

There are also floaters whose coupon formula contains more than one reference rate. A *dual-indexed floater* is one such example. The coupon rate formula is typically a fixed percentage plus the difference between two reference rates. For example, Swedbank Hypotek issued a floater that matures in August 2015 whose coupon formula is the following:

$$20 \text{ year yen swap rate} - 2 \text{ year yen swap rate} + 40 \text{ basis points.}$$

In addition, the issue has a floor of 0.1%.

2. When L is greater than 1, the security is referred to as a *leveraged inverse floater*.

Although the reference rate for most floaters is an interest rate or an interest-rate index, numerous kinds of reference rates appear in coupon formulas. This is especially true for structured notes. Potential reference rates include movements in foreign exchange rates, the price of a commodity (e.g., gold), movements in an equity index (e.g., the Standard & Poor's 500 Index), or an inflation index (e.g., CPI). Financial engineers are capable of structuring floaters with almost any reference rate. For example, in March 1996, the Federal Home Loan Bank issued a structured note with the seven-year swap rate as the reference rate in the coupon formula. Specifically, this inverse floater makes semiannual coupon payments using the following formula:

$$2.5 \times (9.219\% - \text{7-year swap rate})$$

This issue has a floor of 0%.

CALL AND PUT PROVISIONS

Just like fixed-rate issues, a floater may be *callable.* The call option gives the issuer the right to buy back the issue prior to the stated maturity date. The call option may have value to the issuer some time in the future for two basic reasons. First, market interest rates may fall so that the issuer can exercise the option to retire the floater and replace it with a fixed-rate issue. Second, the required margin decreases so that the issuer can call the issue and replace it with a floater with a lower quoted margin.[3] The issuer's call option is a disadvantage to the investor because the proceeds received must be reinvested either at a lower interest rate or a lower margin. Consequently, an issuer who wants to include a call feature when issuing a floater must compensate investors by offering a higher quoted margin.

For amortizing securities (e.g., mortgage-backed and some asset-backed securities) that are backed by loans that have a schedule of principal repayments, individual borrowers typically have the option to pay off all or part of their loan prior to the scheduled date. Any additional principal repayment above the scheduled amount is called a *prepayment.* The right of borrowers to prepay is called the *prepayment option.* Basically, the prepayment option is analogous to a call option. However, unlike a call option, there is not a call price that depends on when the borrower pays off the issue. Typically, the price at which a loan is prepaid is its par value.

Floaters also may include a *put provision* that gives the security holder the option to sell the security back to the issuer at a specified price on designated dates. The specified price is called the *put price.* The put's structure can vary across issues. Some issues permit the holder to require the issuer to redeem the issue on any coupon payment date. Others allow the put to be exercised only

3. The required margin is the spread (either positive or negative) the market requires as compensation for the risks embedded in the issue. If the required margin equals the quoted margin, a floater's price will be at par on coupon reset dates.

when the coupon is adjusted. The time required for prior notification to the issuer or its agent varies from as little as four days to as long as a couple of months. The advantage of the put provision to the holder of the floater is that if after the issue date the margin required by the market for a floater to trade at par rises above the issue's quoted margin, the investor can force the issuer to redeem the floater at the put price and then reinvest the proceeds in a floater with the higher quoted margin.

SPREAD MEASURES

There are several yield spread measures or margins that are used routinely to evaluate floaters. The four margins commonly used are spread for life, adjusted simple margin, adjusted total margin, and discount margin. All these spread measures are available on Bloomberg's Yield Analysis (YA) screen.

Spread for Life

When a floater is selling at a premium/discount to par, a potential buyer of a floater will consider the premium or discount as an additional source of dollar return. *Spread for life* (also called *simple margin*) is a measure of potential return that accounts for the accretion (amortization) of the discount (premium) as well as the constant index spread over the security's remaining life.

Adjusted Simple Margin

The *adjusted simple margin* (also called *effective margin*) is an adjustment to spread for life. This adjustment accounts for a one-time cost-of-carry effect when a floater is purchased with borrowed funds. Suppose that a security dealer has purchased $10 million of a particular floater. Naturally, the dealer has a number of alternative ways to finance the position—borrowing from a bank, repurchase agreement, etc. Regardless of the method selected, the dealer must make a one-time adjustment to the floater's price to account for the cost of carry from the settlement date to next coupon reset date.

Adjusted Total Margin

The *adjusted total margin* (also called *total adjusted margin*) adds one additional refinement to the adjusted simple margin. Specifically, the adjusted total margin is the adjusted simple margin plus the interest earned by investing the difference between the floater's par value and the carry-adjusted price.[4]

4. When the floater's adjusted price is greater than 100, the additional increment is negative and represents the interest foregone.

Discount Margin

One common method of measuring potential return that employs discounted cash flows is *discount margin.* This measure indicates the average spread or margin over the reference rate the investor can expect to earn over the security's life given a particular assumed path that the reference rate will take to maturity. The assumption that the future levels of the reference rate are equal to today's level is the current market convention. The procedure for calculating the discount margin is as follows:

1. Determine the cash flows assuming that the reference rate does not change over the security's life.
2. Select a margin (i.e., a spread above the reference rate).
3. Discount the cash flows found in (1) by the current value of the reference rate plus the margin selected in (2).
4. Compare the present value of the cash flows as calculated in (3) with the price. If the present value is equal to the security's price, the discount margin is the margin assumed in (2). If the present value is not equal to the security's price, go back to (2) and select a different margin.

For a floater selling at par, the discount margin is simply the quoted margin. Similarly, if the floater is selling at a premium (discount), then the discount margin will be below (above) the quoted margin.

Practitioners use the spread measures presented above to gauge the potential return from holding a floater. Much like conventional yield measures for fixed income securities, the yield or margin measures discussed here are, for the most part, relatively easy to calculate and interpret. However, these measures reflect relative value only under several simplifying assumptions (e.g., reference rates do not change).

One of the key difficulties in using the measures described in this chapter is that they do not recognize the presence of embedded options. As discussed, there are callable/putable floaters and floaters with caps and/or floors. However, the recognition of embedded options is critical to valuing floaters properly. If an issuer can call an issue when presented with the opportunity and refund at a lower spread, the investor must then reinvest at the lower spread. With this background, it should not be surprising that sophisticated practitioners value floaters using arbitrage-free binomial interest rate trees and Monte Carlo simulations. These models are designed to value securities whose cash flows are interest-rate-dependent.

PRICE VOLATILITY CHARACTERISTICS OF FLOATERS

The change in the price of a fixed-rate security when market rates change occurs because the security's coupon rate differs from the prevailing rate for new comparable bonds issued at par. Thus an investor in a 10-year, 7% coupon bond purchased at par, for example, will find that the bond's price will decline below par if the

market requires a yield greater than 7% for bonds with the same risk and maturity. By contrast, a floater's coupon resets periodically, thereby reducing its sensitivity to changes in rates. For this reason, floaters are said to be more "defensive" securities. This does not mean, of course, that a floater's price will not change.

Factors That Affect a Floater's Price

A floater's price will change depending on the following factors:

1. Time remaining to the next coupon reset date
2. Changes in the market's required margin
3. Whether or not the cap or floor is reached

We will discuss the impact of each of these factors in the following sections.

Time Remaining to the Next Coupon Reset Date

The longer the time to the next coupon reset date, the more a floater behaves like a fixed-rate security, and the greater is a floater's potential price fluctuation. Conversely, the shorter the time between coupon reset dates, the smaller is the floater's potential price fluctuation.

To understand why this is so, consider a floater with five years remaining to maturity whose coupon formula is the one-year Treasury rate plus 50 basis points, and the coupon is reset today when the one-year Treasury rate is 5.5%. The coupon rate will remain at 6% for the year. One month hence, an investor in this floater effectively would own an 11-month instrument with a 6% coupon. Suppose that at that time the market requires a 6.2% yield on comparable issues with 11 months to maturity. Then our floater would be offering a below-market rate (6% versus 6.2%). The floater's price must decline below par to compensate the investor for the submarket yield. Similarly, if the yield that the market requires on a comparable instrument with a maturity of 11 months is less than 6%, the floater will trade at a premium. For a floater in which the cap is not binding and for which the market does not demand a margin different from the quoted margin, a floater that resets daily will trade at par.

Changes in the Market's Required Margin

At the initial offering of a floater, the issuer will set the quoted margin based on market conditions so that the security will trade near par. Subsequently, if the market requires a higher/lower margin, the floater's price will decrease/increase to reflect the current margin required. We shall refer to the margin that is demanded by the market as the "required margin." For example, consider a floater whose coupon formula is the one-month LIBOR plus 40 basis points. If market conditions change such that the required margin increases to 50 basis points, this floater would be offering a below-market margin. As a result, the floater's price will decline below par value. By the same token, the floater will trade above its par value if the required margin is less than the quoted margin—less than 40 basis points in our example.

The required margin for a particular issue depends on (1) the margin available in competitive funding markets, (2) the credit quality of the issue, (3) the presence of any embedded call or put options, and (4) the liquidity of the issue. An alternative source of funding to floaters is a syndicated loan. Consequently, the required margin will be driven, in part, by margins available in the syndicated loan market.

The portion of the required margin attributable to credit quality is referred to as the "credit spread." The risk that there will be an increase in the credit spread required by the market is called *credit-spread risk*. The concern for credit-spread risk applies not only to an individual issue but also to a sector or the economy as a whole. For example, credit spreads may increase due to a financial crisis (e.g., a stock market crash) while the individual issuer's condition and prospects remain essentially unchanged.

A portion of the required margin reflects the call risk if the floater is callable. Because the call feature imposes hazards on the investor, the greater the call risk, the higher is the quoted margin at issuance, other things equal. After issuance, depending on how interest rates and required margins change, the perceived call risk and the margin required as compensation for this risk will change accordingly. In contrast to call risk owing to an embedded call option, a put provision provides benefits to the investor. If a floater is putable at par, all else the same, its price should trade at par near the put date.

Finally, a portion of the quoted margin at issuance will reflect the issue's perceived liquidity. *Liquidity risk* is the threat of an increase in the required margin due to a perceived deterioration in an issue's liquidity. Investors in nontraditional floater products are particularly concerned with liquidity risk.

Whether or Not the Cap or Floor Is Reached

For a floater with a cap, once the coupon rate as specified by the coupon formula rises above the cap rate, the floater then offers a below-market coupon rate, and the floater will trade at a discount. The floater will trade more and more like a fixed-rate security the further the capped rate is below the prevailing market rate. Simply put, if a floater's coupon rate does not float, it is effectively a fixed-rate security. *Cap risk* is the risk that the floater's value will decline because the cap is reached.

The situation is reversed if the floater has a floor. Once the floor is reached, all else equal, the floater will trade either at par value or at a premium to par if the coupon rate is above the prevailing rate offered for comparable issues.

Duration of Floaters

We have just described how a floater's price will respond to a change in the required margin, holding all other factors constant. As explained in Chapter 7, the measure used by market participants to quantify the sensitivity of a security's price to changes in interest rates is called *duration*. A security's duration

tells us the approximate percentage change in its price for a 100 basis point change in rates. The procedure of computing a security's duration was explained in Chapter 7.

Two measures are employed to estimate a floater's sensitivity to each component of the coupon formula. *Index duration* is a measure of the floater's price sensitivity to changes in the reference rates holding the quoted margin constant. Correspondingly, *spread duration* measures a floater's price sensitivity to a change in the "quoted margin" or "spread" assuming the reference rate remains unchanged.

Price Volatility of an Inverse Floater

An inverse floater can be created by acquiring a fixed-rate security and splitting it into a floater and an inverse floater. The fixed-rate security from which the floater and inverse floater are created is called the *collateral*. The interest paid to the floater investor and inverse floater investor must be such that it is equal to the interest rate paid on the collateral.

Because valuations are additive (i.e., the value of the collateral is the sum of the floater and inverse floater values), durations (properly weighted) are additive as well. Accordingly, the duration of the inverse floater is related in a particular fashion to the duration of the collateral and the duration of the floater. Specifically, the duration of an inverse floater will be a multiple of the duration of the collateral from which it is created.

To understand this, suppose that a 30-year fixed-rate bond with a market value of $100 million is split into a floater and an inverse floater with market values of $80 million and $20 million, respectively. Assume also that the duration of the collateral (i.e., the 30-year fixed-rate bond) is 8. Given this information, we know that for a 100 basis point change in required yield the collateral's value will change by approximately 8%, or $8 million (8% times $100 million). Since the floater and inverse floater are created from the collateral, the combined change in value of the floater and the inverse floater must be $8 million for a 100 basis point change in required yield. The question becomes how do we partition the change in value between the floater and inverse floater. If the duration of the floater is small, as explained earlier, then the inverse floater must experience the full force of the $8 million change in value. For this to occur, the duration of the inverse floater must be approximately 40. A duration of 40 will mean a 40% change in the inverse floater's value for a 100 basis point change in required yield and a change in value of approximately $8 million (40% times $20 million).

Effectively, the inverse floater is a leveraged position in the collateral. That is, ownership of an inverse floater is equivalent to buying the collateral and funding it on a floating-rate basis, where the reference rate for the borrowing is equal to the reference rate for the inverse floater. Accordingly, the duration of the inverse floater is a multiple of the duration of the collateral.

PORTFOLIO STRATEGIES

Several portfolio strategies have been employed using floaters. These include (1) basic asset/liability management strategies, (2) risk arbitrage strategies, (3) betting on changes in the required margin, and (4) arbitrage between fixed- and floating-rate markets using asset swaps. We will briefly describe each of these strategies in turn.

Asset/liability management strategies can be explained most easily using depository institutions. These institutions typically borrow short term, and their objective is to lock in a spread over their short-term funding costs. Not surprisingly, one obvious way to accomplish this objective is to invest in floating-rate products. Naturally, this strategy is not without risks. The floater's coupon rate likely will be capped, whereas the short-term funding may not be. This is known as *cap risk*. Further, the floater's reference rate may not be the same as the reference rate for funding. If this is the case, the institution is exposed to *basis risk*.

Risk arbitrage strategies using floaters are not arbitrage in the true sense of the term. One example of this type of strategy involves money managers using leverage (via repurchase agreements) to invest in agency adjustable-rate passthrough securities that earn a higher spread over their borrowing rate. Of course, this is not a "risk free" transaction. Like before, the manager likely will be exposed to cap risk if the floater's coupon is capped while the funding rate is not. The manager also may be exposed to basis risk if the two reference rates are mismatched. Finally, there is *price risk* if the floater's risk changes for the worse, and the floater must be sold prior to maturity. In this case, the quoted margin will no longer compensate the investor for the security's risks, and the floater will sell at a discount to par. No serious investor believes that a risk arbitrage strategy is a reliable source of spread income.

Investors also can speculate on whether a floater's required margin will change. When a floater is issued, the quoted margin contained in the coupon formula will be set so that the floater will be priced at or near par. After the floater enters the secondary market, the quoted margin for a standard floater does not change. Thus, if the floater's risk does not change and the compensation demanded by the market does not change either, the floater's price will be par on every coupon reset date. In this case, the quoted margin offered by the security and quoted margin required by the market (called the *required margin*) are the same. If conditions change such that the required spread is greater than (less than) the quoted margin, the floater will trade at discount (premium) to par. Given this background, one obvious strategy money managers pursue is betting on a change in the required margin for a single issue or a sector.

Lastly, some money managers arbitrage between floaters and fixed-rate securities using a so-called asset swap. An asset-based swap transaction involves the creation of synthetic security via the purchase of an existing security and the simultaneous execution of a swap.

KEY POINTS

- A floater is a debt security whose coupon rate is reset at designated dates based on the value of some designated reference rate. The coupon formula for a floater with no embedded options is the reference rate plus or minus the quoted margin.
- Typically a floater imposes a cap or maximum interest coupon rate; a floater also may specify a floor or minimum coupon. A collared floater has both a cap and a floor.
- Inverse floaters or reverse floaters are floaters whose coupon rate moves in the opposite direction from the change in the reference rate.
- The different types of floaters include stepped-spread floaters, range notes, and dual-indexed floaters. Although the reference rate for most floaters is an interest rate or an interest rate index, numerous kinds of reference rates appear in coupon formulas.
- A floater may be callable or prepayment. Floaters also may include a put provision.
- Yield spread measures or margins that are commonly used routinely to evaluate floaters are spread for life, adjusted simple margin, adjusted total margin, and discount margin.
- The price of a floater depends on (1) the time remaining to the next coupon reset date, (2) changes in the market's required margin, and (3) whether or not the cap or floor is reached.
- Index duration is a measure of the floater's price sensitivity to changes in the reference rates holding the quoted margin constant. Spread duration measures a floater's price sensitivity to a change in the "quoted margin" or "spread" assuming the reference rate remains unchanged.
- An inverse floater is effectively a leveraged position in the collateral because the position is economically equivalent to buying the collateral and funding it on a floating-rate basis, where the reference rate for the borrowing is equal to the reference rate for the inverse floater.
- The duration of an inverse floater is a multiple of the duration of the collateral.
- Portfolio strategies using floaters include (1) basic asset/liability management strategies, (2) risk arbitrage strategies, (3) betting on changes in the required margin, and (4) arbitrage between fixed- and floating-rate markets using asset swaps.

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CHAPTER
EIGHTEEN

INFLATION-LINKED BONDS

JOHN B. BRYNJOLFSSON, CFA
Managing Director and CIO
Armored Wolf, LLC

Inflation is the key driver of investment performance. It determines how much each dollar of return is worth, and it dictates asset returns themselves. Consider the 17-year period from 1983 to 2000, a period marked by falling inflation. Falling raw materials prices allowed corporate margins to expand. Simultaneously, falling interest rates had a positive impact on the price-to-earnings multipliers being applied to those expanded corporate earnings. The result was doubly explosive equity returns. For different reasons, the inflation-adjusted returns of bonds and cash similarly were favorably affected by falling inflation during this period. The opposite happens during bouts of rising inflation. The 17-year inflationary period from 1966 to 1983 represented one of the worst investment climates in modern history for equities, bonds, and cash.

In the late 1990s, investors found a weapon that effectively offsets this threat to stable and predictable investment returns—and that weapon and its incorporation into twenty-first century fixed income markets is the subject matter of this chapter.

Treasury Inflation-Protected Securities (TIPS)[1] are bonds that promise to protect and grow investors' purchasing power. The U.S. Treasury delivers on this promise by adjusting the principal of TIPS based on changes in the consumer price index (CPI).[2] It repays the bondholders' principal in an amount that exactly maintains the purchasing power of their original investment, as

I wish to thank my clients, colleagues, industry contacts, and many friends for their contributions, insight, and support.

1. United States Secretary of the Treasury Robert Rubin coined the term *TIPS* in 1996, before the official launch of "Treasury Inflation-Indexed Securities" (TIIS) in January 1997. Market participants have gravitated to a generic use of the acronym *TIPS* to refer to all forms of inflation-linked bonds, singular and plural. For clarity, this chapter will do the same. Other terms sometimes used to describe this class of bonds include *inflation-linked bonds, IPBS, TIIS, linkers,* and *real-return bonds.*
2. The Bureau of Labor Statistics, an independent economics-oriented agency of the U.S. Department of Labor, is responsible for gathering and reporting price changes at the consumer level. The CPI series used to calculate TIPS is the non-seasonally adjusted Consumer Price Index for all Urban Consumers (CPI-U) or more simply the CPI used to calculate "headline inflation." See the discussion about the CPI later in this chapter.

EXHIBIT 18–1

Schematic Cash Flow of TIPS

	Purchase	First Annual Coupon	Interim Annual Coupon	Last Annual Coupon	Principal	Return (per Annum) %
Date	1/15/Year 0	1/15/Year 1	1/15/Year 5	1/15/Year 10	1/15/Year 10	1/15/Year 10
Real $ Cash Flow	(1,000)	20.00	20.00	20.00	1,000	2.00
CPI (Base = 200)	200.0	206.0	231.8	268.7	268.7	3.00
Indexed Principal	1,000	1,030	1,159	1,343	1,343	(na)
Nominal $ Cash Flow	(1,000)	20.60	23.18	26.87	1343.50	5.06

defined by the CPI. In addition, the U.S. Treasury pays interest in an amount that also maintains the purchasing power of the stream of semiannual interest payments by calculating coupon payments based on the CPI-indexed principal amounts. (See Exhibit 18–1.)

The U.S. Treasury launched the TIPS program in 1997, and through the end of the first quarter of 2011 had outstanding over $513 billion of the securities according to Bloomberg Financial. According to the Securities Industry and Financial Markets Association, during the first two months of 2011, an average of $8 billion of these securities traded each day. Since the 1940s, at least 15 governments and numerous corporations have issued similarly structured securities. In the United Kingdom, inflation-indexed securities account for more than 20% of government bonds outstanding. For clarity, we will focus our discussion on the U.S. Treasury TIPS and introduce substantive differences of other TIPS where appropriate.

TIPS are best known as a defensive hedge against the fear of inflation, but they offer tactical and strategic advantages as well. Tactically, investors are attracted to the opportunity TIPS afford to speculate on changes in inflation and real interest rates. Strategically, individual and institutional investors with long-term objectives are attracted to TIPS fixed real yield, low correlation to traditional financial assets, and muted volatility. They sense TIPS will help them to achieve their long-term investment goals and reduce risk in the process.

The unique characteristics of TIPS qualify them as a fundamental asset class, as are equities, traditional bonds, and cash. TIPS have relatively high correlation with one-another and modest or negative correlation with other asset classes. As a whole, they form a large, investable, and easily benchmarked universe.

In addition to TIPS' correlative appeal, their novelty and scope, just a decade and a half after their introduction into the U.S., can attest to their importance as an investment instrument. This chapter has two goals; the first and most important is to expose market participants to this important often not well understood investment instrument. The second is to provide portfolio managers with a comprehensive examination of the investment qualities that make TIPS unique.

We begin with the mechanics of TIPS cash flows. We explore real yield and real duration, two measures that are analogous to a nominal bond's yield to maturity and effective duration. The marketplace section narrates a brief history of TIPS, including their trading characteristics. The valuation and performance section presents a framework and evaluates the TIPS market through mid 2011 in the context of that framework. The investors section discusses how professional managers and institutions are using TIPS within portfolios and in asset/liability management. The issuers section introduces the suppliers of TIPS and explains why they use the prevailing structures. We then address common investor concerns, specifically on taxes and deflation.

MECHANICS AND MEASUREMENT

How TIPS Work

The merit of TIPS is that while the principal and interest repaid to investors fluctuates based on the level of the CPI, the purchasing power of each payment is fixed. As a consequence, the *real yield* of TIPS (the growth in purchasing power that a hold-to-maturity investor will earn) is fixed. The assumptions corresponding to Exhibit 18–1 are described below:

- Issuance date of January 15 of Year 1
- Issuance price of $100.00
- 10-year maturity
- 2% real coupon paid annually,
- 3% annualized inflation rate, and
- $1000 original face

If the CPI for the TIPS issuance date is 200.0 and the CPI for a coupon date one year later is 206.0, year-over-year inflation would be reported as 3.00%. The TIPS' adjusted principal would be 1.03 times its original value, or $1,030 per $1,000 of "original face."

This indexed principal is used to calculate the coupon paid. In other words, the Treasury calculates the amount of each coupon payment, *after the principal has been adjusted for inflation.* This exhibit shows that the compounding effect of a 2% real coupon with a 3% inflation rate results in a *nominal* cash-flow annualized return of 5.06%.

The calculations of actual Treasury TIPS cash flows and returns are only somewhat more complicated. TIPS pay interest semiannually at one-half their stated annual coupon rate. The inflation-indexed principal is accrued daily, based on a straight-line interpolation between the two most recent monthly CPI figures reported prior to the settlement month. And lastly, Treasury uses a rather arcane rounding procedure for interim and final calculations.

The Consumer Price Index (CPI)

The specific CPI series used for TIPS indexation is the Non-Seasonally Adjusted, All-Urban Consumer Price Index (NSA CPI-U), and it is reported monthly. Unlike the seasonally adjusted series, the NSA CPI-U is not subject to revision. One consequence of using the NSA CPI-U is that the series includes predictable seasonal fluctuations in inflation. For example, each December when inflation typically is muted by year-end price cutting and inventory liquidations, the NSA CPI-U index tends to fall slightly below its trend growth rate, whereas in certain other months it tends to rise slightly above the underlying trend.

The CPI report that measures the price level in a given month, for example, May, typically is reported on or near the 15th of the following month, in this case June. The two-week hiatus between June 15 and July 1 when the TIPS accruals begin allows for potential delays in the official release of the CPI and eliminates the need to calculate day counts across month-end. The last daily accrual occurs on July 31, about seven weeks after the CPI is reported. Thus the May CPI is fully incorporated into the August 1 TIPS principal.

This relatively quick 15-day turnaround of CPI reports into TIPS indexation is often described as a three-month lag because the May (month 5) CPI is fully incorporated into the TIPS by August 1 (month 8). To calculate the TIPS principal for any settlement date other than the first of a month, for example, July 10, calculate as follows:

1. Find the TIPS principal that applies to July 1; this is based on the April NSA CPI-U report (month 7 – 3 = month 4).
2. Find the TIPS principal that applies to August 1; this is based on the May NSA CPI-U report (month 8 – 3 = month 5).
3. Divide 9, the number of days accrual (the 10th day of the month – the 1st day of the month) by 31 (the number of days in that month).
4. Linearly interpolate by adding 9/31 of the difference between the July 1 and August 1 TIPS' principal values to the July 1 value.

Real Frame of Reference, Real Yield, Nominal Yield, and Break-Even Inflation Rate

Real Frame of Reference

A nominal frame of reference looks at investments in terms of dollars, without regard for any change in purchasing power of those dollars. In contrast, a real frame of reference takes into account the loss of purchasing power due to inflation. Put another way, it calculates how many bushels of wheat, baskets of apples, or more generally, the standard of living to which a given dollar amount corresponds. If it costs 100 "real dollars" to purchase a basket of consumer goods in the Year 0, in Year 20, 100 "real dollars" will still purchase that same basket.

Any investment can be described from either a *real* or *nominal* frame of reference. To directly compare the expected returns of any two investments, one must choose either a real or a nominal frame of reference. For example, in *Stocks for the Long Run,* 1998, Jeremy Siegel describes equities from 1926 through 1997 as having generated *either* a 7.2% real return *or* a 10.6% nominal return.

Ideally, the frame of reference would be dictated by one's goals, but in practice, the choice is heavily influenced by the characteristics of the investment instrument. For instance, conventional bonds are described easily in a *nominal* frame of reference because they have fixed *nominal* coupons and principal. TIPS, on the other hand, are described more easily within a *real* frame of reference because they have fixed *real* coupons and principal. Not surprisingly, TIPS' *real* yield, *real* duration, and other real characteristics are relatively intuitive and as easy to calculate as a nominal bond's yield to maturity, effective duration, and other nominal characteristics.

Real Yield

The real yield of a TIPS bond represents the annualized growth rate of purchasing power earned by holding the security to maturity. Real yield can be calculated easily on a standard bond calculator by entering the TIPS quoted market price, coupon rate, and maturity date. The calculator does not know the bond is a TIPS or that the price and coupon rate are *real.* It is the user's responsibility to interpret the result as the "real yield."[3]

The *real* yield of a *nominal* bond is more difficult to calculate because it can be precisely determined only with the benefit of hindsight. In practice, when analysts speak of a nominal bond's real yield, they may be (1) referring to its "current" real yield (approximated by subtracting the current year-over-year inflation from the bond's nominal yield), (2) "guesstimating" the nominal bond's "expected" real yield based on expectations of future inflation, or (3) speaking of historical realized real yields on bonds that have matured.

Nominal Yield

The opposite situation occurs with nominal yields. While the nominal yield of a conventional bond is determined easily, the nominal yield of TIPS is more difficult to pin down. The nominal yield realized by holding TIPS to maturity depends on the average level and trajectory of inflation over the bond's lifetime. Ignoring the trajectory of the inflation rate, and focusing only on the average level of inflation, the realized nominal yield can be approximated as

$$\text{TIPS realized nominal yield} = (1 + \text{real yield}) \times (1 + \text{inflation}) - 1$$

3. Two phenomena that could cause a minor difference in TIPS quoted real yield from the TIPS realized real yield are (1) real reinvestment rate of coupon cash flows and (2) the time lag between the applicable date for the CPI and the applicable date for TIPS indexing.

Break-Even Inflation Rate

The break-even inflation rate is the rate that results in the holder of a TIPS "breaking even" with the holder of a nominal bond. Using the preceding equation, the nominal yield of the TIPS can be set to equal the nominal yield of the conventional bond. Solving the equation for the break-even inflation rate gives

Break-even inflation rate

= (1 + conventional nominal yield) / (1 + TIPS real yield) − 1

If the conventional bond's nominal yield is 7% and the TIPS real yield is 4% (both expressed in simple annualized terms), the break-even inflation rate is 2.88%. For most purposes, approximating the preceding equation as the simple difference between the two bonds' yields, 3%, is appropriate—and general industry practice.

The 2008 episode is instructive for a different reason. During this period there was rampant deleveraging of financial balance sheets, a sharp contraction in output, a breakdown of the payment system, and fear that monetary policy would be unsuccessful at managing away deflationary inflation expectations. Though it is common to see graphs of 10-year break-even inflation rates reflect this dramatic drop in inflation expectations toward zero, these rates dramatically understate the actual extent of deflationary expectations. In particular, 10-year TIPS are "newly issued" and as such have a "deflation put", struck at-the-money at time of issuance, embedded within them. As such, it is virtually impossible, regardless of how deflationary the outlook is, to observe negative break-even inflation rates on newly issued 10-year TIPS. Off-the-run TIPS, on the other hand, which may have previous positive inflation accruals included in their market value, can lose this principal, and therefore can be, and were, priced at negative inflation break-evens during late 2008 and early 2009.

Although the break-even inflation rate may be useful to assess market inflation expectations or to gauge break-even requirements for narrowly constrained fixed income investors, it generally overstates the risk-adjusted break-even inflation rate applicable to long-term strategies. In particular, the riskier nominal bonds embody inflation risk premiums. Researchers have estimated the embedded inflation risk premium in nominal bonds to be between 0.50% and 1.0%.[4]

Because TIPS pay in real dollars, exhibit low volatility, and have a low correlation with other assets, at least part of such inflation risk premiums should not be embodied in TIPS yields. Therefore, the risk-adjusted break-even inflation rate for TIPS equals the calculated break-even inflation rate minus an inflation risk

4. Citing the tremendous supply of TIPS, the illiquidity of TIPS, and the substantial exposure that TIPS have to changes in real interest rates, Lucas and Quek suggest that a part of (or the entire) "inflation-risk premium" may be offset. See Gerald Lucas and Timothy Quek, "Valuing and Trading TIPS," Chapter 9 in John Brynjolfsson and Frank J. Fabozzi (eds.), *Handbook of Inflation Indexed Bonds* (New Hope, PA: Frank J. Fabozzi Associates, 1999). For a more detailed discussion of implied break-evens and risk-premiums, see the seminal work on expectations and markets by M. Harrison and D. Kreps, "Martingales and Multiperiod Securities Markets," *Journal of Economic Theory* (1979), pp. 381–408.

premium. This means an investor can advantageously use TIPS even when his expected inflation rate equals the calculated break-even inflation rate. Such an investor will gain by lowering overall portfolio risk or from "reallocating" the risk capacity created into other sectors.

Real and Effective Duration

Real Duration

Duration is the measure of a bond's market-value sensitivity to changes in yields—real *or* nominal. The preceding section describing real and nominal frames of reference and real and nominal yields is pivotal to any discussion of duration. By definition, the *real* duration of TIPS is the percentage change in its market value associated with a 1.0% change in its *real* yield. For example, if the market value (MV) of TIPS is $1,000 and the market values associated with a 0.50% decrease and a 0.50% increase in the TIPS real yield are $1,051 and $951, respectively, the TIPS real duration is 10. In order to center the calculation at current yield levels, the 1.0% change in the definition is applied equally as a 0.50% decrease and a 0.50% increase in yield.

Algebraically, the formula for TIPS real duration is

$$100 \times [\text{MV}(\text{real yield} + 0.50\%) - \text{MV}(\text{real yield} - 0.50\%)]/\text{MV}(\text{real yield})$$

Not surprisingly, the TIPS duration formula is identical to that of a nominal bond (excepting the frame of reference). It follows that TIPS' duration can be calculated using a standard bond calculator. As with the calculation for real yield, it is the user's responsibility to remember that the result is the TIPS' *real* duration. (Using real duration within a dedicated TIPS portfolio is discussed in a later section.)

As relevant as real duration is to TIPS' portfolio managers, it is critical to understand that TIPS' real duration does not quantify the exposure of TIPS to changes in nominal yields. First, the correlation of real yields with nominal yields historically has tended to be quite low—real duration measures sensitivity to phenomena that may affect nominal bonds in an opposite way or not at all. Second, real yields tended to be significantly less volatile than nominal yields—so any given "real duration" tended to correspond with significantly less portfolio volatility than the same "nominal duration." Recently this has not been the case. Perhaps this is due to extremely high levels of confidence in the Federal Reserve's ability to successfully and perpetually target a stable inflation rate between 2% and 3%. Correlations between real and nominal yields have been high, and TIPS yield have been almost as, or more volatile than, nominal yields. History will judge how rational this turns out to be in a more uncertain post-2008 world.

Effective Duration

To compare TIPS' risk with that of nominal bonds so that they may be included within a conventional bond portfolio, a manager needs a measure of TIPS' sensitivity to changes in *nominal* interest rates. The method for determining

market-value change of TIPS as a function of nominal-yield change is the "effective duration" calculation. The limitation is that since this calculation must infer a change in real yield from the given change in nominal yield, the measure is statistical rather than deterministic.

Initially, this dilemma caused more than a few managers to conclude that the risk exposure of TIPS could not be managed within the context of a conventional fixed income portfolio. But it was soon realized that in the 1980s, for example, mortgage-backed securities overcame similar concerns. The calculation of effective duration for mortgages calls for an inference that a change in nominal Treasury yield will result in a change in the underlying yield of mortgage cash flows.

Similar to TIPS, yields underlying mortgage pricing are not perfectly correlated with Treasury yields. In fact, during the deflationary scare in the summer of 1998, mortgage prices dramatically underperformed what naive calculations of mortgage effective durations would have predicted. For a brief period, as Treasury yields fell, mortgage yields actually rose. Nonetheless, effective duration is used broadly to determine a mortgage's value change as a function of nominal-yield change. It is incumbent on fixed income managers to manage the remaining mortgage basis risk.

Although crude, the best metric we have found for converting TIPS' real yield into "effective duration" is to apply a 75% multiplicative factor to TIPS' real durations. This approach is often described as a "75% yield beta"—a reference to the second coefficient (beta) of a linear regression of change in real yield against a change in nominal yield. Like mortgages, TIPS' effective duration should be used only as a loose metric for nominal interest-rate exposure because substantial risk (basis risk) remains.

Occasionally, nominal yields fall, and TIPS' real yields rise, meaning that TIPS experience negative effective durations. Conversely, occasionally, nominal yields rise, and real yields rise even more, meaning TIPS experience capital losses greater than what their *ex-ante* effective durations predict. It is incumbent on managers, who use TIPS, to manage the basis risk that TIPS embody beyond their modest effective duration.

The regression results of the weekly change in 10-year TIPS' real yield as a function of changes in the 10-year nominal bond's yield for year 2010 had a highly statistically significant slope of 0.56 and an R-squared of 0.47. This slope indicates that historically the "yield beta" over that period, at 56.51%, has been lower than the 75% that we use. The regression result will vary (as a function of the time period chosen to calculate the individual change), the time period included in the study, the securities chosen, and perhaps most important, the economic environment.

TIPS' real duration measures risk as it relates to change in real yield, and TIPS' effective duration measures risk as it relates to changes in nominal yield. Two broader measures of TIPS' risk are volatility and relative volatility. Volatility is simply the standard deviation of TIPS' prices (or returns). It varies over time and across maturities as a function of the calculation period and measurement interval.

Relative volatility is a measure of TIPS' volatility as a fraction of the volatility of another instrument such as a nominal bond having a comparable maturity. As of May 2011, the TIPS bond exhibited about one-third the price volatility of a comparable-maturity nominal Treasury bond.

MARKETPLACE

A Brief History of TIPS

Conceptually, TIPS are such a fundamental economic instrument that it is possible that they predate nominal bonds and even coins. In essence, the buyer of these bonds is simply "storing" (and earning a return on) a current basket of goods she will consume in the future.

In ancient Mesopotamia, warehouse receipts referencing quantities of grains and other goods were traded in a secondary market and were in some ways preferred to the currency of the day.[5] These receipts "were" TIPS. They could be traded, and on maturity, their value would be redeemed in the form of a "real basket" of consumer goods.

In the United States, TIPS date back to the birth of the nation. In 1780, the state of Massachusetts created debt colorfully inscribed as follows:

> Both Principal and Interest to be paid in the then current Money of said State, in a greater or less Sum, according as Five Bushels of CORN, Sixty-eight Pounds and four–seventh Parts of a Pound of BEEF, Ten Pounds of SHEEP'S WOOL, and Sixteen Pounds of SOLE LEATHER shall then cost, more or less than One Hundred Thirty Pounds current money, at the then current Prices of Said Articles.[6]

Since World War II, more than 15 countries have issued TIPS, or, more generally, inflation-linked bonds (ILBs). ILBs are not just issued by countries experiencing runaway inflation. Countries often issue ILBs as they are embarking on successful disinflationary initiatives. For example, in Iceland from 1949 to 1954, inflation averaged over 15% per year. In 1955, the year following the introduction of their ILBs, Iceland's recorded inflation rate fell to zero.[7]

Quotation and Settlement

In the United States, TIPS are quoted on a "real clean" basis—as distinguished from a "nominal dirty" basis. Fractions of a dollar are quoted as units of 1/32.

5. Glyn Davies, *A History of Money* (Cardiff: University of Wales Press, 1994).
6. Willard Fisher, "The Tabular Standard in Massachusetts History," *Quarterly Journal of Economics* (May 1913), p. 454.
7. *Statistical Abstract of Iceland,* Table 12.5, p. 150.

In this instance, "real" implies that U.S. TIPS' prices are quoted on the basis of 100 *inflation-adjusted* units of principal. The quoted price 95-20 can be interpreted as 95 and 20/32 real dollars, meaning that the investor is paying 95.625% of the *indexed* principal amount. While this may seem intuitive, it is not the only way to quote TIPS' prices. If prices were quoted on a *nominal* basis, as they are in the U.K. linker market, this same purchase would be quoted as 101.512 (95.625×1.06157 = the real price times the index ratio). Similarly, to calculate the clean settlement price, which necessarily is paid in "nominal dollars," multiply the real price by the index ratio.

Clean means that the quoted TIPS' price does not include the accrued-interest amount that the buyer of a TIPS bond owes the seller. Just as with nominal bonds, the TIPS' buyer must compensate the seller for coupon income that has been earned since the last coupon payment. Parties therefore can calculate the settlement proceeds by multiplying real accrued interest by the index ratio and adding the result to the clean settlement price. In practice, a computer algorithm can be used to incorporate prescribed rounding procedures.

Canadian and French TIPS are quoted similarly to U.S. TIPS, except, of course, local inflation indexes are referenced.

The U.K. linker market is quoted on a "nominal clean price" basis, and therefore, some U.K. linkers trade at prices above $200 per $100 original face. This is so because the country's retail price index (RPI) has more than doubled since the Bank of England began issuing these bonds in the early 1980s.

In Australia and New Zealand, ILBs typically are quoted and traded on a "real yield" basis.

Liquidity

The common metrics of liquidity are turnover, bid-ask spread, and transactional size. TIPS are less liquid than conventional coupon Treasuries, but as measured by the bid-ask spread associated with transacting $50 million, they are more liquid than most corporate bonds, nonagency mortgage pass-through bonds, and even some agency debentures. TIPS are significantly more liquid than other inflation hedges such as real estate, commodity futures, precious metal contracts, natural gas partnerships, timberland deeds, and collectable possessions.

VALUATION AND PERFORMANCE DYNAMICS

As with any bond, the holding-period return of a TIPS bond is the sum of its yield and capital gains. For TIPS, changes in real yield determine capital gains. Thus perhaps the most important question for investors evaluating TIPS is: "What direction are real yields heading?"

Over the long term we believe that real yields in the United States should remain at levels below 2.0%. Historically and comparatively, even a 2.0% real return for a riskless instrument is high. Over the past 70 years, long-term

Treasury bonds have realized real yields of just above 2% and short-term Treasury bills just below 1%, with both averages concealing significant volatility in real return. During 1999, real yields on long-term nominal Treasuries averaged about 3.5% and Treasury bills 2.5%. Following the 2008 debt crisis "new normal" lower growth dynamics in the developed world may depress real yields until 2015.

Determinants of Inflation and the Taylor Rule for Real Yields

Professor John Taylor of Stanford University presents a compelling thesis that there is an immutable link between the sustainable real economic growth rate and the sustainable real federal funds rate. "The Taylor rule" argues that over the long term, the real federal funds rate should average the long-term real economic growth rate of the economy, which he estimated to be about 2%. If the monetary authority maintains the real federal funds rate above this for an extended period of time, the inflation rate will diverge toward deflation. If the authority maintains the real federal funds rate below this, the result ultimately will be hyperinflation.[8]

But in 2008 a different risk faced policymakers—the possibility of structural debt deflation. Paraphrasing Fed Chairman Ben Bernanke, we have to be mindful that the risks and costs of deflation may be as great as the risks and costs of inflation.

The implication is clear. Monetary policy should be relatively easy during the next decade. The Fed likely will manage a funds rate that averages at most 2.0% above inflation and substantially less than the 4% above inflation experienced during the 1980s, 1990s, and 2000s.

INVESTORS

Tactical Use (within Fixed Income Portfolios)

There are times when economic fundamentals, financial market dynamics, or simply structure will result in TIPS performing exceptionally well or, as in 1999, less badly relative to other investments. All investors can benefit from understanding how to evaluate and purchase TIPS for tactical gain.

In electing to own TIPS for tactical purposes within a fixed income portfolio, an investor may make a relative valuation assessment by comparing them with debt instruments with similar credit, effective duration, and liquidity. After the investment decision is made, the investor must diligently manage the tracking risk, that is, non–fixed income risk, associated with introducing tactical allocation to TIPS.

International Relative Value Opportunities

The international market for ILBs is currently larger than the U.S. TIPS market. We believe that all global ILBs belong to the same asset class. Tactical opportunities

8. Taylor's equations suggest that in periods of high inflation, high real rates may be temporarily called for.

exist in all these markets because no region is immune from ebbs and flows in the global supply and demand for capital. To some extent, ILBs from different countries are interchangeable.

However, there are nuances that differentiate ILBs from one another. International ILBs provide investors with avenues to exploit a variety of currencies, monetary policies, and other local phenomena. These tactical opportunities can be reduced to perspectives regarding absolute global real yield levels, inflation rates, and intercountry differences from these global averages. Exhibit 18–2 reports ancillary data for nine of the larger government issuers of ILBs.

The first and second columns entitled "Market Cap" and "Real Yield" should be of particular interest because they report, respectively, the size and a long-term measure of relative value. Modified duration is simply the sensitivity issues holdings to changes in real yields. Real yield incorporates the return of real principal and the interim real income that an ILBs' holder will earn.

There are potential international risks not included in Exhibit 18–2 that can affect real yields. The first is the credit profile of the particular issuing country. To the extent that government issuers rarely default on debt instruments denominated in their own currencies, credit risk is low. A second factor is issuance. If a country issues more inflation-indexed supply than domestic and global strategic ILBs investors need, yields are likely to rise until sufficient international tactical investors are attracted.

ILBs can be used tactically within equity and cash portfolios as well. Conceptually, the motivation is similar. In the United Kingdom investors often allocate out of equities into ILBs as a defensive tactic—much as U.S. equity managers reallocate defensively into utility stocks to protect against violent market declines.

EXHIBIT 18–2

Data for Nine of the Larger Issuers of Inflation-Linked Bonds

Country	Market Cap (Billions$)	Real Yield (%)	Modified Duration (Yrs)
US	685.1	1.05	7.90
UK	408.0	0.58	15.86
France	228.9	1.23	8.30
Italy	146.3	2.74	8.52
Germany	62.1	0.64	5.22
Japan	56.1	1.06	5.59
Canada	52.9	1.18	16.11
Sweden	40.3	1.02	7.81
Australia	18.1	2.54	8.61

Source: Barclays Capital Global Inflation Linked Monthly, March 2011.

Strategic Use

Strategic allocations are more deliberate than tactical ones and ultimately speak to the inherent investment qualities of ILBs. ILBs can play a significant role within such top-down strategic allocations. Enduring investor goals, such as matching liabilities, diversifying risks, controlling downside exposures, and achieving real return objectives, typically drive these strategic allocations. In contrast, bottom-up valuation, market timing, and other opportunistic considerations rarely are important aspects of the strategic decision-making process.

Investors typically make strategic asset allocations among the fundamental asset classes: equities, bonds, cash, and inflation hedges. Unadvisedly, some investors opt for finer gradations using more unwieldy sets of narrowly defined asset classes such as large-capitalization, midcap, small-cap equities, and government bonds at the top-level of their asset allocation framework.

Typically, the thread that holds the elements of an asset class together is that each element's returns are driven primarily by common fundamental phenomena. Simply, correlations between members of the same asset class will be high, whereas correlations between assets that are members of different asset classes will be low.

For ILBs, inflation and real global interest rate are the identifying fundamental phenomena that drive returns. Thus it is reasonable that all ILBs (Treasury, international, agency, and corporate) comprise a distinct asset class, separate from equities, (nominal) bonds, and cash. Real estate, commodities, and certain other "inflation hedges" also fall into this inflation-hedging asset class.

There are three general situations that warrant a strategic reallocation into ILBs. First, portfolio managers looking for higher returns without increased risk may investigate moving out of low-risk assets such as cash. Second, those motivated toward preserving past gains might consider a defensive allocation out of higher-risk assets such as equities or real estate. Importantly, a defensive allocation will tend to decrease or eliminate shortfall probability dramatically. (Shortfall probability is the likelihood that a portfolio will fall below a minimum acceptable threshold.) And third, ILBs can be used strategically in an asset/liability management context.

Asset/Liability Management (ALM)

Asset/liability management is closely related to asset allocation. Traditionally, asset allocation studies do not explicitly incorporate liabilities. They tend to focus on increasing absolute levels of return through allocations to higher-returning assets or through diversification of assets, thereby reducing risk calculated without regard to liabilities.

ALM studies focus on reducing the mismatch between assets and liabilities. Traditionally, researchers have studied ALM in a conventional nominal frame of reference where the exposure of assets and liabilities to conventional yield changes is compared and to some extent matched. Liabilities are assumed to be nominal liabilities even when they are in fact inflation-sensitive.

The large-scale introduction of TIPS by the U.S. Treasury has given asset-liability managers the ability to measure and manage both assets and liabilities that are predominantly real. This is a reprieve for the many investors discussed later.

Investors are not limited to choosing between asset allocation or asset-liability management. The two can be combined into a framework generally termed *surplus management*—optimizing the return and risk of surplus (assets net of liabilities). Although developed at one asset management firm in the 1970s, this framework comes into and out of favor periodically.

Risk/Return Optimization

The novelty of ILBs as an asset class in the United States poses challenges for strategic users of the securities. In particular, to include ILBs in a standard nominal Markowitz mean-variance optimization, the analyst must input appropriate expected return, variance, and correlation data for ILBs as well as other assets (or liabilities) included in the optimization.

Although conceptually inputs for such optimizations are forward-looking, practitioners usually rely heavily on historical data. Since U.S. TIPS have existed since 1997, correlation matrices are built using asset class returns from 1997 forward or from pro forma estimates of TIPS returns prior to 1997. Although most optimization models function in a nominal frame of reference, some practitioners appropriately implement them in a real frame of reference.

Managing Dedicated ILB Portfolios Using Real Duration

After a ILBs allocation has been determined, an implementation strategy must be executed. For this, an investor chooses between active or passive management. In either case, real duration is a useful metric of exposure because it measures the allocation's relative sensitivity to changes (parallel shifts) in the real yield curve.

To construct an ILB portfolio, the practitioner needs first to choose a target "real duration" for the portfolio and then to devise a variety of candidate portfolio structures. The candidate portfolios might include a bulleted portfolio having all its ILBs close to the target duration and a barbell portfolio with a combination of longer and shorter ILBs weighted to achieve the target duration.

To select the most advantageous portfolio structure from those with the same real duration, the practitioner need only concern herself with the exposure to changes in the general real yield curve slope of the various candidate portfolios. This is so because the candidate portfolios have the same real yield duration, so their response to parallel shifts will be very similar.

A recent development in the management of TIPS portfolios is increased demand for "break-even" structuring. Typical TIPS portfolios embody inflation protection by locking in to maturity the real yield of instruments owned. Break-even structuring involves selling similar maturity fixed-rate Treasuries, futures, or paying fixed on interest-rate swaps. This in essence nullifies the real yield and real duration of TIPS, leaving the holder with the inflation indexation of the TIPS held.

Of course, realized inflation will need to equal or exceed the inflation which is priced into the nominal market in order to profit from this strategy. In essence this strategy become attractive when (1) real yields are low, so that not much is being given up, and (2) the investor believes that inflation will rise more than what the Treasury market has priced in, or that certain risks are associated with inflation that the investor particularly wants to hedge.

Investor Types: Pension Plans, Endowments, Foundations, and Individuals

Defined-benefit pension plans have both retired-lives and active-lives liabilities. Although ILBs as assets may match the active-life portion of these plans extremely well, plan sponsors typically do not rely exclusively on ILBs to back their active-lives liabilities. Instead, they reach for higher expected returns by using other asset classes with higher risk and return qualities. Given that ILBs and the active-lives liabilities are both linked to inflation,[9] sponsors realize that to reach for higher returns, they take on some risk of underperformance in inflationary environments. In addition to generic asset allocations, pension plans may use ILBs to protect a surplus, to offset substantial equity risk exposure, or to reduce the variability of annual funding requirements. Defined-contribution pension plans and their participants also may benefit from the inclusion of ILBs as described separately below.

Endowments, foundations, and other eleemosynary organizations also may have return objectives that are formulated in *real* terms. Typically their goal is to generate a 5% or higher real return on their investment portfolio. (The IRS generally requires that 5% of a charitable foundation's assets be spent on the delivery of charitable services each year—so a 5% real return, net of expenses and contributions, is required to maintain the foundation's inflation-adjusted size.)

Establishing a real-return target for investment performance makes sense for these organizations. Educational or charitable programs, whether they involve physical infrastructure or services, often are budgeted for using inflation-adjusted dollars. Implicitly, such goals, objectives, and plans represent real liabilities.

This suggests that eleemosynaries employ ILBs as a core pillar in their investment strategy. ILBs will not generally achieve 5% returns in isolation, but they go a long way toward engineering out much of the downside risk of return distributions. With the downside risk truncated, more aggressive use of a higher-returning (riskier) asset can be used. As of this writing, eleemosynaries generally have used ILBs only at the margin.

9. More specifically, active-lives liabilities are tied to increases in wages of employees. The pension plans may prescribe that an employee's retirement benefit is a fixed annuity, with each monthly payment being a fraction of employees' highest annual income. This income level is in turn not explicitly but generally highly correlated with the CPI.

Individuals save primarily to provide for retirement needs and secondarily for children's education, bequeathment, and other goals. Younger individuals may be relatively immune to the damage that inflation can cause in the context of such liabilities. They hold a large proportion of their "wealth" in the intangible real asset known as *human capital* (future earning power). As individuals age, the proportion of their real assets typically decrease as their financial assets increase—leaving those in their late 40s and older relatively vulnerable to the inflationary erosion of retirement living standards.

ISSUERS

Although corporations and agencies can and do issue ILBs, governments are by far the largest issuers. By issuing ILBs, government officials make clearer their commitment to maintaining a low level of inflation. A government's willingness to assume the financial risk of inflation is a powerful signal to the marketplace regarding future policy. Donald T. Brash, governor of the Reserve Bank of New Zealand, characterized this attitude in a speech following New Zealand's introduction of these securities:

> The only "cost" to Government is that, by issuing inflation-adjusted bonds, it foregoes the opportunity of reducing, through inflation, the real cost of borrowing . . . Since [the New Zealand] Government has no intention of stealing the money invested by bondholders, foregoing the right to steal through inflation hardly seems a significant penalty.[10]

How can an investment instrument that makes so much sense for investors, as described in preceding sections, also be advantageous to the issuer? Brash's quote provides one example of how investors gain while the issuer forfeits something it considered worthless to begin with. Next we discuss the U.S. Treasury rationale for issuing TIPS.

U.S. Treasury's Rationale

A goal of the Clinton administration was to reduce the future interest burden of the Treasury's debt. Balancing the budget was the main target of this policy, but a secondary objective took aim at "bond market vigilantes." The administration recognized that because of the "maturity premium" inherent in longer-term debt, rolling over a 3-year bond ten times likely would incur less interest cost than issuing a single 30-year bond. One of the most important programs Treasury embarked on during this administration was a deliberate effort to reduce the average maturity of outstanding debt.

10. Donald T. Brash, "Monetary Policy and Inflation-Adjusted Bonds," an address to the New Zealand Society of Actuaries, April 12, 1995.

TIPS Program

The TIPS program was instituted in this spirit. Like floating-rate debt, TIPS have long *stated* but short *effective* maturities, reducing the "rollover risk" inherent in short-term debt. Additionally, TIPS explicitly provide market-based inflation forecasts for use by the Fed. TIPS reduce the expected cost of financing a government's debt because they are conceptually free of the inflation risk premium built into nominal long-term bond yields. Normally one might conclude that by relieving bond investors of this risk, the Treasury implicitly absorbs a burden or risk equal in magnitude. This is not the case here, however.

By reducing nominal debt and increasing inflation-indexed (real) debt, the Treasury has in effect changed the structure of its liabilities to better match its only asset—its authority to tax. Put another way, the Treasury is the ideal issuer of inflation-indexed debt.

The issuance of TIPS improves taxpayer welfare by eliminating the 0.5% to 1.0% inflation risk premium that researchers believe is embedded in nominal bond yields. At the margin, investors are indifferent to accepting lower yields versus living with the higher risk of nominal debt—so conceptually they are no better or worse off. The elimination of this inflation risk premium is therefore a true welfare gain. In practice, the welfare gains of issuing TIPS have been split between issuers and the investors.

Moral Hazard

The government is both the issuer of TIPS (Department of Treasury) and publisher of the CPI (BLS, Department of Labor). The inherent ambiguity in measuring the CPI creates a moral hazard because the government can directly control the economic value of its liability. Fortunately, several factors mitigate the risk of the government publishing statistics that are not scientifically based.

First, professional integrity, a strong institutional infrastructure, and influential political constituencies combine to preclude the government from manipulating the CPI. Second, any confiscation of value through index distortions would be perceived by the financial community as an erosion of credibility or, if blatant, tantamount to default. Since the issuance process is a repeated game of substantial proportion, such an erosion of credibility would have long-term repercussions on future debt issuance and other government promises that would greatly outweigh any apparent short-term economic or political benefits.

International Issuers

The ILB market in the United Kingdom is large and well developed, comprising about 20% of outstanding debt. Additionally, Canada, Australia, France, Italy, and Sweden have issued ILBs in large enough quantities to ensure reasonable market liquidity as well.

While each of these countries shares the basic inflation-protection concept with their U.S. cousins, differences include market size, trading liquidity, time lag associated with the inflation indexation, taxation, day-count conventions, and quotation conventions. These differences substantially influence both observed quoted real yields and "true" real yields available to investors.

All the ILBs issued by these six governments, together with those issued by the U.S. Treasury, make up a performance benchmark of liquid global inflation bonds known as the *Barclays Capital Global Inflation-Linked Bond Index.*

Corporate Issuers and CPI Floaters

In addition to the U.S. Treasury and non-U.S. government issuers, U.S. corporations, agencies, and municipalities have issued inflation-indexed bonds. Two of the earliest corporate issuers were the Tennessee Valley Authority and Salomon Brothers. Their inflation-indexed bonds were virtually identical in structure to U.S. Treasury TIPS. Other issuers, including Nationsbank, Toyota Motor Credit, the Student Loan Marketing Association (SLMA), and the Federal Home Loan Bank (FHLB), have chosen to structure their bonds as CPI floaters.

A CPI floater is a hybrid between TIPS and a conventional floating-rate note (FRN). Like a TIPS, its return is closely linked to CPI inflation. Like a conventional floating-rate note, its principal is fixed in size. The coupon rate of a CPI floater fluctuates and is typically defined as the CPI inflation rate plus a fixed-percentage margin.

OTHER ISSUES

Taxation

U.S. TIPS are taxed similarly to zero-coupon bonds. They incur a tax liability on phantom income (income earned but not paid.) This does not mean that investors in TIPS pay more taxes or that they pay taxes sooner than holders of nominal bonds. In fact, if inflation, nominal yields, and tax rates are constant, the cash-flow profile of taxes paid and payments received on TIPS is comparable with those of nominal bonds (assuming reinvestment of the excess coupon). In practice, many taxpayers hold TIPS in tax-exempt accounts (401(k)s, etc.) or within mutual funds (which are generally required to distribute taxable income).

Deflation Protection

Questions naturally arise regarding how TIPS would behave in a deflationary environment (one where prices are literally falling). Applying CPI indexation, the current adjusted principal value would be less than the prior adjusted principal value. This would affect semiannual interest payments accordingly.

Extending this premise, it is certainly possible for the adjusted principal value to fall below the original principal value—and therefore for coupon payments to be calculated on a shrinking base. Note that they would still be positive and almost equal to their original size. For example, even after 10 years of 1% deflation and a resulting price level that was 10% lower than when it started, the semiannual coupon payments on a $1,000 TIPS would still be about $18 (rather than $20 originally). The final principal repayment would be treated even more favorably.

In particular, *the Treasury has guaranteed that for the maturity payment of principal (and only the maturity payment), the investor will not receive less than the original principal amount.*

In such deflationary circumstances, in order to maintain acceptable nominal returns, the Treasury would in effect be paying a higher real return than initially promised. The Treasury decided that the regulatory, institutional, and psychological benefits of providing this guarantee would facilitate distribution of the bonds to an extent that more than justifies the theoretical contingent cost to the government.

This government guarantee of 100% principal return distinguishes TIPS from all other inflation hedges.

KEY POINTS

- The inflation indexed bond market has existed for centuries in various forms, but blossomed in 1997 when the U.S. Treasury introduced Treasury Inflation-Protected Securities or TIPS, and in years since as investors have adopted them strategically.
- The market real yield on TIPS can be subtracted from the market nominal yield of similar maturity fixed-rate Treasuries to arrive at the "break-even inflation rate."
- A broad range of investors incorporated TIPS into their asset allocations in order to lock in fixed real yields, while protecting their principal from erosion of purchasing power.
- Currently investors utilize a "break-even" structure in determining their allocations to TIPS. This involves hedging out the relatively low real yields currently priced by the market in order to profit more directly from a rise in inflation, which may or may not be accompanied by rising real yields.

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CHAPTER
NINETEEN

INTERNATIONAL BOND MARKETS AND INSTRUMENTS

KARTHIK RAMANATHAN
Senior Vice President and Director of Bonds
Fidelity Management and Research Company/Pyramis Global Advisors

This chapter will focus on the important role of international bond markets as a source of funding for major corporations, sovereigns, and supranationals, as well as the instruments used in this market. After defining the breadth of the international bond market and providing historical context on the growth and motivations for issuing debt in this market, the primary instruments used in this market—domestic bonds, Eurobonds, and foreign bonds—will be described in detail. Importantly, the key differences between the dollar-denominated and non-dollar-denominated bonds will be explained as well as some of the vehicles investors and debt issuers use to access these markets. Finally, the risk and return components resulting from currency exposure in non-dollar-denominated bonds will be highlighted, as will the merits of hedging this component of risk.

OVERVIEW AND SCOPE OF INTERNATIONAL BOND MARKETS

With more than 60% of all fixed income securities trading outside of the United States, investor interest in international bond markets has risen substantially in the first decade of the twentieth century. While the total face value of fixed income securities in the U.S. remains significantly larger than that of its closest peers—the Eurozone region[1] and Japan, respectively—the breadth of international debt instruments has greatly expanded. For example, between 2000 and 2010, global fixed income markets grew at an annual rate of nearly 10%. Much of that growth was concentrated in lesser developed countries.[2]

The contributions of Christopher Steward (Pyramis Global Advisors) and Nancy Taylor (Fidelity Investments) in reviewing this chapter were greatly appreciated.

1. Eurozone region consists of those countries which use the euro dollar as their currency.
2. Unless otherwise noted, global bond market size and other relevant data in this chapter are derived from *BIS Quarterly Review* reports (particularly Tables 14A, 14B, and 16A).

Domestic bonds often are included in diversified portfolios because their price movements are generally less volatile than equities, they pay a known amount of interest at regular intervals, and they repay principal at maturity (unless default takes place). U.S. dollar–denominated international bonds behave much like domestic U.S. domestic bonds. For the U.S.-based investor, international bonds generally consist of bonds issued in markets outside of the United States that can be denominated in dollars or other currencies. However, for the U.S.-based investor, the behavior and returns of non-dollar-denominated bonds tend to be more volatile because of the currency component.

Since the 1980s, the sophistication of debt issuers has increased at the same time as currency and global interest rate markets multiplied in size. In addition, the access to continuous market information and the development of robust pricing tools such as Bloomberg have resulted in greater transparency and ease of issuance. As a result, borrowing in the international bond market has flourished.

Historical Context

The broader trend toward issuing debt instruments globally is not recent, however. Cross-border investments in government bonds were common before World War I. By 1920, Moody's was providing credit ratings on over 50 sovereign borrowers. Yet, most of these foreign investments ended badly for U.S. investors. Hyperinflation under the German Weimar Republic of the 1920s rendered the Reichsmark worthless. Similarly, during the 1920s, U.S. investors saw their foreign investments decline in U.S. dollar terms by 86% in France, 70% in Italy, and 50% in Spain. Interestingly, some of the countries that avoided sharp devaluations during this period including the United Kingdom, Sweden, and Argentina have seen their bonds lose much of their value since the collapse of the Bretton Woods system of fixed exchange rates in the 1970s.

Between 1930 and 1970, capital controls and domestic regulations sharply curtailed cross-border bond investment. The development of offshore markets and the growth of international banking institutions led the way toward greater cross-border investment flows in the early 1980s, prompting governments to reverse course. Market reforms liberalizing capital flows in money, bond, and equity markets were introduced to bolster domestic capital markets and to attract foreign capital.

The elimination of capital controls in many countries as well as advances in the dissemination of information led issuers and investors to focus on opportunities in international bond instruments. Indeed, according to data compiled by the Bank for International Settlements (BIS), the nominal value of global outstanding debt[3] increased from $35 trillion in 2000 to more than $90 trillion in 2010. Bonds denominated in U.S. dollars are consistently the largest single component of the world bond market. However, international debt issued in other currencies, such as euro dollars, yen, and emerging market denominations continue to gain market share.

3. Global outstanding debt is defined as international debt, money market instruments, and domestic debt issued by all entities in a country.

One indicator demonstrating the willingness of borrowers to broaden their universe of funding opportunities is the share of debt issued in domestic versus international markets. Between 2000 and 2010, global borrowers doubled their issuance of international bonds to nearly 30% of total global debt outstanding. Issuers in the United States and the Eurozone shifted to international bond markets most aggressively during this period. In Japan, however, nondomestic debt issuance remained close to nil over this 10-year period.

Although the sheer size of the U.S. economy ensures a central role for U.S. bonds in world capital markets, the growth in volume and the expansion of participating countries in the international bond sector is a long-term trend. In particular, the gradual removal of currency trading restrictions in countries such as China, which limit foreign investment, will accelerate this global trend. This chapter will provide a broad overview of the instruments, markets, and participants in international bond investing. First, the instruments and markets for the dollar-denominated sector of the international bond market are described. Then, the non-dollar-denominated sectors of the international bond market as well as vehicles used to access these markets are outlined. Finally, we focus extensively on the contribution of currency to returns and volatility for U.S. dollar–based investors.[4]

Motivations for International Bond Issuance

The financing techniques used in these international bond markets rival those in the U.S. domestic market in terms of sophistication. Sovereigns, quasi-government, and foreign government entities, financial institutions, and corporate issuers typically vie for the lowest borrowing costs regardless of currency and country. Issuing debt on an international scale broadens the pool of potential investors, potentially lessens regulatory burdens, and allows the construction of more customized investment strategies. Regardless of their motivation, the instruments used by issuers generally fall into several well-defined categories.

THE INSTRUMENTS: DOMESTIC, EURO, AND FOREIGN

International bonds are divided into three general categories: domestic, euro, and foreign. The classification depends on the domicile of the issuer, the nature of the underwriting syndicate, the domicile of the primary buyers, and the currency denomination. Domestic bonds are issued, underwritten, and traded under the currency and regulations of a country's domestic bond market by a borrower located within the country. Eurobonds are underwritten by an international syndicate and

4. In this chapter, the terms *foreign currency bonds* or *offshore bonds* refer to bonds denominated in a currency different from that of the issuer's residence. *Local currency bonds* or *onshore bonds* refer to bonds denominated in the same currency as that of the issuer's residence. For simplicity, we will assume the perspective of a U.S.-based investor. As a result, we use the terms dollar-denominated and non-dollar-denominated bonds.

traded outside any one domestic market. Foreign bonds are issued under the regulations of a domestic market and are intended primarily for that country's domestic investors by a foreign-domiciled borrower.

Examples of international bonds:[5]

> **Domestic Bond:** A Japanese based company issues debt in Japan with principal and interest payments denominated in Japanese Yen.
>
> **Eurobond:** A Japanese based company issues debt in Germany with principal and interest payments denominated in Japanese Yen.
>
> **Foreign Bond:** A Japanese based corporation issues debt in Germany with principal and interest payments denominated in Euro Dollars.

The most decisive influence on the price or yield of an international bond is its currency denomination. For U.S. investors, the pertinent division is between international bonds denominated in U.S. dollars and those denominated in other currencies. Regardless of the domicile of the issuer, the buyer, or the trading market, prices of issues denominated in U.S. dollars (dollar-denominated) are affected principally by the direction of U.S. interest rates, whereas prices of issues denominated in other currencies (non-dollar-denominated) are determined primarily by movement of interest rates in the country of the currency denomination. Thus, for U.S. dollar–based investors, the analysis of international bond investing can be separated into two parts: dollar-denominated bonds and non-dollar-denominated bonds.

Most dollar-denominated international bonds can be included in a domestic bond portfolio with little change to the management style and overall risk profile of the portfolio. In most cases, a marginal extra effort is required to analyze the credits of unfamiliar issuers and incorporate the settlement procedures for these bonds. The notable exception in the dollar-denominated bond sector is in emerging market debt, which, as detailed below, can be far more volatile than most other dollar-denominated bonds.

The currency component of non-dollar-denominated bonds, however, introduces a fair degree of return volatility, and has a far different risk profile than domestic U.S. and dollar-denominated international bonds. The question of currency hedging (either passive, active, or not at all), plus considerations of trading hours, settlement procedures, withholding taxes, and other nuances of trading non-dollar-denominated international bonds, requires greater risk and portfolio management oversight.

5. The term "eurobond" at times creates confusion. Eurobonds need not be denominated in Euro Dollars. For example, the same Japanese based company could issue debt in Switzerland with principal and interest payments denominated in Japanese Yen. This instrument would be referred to as a eurobond also, or more specifically, a yen eurobond or euroyen bond.

DOLLAR-DENOMINATED INTERNATIONAL BONDS

The dollar-denominated international bond market includes Eurodollar bonds, which are issued and traded outside any one domestic market, and Yankee bonds, which are issued and traded primarily in the United States. In addition, global bonds are issued in both the Yankee bond and Eurodollar bond markets simultaneously. Domestic investors, however, are generally indifferent between global and straight Yankee bond issues except where liquidity differs.

Emerging market debt traditionally had been primarily issued in dollars; however, over the past decade, domestic (local currency) debt issuance has vastly surpassed dollar-denominated debt issuance. In addition to these instruments, Regulation 144A Private Placements and Euro Medium Term Note markets are often denominated in dollars. Before examining these instruments in depth, some of the more basic questions regarding dollar-denominated international bonds should be addressed.

Why Do Foreign-Domiciled Issuers Borrow in the U.S. Dollar Markets?

The U.S. bond market is the largest, most liquid, and most sophisticated of the world's bond markets. By issuing in the U.S. market, foreign entities diversify their sources of funding. Also, as companies have become more global in production and distribution, they have assets and liabilities in many different currencies and hence are less tied to their domestic bond markets. Financial innovations, particularly the advent of the interest-rate and currency swap markets, have greatly expanded the diversity of borrowers, notably in the corporate sector.

Companies in need of floating-rate financing often have been able to combine a fixed-coupon bond with an interest-rate swap to create a cheaper means of finance than a traditional floating-rate note. Similarly, when currency swap terms are favorable, a company in need of funding can issue debt outside their domestic market and use swaps to hedge the associated currency risk. For example, a U.K.-based institution seeking funding could issue a Eurodollar bond and combine it with a currency swap to create a cheaper source of funds than a traditional U.K. sterling denominated bond issue.

Why Should U.S. Dollar–Based Investors Be Interested in Dollar-Denominated International Bonds?

Investors may be able to find a higher yield on a dollar-denominated international bond than on other comparably rated issues, especially where the credit may be less familiar to United States investors. Moreover, these debt issues can offer sector and credit diversification. Yankee bonds are registered with the Securities and Exchange Commission (SEC) and trade like any other U.S. domestic bond. The credit quality of issuers in the Yankee bond market is generally strong. Eurodollar bonds generally are less liquid than Yankee bonds, but sometimes can offer more attractive yields and a broader list of available credits.

What Are the Differences between a Yankee Bond and a Eurodollar Bond?

The primary difference is SEC registration. Yankee bonds are registered with the SEC and are issued and traded in the United States. Eurodollar bonds are issued outside the United States in unregistered, or bearer form, and are traded primarily by foreigners. Eurodollar bonds are issued mostly by corporate issuers, whereas Yankee bonds are issued mostly by high-credit quality sovereign and sovereign-guaranteed issuers. The size of the Eurodollar bond market historically has been larger than the size of the Yankee bond market. Finally, Yankee bonds pay interest semiannually, whereas Eurodollar bonds carry annual coupons.

Eurodollar Bonds

The Eurobond market existed long before the launch of the pan-European currency known as the euro. In the international bond market, the prefix Euro- has come to mean offshore, or debt issues that are marketed outside any domestic jurisdiction in a denomination other than the local currency.

The Eurodollar banking market began during the Cold War. The Soviet Union, wary that the United States might freeze their dollar deposits, preferred to hold their dollar-denominated bank deposits outside the reach of the U.S. authorities. The Eurodollar market[6] continued to grow as banks sought to avoid domestic banking restrictions such as Regulation Q, which set a ceiling on interest levels paid on deposits, and the Glass-Steagall Act, which prohibited banks from engaging in underwriting and brokerage. In addition, restrictions placed on direct investment overseas by U.S. companies in 1968 encouraged companies to raise capital offshore, thus increasing the size of the Eurobond market.

However, the most significant growth in the Eurodollar market occurred in the late 1970s as the recycling of large dollar surpluses by OPEC countries (since oil is denominated in dollars) injected huge amounts of liquidity into the market. Balance-of-payments deficits, due in part to higher oil prices, also increased sovereign and sovereign-guaranteed Eurodollar issuance.

While eurobonds encompass securities of all different currency denominations, Eurodollar bonds are by far the largest single component of the Eurobond market. Eurodollar bonds are:

1. Denominated in U.S. dollars
2. Issued and traded outside the jurisdiction of any single country
3. Underwritten by an international syndicate
4. Issued in bearer (unregistered) form
5. Pay investors interest and principal payments in dollars

6. Eurodollars are short-term money market instruments denominated in dollars issued offshore.

A Eurobond that is denominated in dollars is called a *Eurodollar bond*. Since Eurodollar bonds are not registered with the SEC as U.S. domestic new issues are required to be, underwriters are legally prohibited from selling new issues to the U.S. public. However, once the bond has traded in the secondary market for a certain period of time, or seasoning period, such sales are permissible. An issue is usually considered seasoned 40 days after it has been initially offered. This seasoning requirement effectively locks U.S. investors out of the primary market. Even though a portion of Eurodollar bonds end up in U.S.-based portfolios after the seasoning period expires, the lack of participation by U.S. investors in new offerings means that foreign investors dominate this market. Although no single location has been designated for Eurodollar bond market making, London is the de facto primary trading center.

The first Eurodollar bond issue was in 1957 by Petrofina, a Belgian petroleum company for the small amount of $5 million. Marketability of Eurodollar bonds has improved as the market has grown. In the past, many straight fixed-coupon Eurobonds traded infrequently, particularly among the older issues, which were often only $50 million or less in individual issue size. Normal issue size today is $200 to $500 million or higher.

Despite the increase in market size, liquidity remains constrained since demand is typically driven by buy and hold investors. As a result, trading volumes can be lower than other comparable debt while bid/ask spreads can be wider. Since Eurodollar bonds are held in unregistered form, details about major holders are often unreliable. Market participants estimate that retail investors participate extensively in the Eurobond market by directly purchasing these instruments or participating via mutual funds.

Borrowers in the Eurodollar bond market may be divided into four primary issuers: supranational agency, sovereign, financial and corporate. Supranational agencies, such as the World Bank and the European Investment Bank, are consistently among the top borrowers, reflecting their constant need for development financing and their lack of "home" issuance market.

Sovereign and sovereign-backed borrowers are also prominent, although the growth in sovereign Eurodollar bond issuance slowed in the late 1980s as governments either cut back on their external borrowing in favor of their domestic bond markets or chose to borrow in the non-dollar markets to diversify their currency exposure. Similarly, fiscal retrenchment in many emerging market sovereigns and the growth of domestic bond markets have served to reduce the role that sovereign issuers play in this market. Bank and finance companies continue to dominate the new issuance market; however, corporate issuance has increased.

One driver of growth in the Eurodollar bond market is the general economic climate. In the late 1980s, Japanese companies were among the most active issuers in this market due to large borrowing needs and limited foreign participation in its domestic bond markets. However, the opening up of the Japanese domestic bond market (thus diminishing the relative attractiveness of issuing debt in the offshore market) and the deleveraging by companies as the economy fell into a long-running recession led to a sharp drop in Eurodollar bond issuance.

The strength in the dollar from 1987 to 1990 and again in the late 1990s increased investor appetite for dollar-denominated securities and encouraged Eurodollar bond issuance. Similarly, the dollar's weakness versus the yen from 1994 to 1995 and versus the euro dollar from 2003 to 2008, led to reduced issuance of Eurodollar bonds by international borrowers as investor appetite abated.

Similarly, following the introduction of the euro in 1999, many traditional Eurodollar bond issuers could also look to pan-European sources of funding denominated in euro dollars. Increased competition between regional underwriters also resulted in the decline in underwriter gross spreads and lower borrowing costs for issuers. Conversely, during the 2007–2009 credit crisis, Eurodollar bond market liquidity diminished leading to higher borrowing costs, and market access was limited to the highest quality issuers.

Over the long term, however, the size and vitality of the market likely will be decided by policy decisions regarding the regulation of financial markets and securities. As national governments deregulate their domestic bond markets, the attraction of Eurodollar bonds to issuers and investors diminished. However, greater scrutiny by regulators in the United States following the 2007–2009 credit crises as well as the growth of the global bond market could once again fuel Eurodollar bond issuance.

Yankee Bonds

The other portion of the dollar-denominated international bond market is referred to as the *Yankee bond market*. This market encompasses foreign-domiciled issuers who register with the SEC and borrow dollars via issues underwritten by a U.S. syndicate for delivery in the United States.[7] An example of a Yankee bond would be a Japanese based company which issues debt in the United States with principal and interest payments denominated in U.S. dollars. The principal source of demand is in the United States, although foreign buyers can and do participate.

Unlike Eurodollar bonds, which do not have registration requirements, companies offering Yankee bonds are subject to strict requirements to ensure that they are financially stable and capable of making payment when the bonds reach maturity. In general, any bond not registered with the SEC cannot be sold to U.S. citizens at the time of the issue. Yankee bond issuers usually face a four-week registration period and ongoing disclosure requirements. At the same time, the registration period review generally provides investors with greater clarity regarding the new issue. As a result, Yankee bonds tend to be viewed as lower in risk than other types of foreign bond securities which have not been similarly vetted.

The Yankee bond market is much older than the Eurodollar bond market. Overseas borrowers first issued Yankee bonds in the early 1900s. The repayment record of these early issues, however, was not good; as much as one-third of the

7. A small portion of outstanding Yankee bonds are foreign-currency-denominated. These are not included in this analysis.

outstanding "foreign" bonds in the United States were in default on interest payments by the mid 1930s. After years of slow growth, the market expanded rapidly after the abolition of the interest-equalization tax in 1974.[8] Since then, the Yankee bond market has become a critical source of financing for international issuers second only to the Eurobond market.

Supranational agencies, Canadian provinces (including provincial utilities), and financial institutions historically have been the most prominent Yankee bond issuers, comprising well over half the total market. Issuing in the Yankee bond market is preferred by many institutions that need to borrow significant amounts but cannot access such liquidity in their local markets or who can identify more attractive borrowing terms abroad. Secondary market trading for Yankee bonds tends to be more liquid leading to smaller bid/ask spreads compared with Eurodollar bond offerings. Moreover, using Yankee bonds can at times be appealing to debt issuers because of the attractive terms to swap the bonds back to local currencies.

Regulatory measures meant to boost the capital levels of financial institutions also prompted issuance in the Yankee bond market. For example, between 2001 and 2010, in order to boost capital levels and comply with proposed stricter banking regulations, European banks issuance of Yankee debt increased nearly fourfold.

The corporate sector, which is a growing borrower in the Eurodollar bond market, is of only minor importance in the Yankee bond market. The increased use of global bonds, however, has blurred the distinction between the Yankee and Eurodollar bond markets.

The Market for Eurodollar and Yankee Bonds

Foreign investors play a role in the Yankee market, although the market's location in the United States prevents foreigners from having as dominating a presence as they have in the Eurodollar bond markets. Prior to 1984, foreign investors had a preference for dollar-denominated international bonds which included both Yankee bonds and Eurodollar bond issues. These instruments were not subject to the 30% withholding tax imposed by the U.S. government on all interest paid to foreigners.

When the withholding tax exception was abolished in July 1984, a major advantage of these dollar-denominated international bonds over U.S. Treasuries and domestic corporate bonds was eliminated. This made Yankees and Eurobonds less attractive relative to the U.S. domestic market. However, foreign investor demand remained robust due to the yield differential between the U.S. domestic bond market and the dollar-denominated bond market. Yankee bonds and Eurodollar bonds tend

8. The interest equalization tax was imposed on purchases of foreign securities by U.S. residents between 1963 and 1974. The intent and effect of the tax was to discourage foreign borrowing in the United States by increasing the cost of capital. To make returns after the interest equalization tax competitive with rates on domestic issues, gross rates on foreign borrowings had to be higher than otherwise would have been the case.

to offer a higher yield because of lower liquidity and perceived lower credit quality relative to U.S. domestic debt. Moreover, foreign buyers are often more familiar with these credits than they are with U.S. domestic credits. Finally, Yankee and Eurodollar issuers sometimes compensate foreign investors in the dollar-denominated market by offering bonds with features that traditionally appeal to them, including shorter maturities and structures with greater call protection.

For these reasons, when foreign buyers seek exposure to dollar-denominated bonds, they often buy dollar-denominated international bonds—Eurodollar or Yankee—instead of U.S. domestic issues. The degree of interest of foreign buyers in dollar-denominated securities, or lack thereof, is reflected in narrowing or widening of the yield spread to U.S. Treasury bonds. This is particularly true of Eurodollar bonds because foreign interest governs this market to a greater extent than the Yankee market which is instead more attuned to U.S. investor preferences.

The fact that the Eurodollar bond market and the Yankee bond market have different investor bases occasionally leads to trading disparities between the two markets. For example, similarly structured Canadian Yankee bonds often trade at lower yields than Canadian Eurodollar bonds because U.S. investors tend to be more comfortable with Canadian credits due to the close proximity of the two countries.

Global Bonds

The globalization of the investment world has brought the Yankee bond and Eurodollar bond markets closer together, and it is not uncommon for investors to arbitrage the two markets when yield disparities appear. The advent of the global bond blurred the dividing line between the two markets. A global bond is normally a large international bond offering by a single borrower that is simultaneously sold in multiple currencies in North America, Europe, Asia, and other regions. Institutional investors are the primary purchasers of these instruments.

The World Bank issued the first global bond in 1989, with a $1.5 billion issue that was placed simultaneously in both the Yankee bond and the Eurodollar bond markets. Since investors purchased and traded the security in both Europe and the United States, liquidity was greater, while issuance costs (compared to several separate Eurobond issues) were lower. Although these securities were in registered form unlike Eurodollar bonds, investors valued the larger, more liquid nature of these bond issues more than the anonymity offered by bearer bonds.

The rationale for the global bond was to create an instrument that had attributes of both a Yankee bond and a Eurodollar bond. As a result, the market segmentation that inhibited liquidity and created yield disparities would be eliminated. The success of global bond issues is further evidence of the melding of the Eurobond markets and domestic debt markets that has lowered barriers to cross-border capital movements. Issuers that can consistently borrow across markets and currencies using global bond instruments because of their strong credit profiles also tend to be viewed positively by investors.

The global bond market has been used primarily by central governments and supranational organizations. Frequent global bond issuers include development banks such as the Asian Development Bank and World Bank, and sovereigns such as the Republic of Brazil and the United Mexican States. These institutions issue liquid benchmark bonds across the yield-curve which, in turn, increases price transparency and reduces borrowing costs.

Regulation 144A Private Placements

To encourage international firms to issue debt in the United States while minimizing costs associated with disclosure, the Securities and Exchange Commission enacted Regulation 144A (Reg 144A) in 1990. Privately placed fixed income securities are sold directly to a limited number of sophisticated investors (such as insurance companies, pension funds, and certain high net worth individual investors) and are exempt from registration with the SEC.

Since the SEC ruling, the Reg 144A market has become a trillion dollar market with most issues rated by the major credit-rating agencies. U.S. companies are the predominant issuer in this market followed by European multinationals, and the majority of issuance remains dollar-denominated. Initially Reg 144A securities, due to the somewhat smaller issuance size, offered slightly higher yields versus public debt instruments. As the Reg 144A market has grown, however, this differential has decreased.

Reg 144A provides foreign borrowers with greater access to institutional investors. Since issuers only need to disclose the documentation required by their home-market regulators, they do not need to follow the more cumbersome SEC registration process. Many private companies prefer this market in order to maintain confidentiality with regard to their financial statements. Other institutions employ Reg 144A offerings in order to create and distribute more customized debt products. Many Reg 144A offerings are issued with registration rights that allow the issuer quick access to capital and the ability to broaden the issue's size if desired by registering with the SEC.

Major insurance companies, pension funds, and long-term institutional asset managers are traditionally the largest investors in this market. Reg 144A debt offerings potentially offer investors diversification benefits which result from stricter covenant protections and credit enhancement. Generally, international issuers looking to access investors in this market need to offer these additional incentives to reassure investors given limited financial disclosure.

Euro Medium Term Note Market

Euro Medium Term Notes (EMTNs) allow for debt issuance in different currencies and maturities under one umbrella agreement. This agreement is similar to a "shelf registration" in which investors can issue debt on multiple occasions for a specified period of time but need only file one offering prospectus. Thus borrowers can use EMTNs to tap the markets more quickly and efficiently than with

traditional Eurodollar bonds which require separate documentation for each bond issue. Although EMTNs were used originally only for non-underwritten private placements, they are now often underwritten by syndicates also. As a result, the distinction between Eurobonds and EMTNs has also blurred. Because these securities are offered outside of the United States, they are not subject to filing or review requirements with the SEC.

The majority of all Eurobond issues are swapped into floating-rate debt. At times, market opportunities to obtain favorable swap terms can be limited. As a result, borrowers respect the flexibility of EMTN programs. The maturity and other issue terms can be structured to suit specific investor needs, which in turn allow companies to opportunistically issue debt. These notes have been used extensively for small, illiquid, structured private issuance. As the EMTN market has gained traction, larger, more standard debt issues have become common and often compete with offerings in the Eurodollar bond and Reg 144A markets.

Dollar-Denominated Emerging Market Debt

Emerging market bonds are often found in international bond portfolios. Initially, most of these bonds were denominated in U.S. dollars or other major currencies such as sterling or deutsche marks. However, non-dollar-denominated debt instruments, such as Mexican Cetes, soon became widely available to international investors over time. One of the key milestones that marked the growth of the dollar-denominated emerging market bond market was the development of the Brady Bond market.

Brady Bonds were named after U.S. Treasury Secretary Nicholas Brady, who developed a market-oriented approach to the Latin American debt crisis in the 1980s by repackaging nonperforming bank loans into marketable securities. As a result, commercial banks could remove these loans from their balance sheets. The first Brady Bond agreement was reached with Mexico, and the bonds were issued in March 1990. At its peak, the nominal value of the Brady bonds outstanding was approximately $130 billion.

Most countries have since retired their Brady bond debt, instead turning to cheaper financing through Eurobond issues or domestic credit market issuance. Emerging market sovereign issuers returned to financial markets following the Latin American debt crisis to issue dollar-denominated and non-dollar-denominated debts at attractive yields.

Regardless of currency denomination, emerging market debt investors need to consider the additional risk characteristics of these securities. The reasons for default can include not just the inability to service debt but also the potential for the government to favor some creditors versus other creditors. Investors need to monitor not just credit quality in emerging market debt, but also political risk.

The market risk of holding emerging market securities has generally been higher than the risk of holding developed country credits. While many emerging market sovereign defaults such as those in Ecuador (2008), Belize (2006), and the Dominican Republic (2005) have had little impact on broader financial markets, other sovereign defaults such as Russia (1998) and Argentina (2001) created significant regional and even global credit market stress.

The developed country financial markets largely escaped the turmoil of the 1997 Asian crisis; however, they were severely affected by the Russian default in August 1998. The resulting flight to safety not only damaged emerging market bond prices and overall confidence, but also led to a sharp widening of U.S. corporate and agency spreads.

Investor confidence in emerging market debt was once again battered between 1999 and 2002 when Latin America faced another round of economic distress. The devaluations of the Brazilian real and the Argentine peso and the sovereign default of Argentina pressured emerging markets globally. Although both events shook financial markets, the outcomes were very different. Brazil pursued a path of fiscal austerity and inflation targeting, and reentered the sovereign debt markets shortly thereafter. Argentina, on the other hand, defaulted on both its local debt and foreign currency debt, and could not borrow in the international debt markets nearly a decade later.

The credit crisis of 2007–2009 also created great stress on emerging market debt as investors who had been seeking higher yielding securities collectively unwound their positions in these foreign markets and shifted to "safer" assets such as U.S Treasuries. However, once again, investors returned to these same emerging market sovereigns as the crisis subdued and growth prospects once again appeared attractive.

Ironically, while emerging market sovereign debt regained favor following this crisis, many sovereigns in developed markets—particularly in Europe—remained fragile. Large structural deficits, weak banking systems, and low growth prospects at the close of the decade led investors to question the fiscal sustainability of sovereigns such as Ireland, Greece, Portugal, and Spain. Even the bond markets of Italy and France were sorely tested. Many "developed" sovereign debt traded cheaper to traditional "emerging market" debt. These concerns significantly weighed on financial market participants despite the purchase of securities by the European Central Bank in the secondary market and the creation of various extraordinary liquidity facilities by the governments of Eurozone countries.

As a result of this crisis, the delineation between emerging markets and developed markets became less obvious. More than 50% of emerging market debt issuers now have investment-grade ratings by the major rating agencies. More importantly, debt issued in the currency of these sovereigns has become a rapidly growing segment of the international fixed income markets. Investor demand has shifted from dollar-denominated debt to non-dollar-denominated debt issued in domestic bond markets.

NON-DOLLAR-DENOMINATED DEBT INTERNATIONAL BONDS

From the standpoint of the U.S. investor, non-dollar-denominated international bonds encompass all issues denominated in currencies other than the dollar. The currency component introduces a significant source of volatility. The most important question facing U.S. investors investing in non-dollar-denominated international

bonds is whether or not to hedge currency exposure. The theoretical underpinnings of the currency hedge question, however, are beyond the scope of this chapter, but understanding the various perspectives is important.

Just as in the U.S. bond market, non-dollar-denominated fixed income instruments are determined by the domicile of the issuer and the location of the primary trading market, The three major venues are: the domestic market; the foreign market where the issuer is domiciled outside of the country of issuance; and the Euro market, which trades outside of any national jurisdiction.

The Non-U.S. Domestic Markets

Securities issued by a borrower within its home market and in that country's currency typically are termed *domestic issues*. These may include bonds issued directly by the government, government agencies, and corporations. In most countries, the domestic bond market is dominated by government-backed issues, central government issues, government agency issues, and state (provincial) or local government issues. The United States has the most well-developed, actively traded corporate bond market, followed by Europe. In contrast, Japanese corporations rely heavily on bank loans instead of corporate debt issuance. As a result, the corporate bond market in Japan tends to be illiquid.

As discussed in the previous section, non-dollar-denominated debt issued in emerging markets has been a rapidly growing segment of the international bond market. These domestic markets have exhibited significant growth for a number of reasons, including the liberalization of currency controls, the implementation of sound economic and regulatory practices, and the desire to attract additional potential sources of liquidity.

Many emerging market nations tend to continuously issue dollar-denominated debt at specific points on the yield-curve. These benchmark issues tend to be liquid and offer greater pricing transparency for international investors. As liquidity in these offshore markets develops, local debt markets tend to follow as an important source of borrowing. For these sovereigns, issuing debt in their own currency rather than in dollars allows a better matching of liabilities with assets.

Moreover, a deep, liquid domestic bond market generally promotes the growth of corporate debt markets which reduces the reliance for companies to borrow only from banks. By issuing debt in both the domestic market and the dollar-denominated markets, issuers access a broader set of investors, lower borrowing costs, and reduce the risks associated from currency fluctuations and exogenous events.

Increased liquidity in domestic emerging market debt markets offers international fixed income investors access to a much broader set of debt instruments (beyond dollar-denominated debt). Indeed, between 2000 and 2010, the market for local currency debt doubled in size relative to the dollar-denominated market. The diversification benefits offered by emerging market debt have been a key driver of demand.

Bulldogs, Samurais, and Other Foreign Bonds

The foreign bond market consists of debt sold primarily in one country and currency by a borrower of a different nationality. The Yankee bond market is the U.S. dollar version of this market. Other examples are the Samurai market, which consists of yen-denominated bonds issued in Japan by non-Japanese borrowers, and the Bulldog market, which is composed of U.K. sterling denominated bonds issued in the United Kingdom by non-British entities.

Other foreign bond markets (many with colorful names) include those in the emerging markets. Some of these foreign bonds include Matrioshka bonds (Russian ruble-denominated bond issued in the Russian Federation by non-Russian entities), Arirang bonds (Korean won-denominated bond issued by a non-Korean entity in the Korean market), Panda bonds (Chinese renimbi-denominated bond issued by a non-China entity in the People's Republic of China market), and Dim sum bonds (Chinese renimbi-denominated bond issued by a Chinese entity in Hong Kong).

Relative to the size of their domestic bond markets, these foreign bond markets are small, and liquidity can be limited. For borrowers, the major advantage of the foreign bond markets is access to a broader set of investors in the country in which the bonds are issued. The Samurai market, for example, allows borrowers to tap the huge pools of investment capital in Japan. For investors, foreign bonds offer the convenience of domestic trading and settlement and often additional yield. However, the increasing liquidity and diversification benefits offered by domestic bond markets (including currency and duration exposure) have slowed the growth of the foreign bond markets.

The Offshore Non-Dollar-Denominated Market

Securities issued directly into the international ("offshore") markets are called Eurobonds. Eurobonds can be issued in any currency such as euros, Japanese yen, South African rand, or Czech koruna. The Eurobond market encompasses any bond not issued in a domestic market, regardless of issuer nationality or currency denomination. Eurodollar bonds are the U.S. dollar-denominated version of Eurobonds. These securities typically are underwritten by international syndicates and are sold in a number of national markets simultaneously. They may or may not be obligations of, or guaranteed by, an issuer domiciled in the country of currency denomination. Issuers include sovereigns, corporations, and supranationals. As with the foreign bond markets, the liquidity of Eurobonds is typically less than the liquidity of domestic government issues.

Most Eurobonds have been issued in dollars and euro dollars. However, between 2000 and 2010, dollar-denominated Eurobond issuance declined. The decline of the share of the U.S. dollar in Eurobond issuance can be traced to three general trends: the depreciation of the dollar versus other major currencies from its peak in 1984, a desire by major institutions to diversify currency exposure and funding sources, and the liquidity offered by the swaps and other derivatives markets.

Accessing International Bond Markets through Other Vehicles

Adding international bonds to a fixed income portfolio has allowed investors to broaden their investable universe. At the same time, investors can enjoy the benefits of diversification. However, for individual investors, accessing these markets can be difficult as a result of lack of transparency in prices, wide bid/ask spreads and costly transaction fees. As individual investors have become more educated regarding the characteristics of international bonds, investment products have been developed that offer more efficient access to these markets. Two products that have seen a large inflow of funds and have in turn fostered the growth of international debt markets include global bond mutual funds and exchange-traded funds.

International Bond Mutual Funds

Although many international bond funds and emerging market debt funds have been in operation since the late 1980s, the real growth of these products commenced in the past decade. These bond mutual funds have been particular beneficiaries of investor demand for additional yield, yet still remain a small part of total fixed income mutual fund assets. Of the over $2 trillion in taxable bond funds as of December 2010, about $200 billion was invested in international fixed income assets.[9]

U.S. investors typically have added these funds to their portfolio for diversification purposes and to gain non-dollar exposure. With daily pricing transparency and professional active or passive management, global bond funds offer investors another avenue to access the international debt markets.

Bond funds that invest in fixed income assets abroad encompass many strategies. More generally, however, three primary categories exist: emerging markets debt funds, global bond funds, and international bond funds. Emerging market debt funds invest the majority of their assets in emerging market countries which are determined by specific rating agency criteria. Global bond funds invest in debt both within the United States and abroad. As a result, these funds incur U.S. dollar exposure. International bond funds, however, maintain no exposure to U.S. dollars since their assets are invested in countries *excluding* the United States. Corporate, sovereign, supranational or other debt could all be potential investment based on the individual guidelines of each bond fund.

International Bond Exchange-Traded Funds

Just as global bond mutual funds offer a breadth of strategies and opportunities for investors, exchange-traded funds (ETFs) dedicated to fixed income—and in particular international fixed income—have greatly increased in size. Of the nearly $1 trillion in assets dedicated to ETFs as of December 2010, about 15% of

9. Investment Company Institute, *Trends in Mutual Fund Activity Investing*, Haver Analytics (Monthly Data, December 2010).

these assets were invested in fixed income strategies. International fixed income ETFs totaled just about 5% of total fixed income ETF assets though this segment continues to grow rapidly.

ETFs have certain characteristics that have made them attractive to investors. Like a traditional mutual fund, public investors claim an undivided interest in a pool of securities and other assets. The shares of many ETFs often trade on the secondary market at prices close to the net asset value of the shares, rather than at discounts or premiums.[10] Many have lower expense ratios and certain tax efficiencies compared with mutual funds, and they all allow investors to buy and sell shares at intra-day market prices. Moreover, investors can sell ETF shares short, write options on them, and set market, limit, and stop-loss orders on them.

Bond ETFs usually track well recognized bond indices such as the Barclays Global Bond Aggregate Index, the Citigroup World Government Bond Index, and the JP Morgan Emerging Market Bond Index. These indices represent a segment of the bond market by maturity, sector, and/or quality. Methods such as stratified sampling can reduce the number of bonds that need to be purchased to match a particular index or strategy. Actively managed bond ETFs may employ customized benchmarks and engage in various strategies, including the use of leverage when managing their international bond and currency exposures. Moreover, these strategies can take different approaches to hedging currency exposure.

INTERNATIONAL FIXED INCOME AND UNDERSTANDING CURRENCY RISK

While the diversification benefits of adding international bonds to a global portfolio of assets is generally assumed to be positive, the foreign currency element often overwhelms any other return component. For single country foreign bond investments, currency risk contributes up to 95% of overall risk as measured by volatility according to various studies.[11] The volatility and return objectives of each investor will drive the decision to hedge, partially hedge, or not hedge currency exposure.

Hedging and its implications for international bond portfolio management is a controversial topic. Some well-regarded academic studies conclude that for investors with long-term horizons, the volatility of a hedged portfolio of bonds exceeds the volatility of the equivalent unhedged portfolio. Specifically, mean reversion toward purchasing power parity provides a "natural hedge." As a result, not hedging currency exposure is better over long-term horizons (for bond portfolios, greater than seven years).[12] This argument suggests that an unhedged portfolio over long-term horizons would also offer higher returns versus a hedged portfolio.

10. "Exchange-Traded Funds (Proposed Rule)," *Federal Register*. 73:50 (March 18, 2008). p. 14618.
11. Jochen M. Schmittmann, "Currency Hedging for International Portfolios," IMF Working Paper 10/151, June 2010, p. 12.
12. Kenneth A. Froot, "Currency Hedging Over Long Horizons," NBER Working Paper, No. 4355, 1993, p. 26.

However, other more studies offer a different conclusion. According to a sample of international bond returns between 1975 and 2009, full hedging of bond portfolios was determined to be the optimal strategy in almost all cases up to five years.[13] In addition, depending on the base currency of the investor, hedging of currency risk meaningfully affects returns.

Components of Return

To the dollar-based investor, there are two components of return in actively managed dollar-denominated bond portfolios: coupon income and capital gains. Capital gains can result from either interest-rate movements or a change in the perceived creditworthiness of the issuer. Also, because of the characteristic of bonds to "pull to par" (or call price), time also plays a factor in capital gains.

In non-dollar-denominated investing, a third component of return must be considered: foreign currency movements. The U.S. investor must couple the domestic capital gain with income and then translate the total domestic return into dollars to assess the total return in U.S. dollars.

For the U.S. investor in foreign-currency bonds, the prospects for return not only should be viewed in an absolute sense, but also should be analyzed relative to returns expected in the U.S. market. The analysis can be separated into three questions.

Are International Bond Returns Entirely a Function of Currency Movements?

The answer to this question depends on the time horizon. Exhibit 19–1 shows that in six of the eight interim periods, including the 25 year period between 1985 and 2010, the income component of return proved to be the largest of the three return components, as measured by the Citigroup Non-U.S. World Government Bond Index.

Over shorter time horizons, however, foreign currency or domestic capital gains can be significantly more important. This result is similar to more recent research which states that hedging currency exposure for risk reduction purposes in international bond portfolios is prudent in time horizons of up to five years. While volatility can be reduced in these portfolios, returns can also be meaningfully limited.

Exhibit 19–2 breaks down the 1985–2010 period into annual returns to demonstrate the influence of domestic capital changes and movements in exchange rates on total returns over the short term. Domestic capital gains ranged from –10.0% in 1994 to +9.3% in 1993, and currency returns varied from –12.6% in 2005 to +25.5% in 1987. (Recall that negative foreign currency returns for dollar-based investors correspond to a strengthening in the dollar versus other currencies, and vice versa.) The income component of return varied in a much narrower range throughout the period, from a low of +2.9% in 2010 to a high of +8.3% in 1990.

13. Schmittmann, "Currency Hedging for International Portfolios," p. 40.

EXHIBIT 19–1

Average Annual Returns of International Bond Index by Components by Regime

	Contribution to Return			
Time Period	Income (%)	Domestic Capital Gain (%)	Foreign Currency (%)	Total Dollar-Converted Average Annual Return (%)
1985–1988	+7.6	+1.6	+14.6	+23.7
1989–1992	+8.0	+0.4	–0.5	+7.9
1993–1996	+7.2	+2.4	+1.1	+10.7
1997–2000	+5.5	+0.3	–4.5	+1.3
2000–2003	+4.2	+0.6	+2.9	+7.8
2004–2006	+3.4	–0.3	–0.2	+2.9
2007–2010	+3.2	+0.5	+3.9	+7.6
1985–2010	+5.7	+0.8	+2.9	+9.3

Monthly total returns in this exhibit were derived from Citigroup World Government Bond Indices. The income component of total return was computed from principal local market returns provided by Citigroup.

For individual countries, the variation in components of return can be much greater. Currency movements can be the most volatile component of return, with historical annual gains or losses as high as 20% to 30% against the U.S. dollar. Capital gains have proved much less volatile but still can generate double-digit gains or losses during periods of interest-rate volatility.

Lastly, although the income component is by definition always positive, it too can vary substantially from country to country, as noted in the comparison of bond yields in Japan and New Zealand in the discussion later in the chapter. These data show clearly that U.S.-based investors need to factor all of these components of return—income, capital change, and currency movement-on an absolute level as well as relative to U.S. alternatives.

What Is the Initial Yield Level Relative to Yield Levels on U.S. Bonds?
When the non-dollar-denominated debt issue has a higher yield relative to U.S. bonds, the income advantage will, over time, provide a cushion against a decline in the foreign bond price relative to U.S. bonds or against deterioration in the value of the foreign currency. The longer the time horizon, the greater the cushion provided by this accumulating income.

On the other hand, if the initial yield on the non-dollar-denominated debt is lower than that of comparable U.S. bonds, this income shortfall must be offset. To provide comparable returns, the foreign currency needs to appreciate relative to the U.S. dollar, or the bond needs to initially trade at a discount relative to U.S. bonds in order to realize a capital gain.

EXHIBIT 19–2

Average Annual Returns of International Bond Index by Component

	Contribution to Return			
Year	Income (%)	Domestic Capital Gain (%)	Foreign Currency (%)	Total Dollar-Converted Average Annual Return (%)
1985	8.1	2.8	21.6	32.4
1986	7.4	3.6	18.1	29.1
1987	7.2	0.4	25.5	33.2
1988	7.6	–0.5	–4.4	2.7
1989	7.7	–4.9	–5.7	–2.9
1990	8.3	–3.5	10.2	15.1
1991	8.1	5.8	1.7	15.5
1992	7.9	4.8	–7.3	5.4
1993	7.6	9.3	–2.0	14.8
1994	7.4	–10.0	9.6	7.0
1995	7.1	8.5	2.9	18.5
1996	6.7	3.0	–5.3	4.4
1997	6.2	2.3	–11.9	–3.4
1998	5.7	3.3	7.9	16.9
1999	5.1	–5.0	–4.9	–4.8
2000	4.7	0.9	–7.8	–2.2
2001	4.4	0.4	–8.0	–3.2
2002	4.1	2.8	14.0	20.9
2003	3.7	–1.5	16.0	18.2
2004	3.6	1.6	6.6	11.7
2005	3.3	0.6	–12.6	–8.7
2006	3.3	–3.1	6.8	7.0
2007	3.4	–1.0	8.8	11.3
2008	3.4	4.1	2.3	9.8
2009	3.1	–0.7	2.0	4.4
2010	2.9	–0.4	2.7	5.2

Monthly total returns in this exhibit were derived from Citigroup World Government Bond Indices. The income component of total return was computed from principal local market returns provided by Citigroup.

This latter situation when initial yields are lower than U.S. bond yields may appear less palatable for investors. However, between 1970 and 1980, bonds with the lowest income levels actually had the best dollar returns. This same result was achieved in the 1980s, when Japanese yen bonds had the world's best total returns in U.S. dollar terms despite the fact that yen bonds offered the lowest interest rates of the world's major bond markets. The underlying rationale

for this result is that bonds with low yields are denominated in currencies of countries with low inflation rates which theoretically translates into currency appreciation relative to the U.S. dollar.

Between 2000 and 2010, investors in many non-dollar-denominated debt markets benefited not only from a general decline in overall interest rates, but also a continued appreciation of these currencies versus the U.S. dollar. The high returns led to strong institutional and retail investor demand. Even the credit crisis of 2007–2009 did little to deter these trends.

What Are the Prospects for Capital Gains Relative to Expectations for U.S. Bond Prices?

This factor can be broadly discussed in terms of changing yield spreads of non-dollar-denominated bonds versus dollar-denominated issues in the same way that changing yield spreads are analyzed within the domestic U.S. market. However, several points should be considered with regard to this analogy. First, in the U.S. market, all bond prices generally move in the same direction, although not always to the same extent, whereas domestic price movements of non-dollar-denominated bonds may move in the direction opposite to that of the U.S. market.

Second, although yield-spread relationships within the U.S. market may deviate at times, in most cases there is a normal well-understood correlation. However, changing economic, social, and political trends between the United States and other countries suggest that there are few reliable relationships to serve as useful guidelines over the long term in non-dollar-denominated bonds.

Third, investors must be aware that similar interest-rate shifts may result in significantly different capital price changes. Both U.S. and international investors are very familiar with the concept of duration; that is, that equal interest rate movements will result in differing price movements depending on the individual security's current yield, maturity, coupon, and call structure. However, since international bond investors are typically focused on the higher absolute yield of these securities versus the benchmark market, they often pay less attention to the consequences of duration on similar-maturity bonds across markets.

For example, the low yield on Japanese long bonds, currently around 1.3%, makes Japanese 10-year bond prices about 15% more sensitive to changes in yield than New Zealand bonds, where yields are about 5.5%.

Thus, a 20-basis point (0.2%) decline in the yield of a 10-year New Zealand fixed-coupon government issue starting at a 5.5% yield results in a 1.55% price change, whereas the same 20-basis point move for a 10-year Japanese issue with a starting yield of 1.3% equates to a 1.90% price change.

When the more commonly analyzed effects of varying maturities and differing yield changes are added to the impact of different initial yield levels, the resulting changes in relative price movements are not intuitive.

Finally, changes in credit quality can have a dramatic influence on bond prices. Dislocations in credit markets, such as that experienced in Argentina in 2001 or with financial institutions during the 2007–2009 period can significantly

shift investor sentiment and highlight underlying structural weaknesses in these instruments. As a result, corporate debt premiums in addition to sovereign spreads are often negatively impacted in these countries.

What Are the Prospects for Currency Gain versus the U.S. Dollar?
Like the stock and bond markets, a number of factors directly affect foreign exchange rates. The common problem faced by forecasters is whether these factors already have been fully discounted in prices and which factor will dominate at any given time. Those factors generally regarded as affecting foreign currency movements include:

1. The balance of payments and prospective changes in that balance
2. Inflation and interest-rate differentials between countries
3. The social and political environment, particularly with regard to the impact on foreign investment
4. Relative changes in monetary policy
5. Central bank intervention in the currency markets

Exchange rate forecasters have had a dismal record. The factors affecting currency movements, the interactions between each factor, and the massive flows in this market make short- and medium-term predictions especially difficult. Based on a 2010 survey conducted by the Bank for International Settlements, average daily turnover in the foreign exchange markets is estimated to be $4.0 trillion, nearly double the level five years earlier. According to the survey, the increase in turnover was driven by greater activity of high-frequency traders, more trading by smaller banks and financial institutions, and the emergence of retail investors.[14] Extrapolating trends from this deluge of information and flows is extremely difficult.

KEY POINTS

- International bonds, both dollar-denominated and non-dollar-denominated, represent a significant and growing share of the world's fixed income markets.
- Dollar-denominated international bonds generally have similar characteristics as domestically issued bonds and respond to similar market factors.
- The potential returns—and risks—are higher in non-dollar-denominated international bonds, which require greater expertise to effectively manage the currency risks unique to global bond investing.

14. King, Michael R. and Rime, Dagfinn, "The $4 trillion question: what explains FX growth since the 2007 survey?", Monetary and Economics Department, *BIS Quarterly Review,* Basel, Switzerland, December 2010, p. 28.

- Dollar-denominated fixed income instruments, which include Eurodollar bonds, Yankee bonds, global bonds, emerging market debt, Reg 144A debt offerings, and Euro Medium Term Notes, have fostered growth in international bond markets.
- The prefix *Euro-* in international bond markets has come to mean offshore, or debt issues that are marketed outside any domestic jurisdiction in a denomination other than the local currency.
- Non-dollar-denominated debt, including foreign bonds, Eurobonds, and local currency domestic debt, potentially offer greater return opportunities but with additional risk given the exposure to foreign currency.
- The components of return in non-dollar-denominated bonds include income, domestic capital gains, and foreign currency returns.
- The potential investor base for international fixed income assets has broadened as a result of the rapid growth of bond mutual funds which invest abroad (such as emerging market debt funds, global debt funds, and international debt funds) and ETFs dedicated to international bond strategies.
- International bond investors need to consider volatility and potential returns resulting from currency hedged and unhedged portfolios.
- Over shorter time periods, currency volatility and returns dominate international bond portfolio returns, suggesting that hedging such exposure may be beneficial. Over longer time horizons, the income component of fixed income securities exhibits positive returns suggesting that hedging may be unnecessary.

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CHAPTER
TWENTY

EMERGING MARKETS DEBT

JANE SACHAR BRAUER
Director
Merrill Lynch

Emerging markets are comprised of nations whose economies are viewed as developing, or emerging, from underdevelopment. It usually includes most or all of Africa, eastern Europe, Latin America, Russia, the Middle East, and Asia (excluding Japan). Additionally, some investors use credit rating as a criterion, viewing an investment-grade credit rating as an indication that the country has fully emerged. Some of these emerging economies are heavily dependent on commodity exports, whereas others have extensive service and manufacturing sectors. Emerging markets debt includes sovereign bonds and loans issued by governments, as well as fixed income securities issued by public and private companies in emerging market countries. The assets could be denominated in any currency. Many of these countries had defaulted on bank loans in the 1980s and began the 1990s by converting defaulted commercial bank loans to restructured sovereign bonds, known as *Brady bonds*. While the early to middle 1990s might be thought of as the era of defaulted loans to global restructurings, the late 1990s onward will be thought of as the era of defaulted bonds to new bond restructurings. We discuss the defaults, restructurings, and current status of the asset class.

THE DEBT UNIVERSE

Emerging markets tradable debt stock is over US$3 trillion. The tradable debt universe expanded throughout the 1990s, but the rate of growth of debt generally was slower than the annualized growth rate of the economies. This is partly due to a collective improvement in fiscal stances throughout emerging markets that led to a reduced need to borrow.

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Domestic versus External Debt

Domestic debt is issued locally under the local laws of the country in which it is issued, whereas external debt is issued externally under the laws of a foreign country. Domestic debt comprises 77% of the total emerging markets tradable debt universe. The lower liquidity, frequent investment restrictions, varied practices, and higher convertibility risk make trading in domestic bonds more difficult for foreign investors than trading in external bonds. As a result, most emerging market investments by foreign holders are concentrated in external debt.

Among external bonds, the majority are sovereign bonds. The outstanding face value of external sovereign bonds in the market has reached US$440 billion as of year end 2003, with the vast majority of growth through issuance of *global bonds* or *Eurobonds,* terms that are often used interchangeably.[1] At the same time, the outstanding face value of sovereign Brady bonds has declined from US$170 billion to US$42 billion as a number of governments have either retired their more expensive Brady debt or defaulted.

Debt Stock by Region

Latin America and Asia continue to dominate the external tradable debt universe. Tradable debt excludes nontradable debt such as International Monetary Fund (IMF) loans but is not necessarily liquid debt. Tradable debt should not necessarily be considered debt qualifying for benchmark indexes because the latter has an additional requirement of liquidity for valuation purposes. Since 1999, the regional breakdown of outstanding debt has been relatively stable. Latin America now represents 48% of total debt outstanding; Asia, 25%; emerging Europe, 20%; and the Middle East and Africa, 7%. In the case of Latin America, high sovereign refinancing needs have resulted in higher levels of new issuance, and corporate borrowers continue to gain access to the international capital markets. In Asia, as countries have repaid emergency multilateral financing packages, they have issued increasing amounts of domestic bonds relative to external bonds, causing domestic debt to comprise 89% of the outstanding emerging Asian debt. In contrast, domestic debt is only 57% of the outstanding debt in Latin America. While the majority of external sovereign debt is from Latin America, domestic debt is large in both Latin America and Asia.

Diversification of Issuers

Since the early 1990s, there has been an expansion of the stock of external debt in terms of both the amount of debt per country and the number of countries issuing external debt. External debt issuance since 1996 has been running at an average rate

1. A Eurobond is a bond that is issued and sold to international investors and is not subject to registration. A global bond is a bond that is registered in the jurisdictions of the major financial centers.

of about US$70 billion annually compared with about US$30 billion during the early 1990s. Over half the issuance is sovereign debt. The increase in the number of issuing countries has been beneficial to investors seeking diversification whose investment performance is benchmarked against an index, because it has reduced the concentration of the largest countries in any of the major emerging market indexes. The major market indexes typically are comprised of outstanding external sovereign debt with sufficient liquidity to provide daily pricing. External bonds have few trading restrictions and therefore are of greatest interest to nonlocal investors. In contrast, local bonds in many countries have trading restrictions, preventing foreign investors from easily entering or exiting the market. In addition, sovereign bonds are more liquid than most corporate bonds and offer more accurate index valuation. In the last few years, investors have become increasingly interested in local currency investments, and such local market indexes are beginning to play a role in the asset class as well.

Since 1991 when the external debt market indexes began, the number of emerging market countries has increased from 4 to over 35. This was a result of large countries with bank loans converting those loans to bonds and smaller countries beginning to tap the external debt markets. For example, the Merrill Lynch Emerging Markets Sovereign Plus Index (IGOV) includes all emerging countries rated BBB+ or below and currently has a face value of about US$238 billion as of 2004. In this index, the five largest countries comprised 98% of the index in 1993 but only 66% over a decade later.

While 98% of the market capitalization at inception of the IGOV was concentrated in Latin America, over the last 12 years, eastern European, African, Middle Eastern, and Asian markets have gained market share. This has left Latin America with only 58% of both the face value and market capitalization of external debt qualifying for index inclusion. A similar diversification phenomenon is true of other major dealers' external debt indexes.

Quality of Emerging Market Countries

Emerging markets as an asset class actually have improved in credit quality. It is now a diverse asset class ranging from investment-grade credits to defaulted debt. The asset class was created from weak economies that were struggling to improve after the 1980s. Many countries have pursued macroeconomic policies that allow them to better weather external shocks and reduce their sensitivity to changes in capital flows; their credit quality has improved as a result.

Despite the difficulties surrounding the Russian default in late 1998, there have been many more positive than negative ratings actions since 1998. Emerging market indexes retain many of the improved countries owing to their historical presence in the asset class. Thus the percentage of investment-grade bonds in the major benchmark indexes has risen from about 8% in 1997 to a much larger representation in the 25% to 50% range depending on the particular index. The average credit quality also rose a notch from BB–/Ba3 to BB/Ba2.

The Investor Base

As a result of the growth of emerging markets debt and excess historical returns, the profile of the emerging markets' sovereign investor base has become more diverse. Ownership was once concentrated in the hands of a few creditor banks and dealers but now is distributed more widely through actively traded global bonds.

Thirty years ago, emerging markets debt was in the form of loans from commercial banks. In the 1980s, intermarket dealers traded participations in those loans. Originally, the principal nonbank investors were high-net-worth individuals from emerging markets countries. They were the first to realize that these countries had begun to "turn the corner," and in the late 1980s, they began to repatriate their funds by buying distressed assets. This, in turn, triggered a steady recovery in asset values, which was further supported by the subsequent issuance of Brady bonds.

The high returns on these bonds increasingly attracted institutional interest. The first institutional investors were the more aggressive fund managers (hedge funds, global growth funds, dedicated emerging markets funds, etc.) and broker-dealers (including major Wall Street firms and several of the original lending banks that had participated in the Brady exchange). Soon after, "crossover" investors from the domestic high-yield bond market (where yields were no longer as attractive) began to view emerging markets as an asset class to include in their portfolios (see Exhibit 20–1).

EXHIBIT 20–1

Emerging Markets and U.S. High-Yield Spreads (Basis Points)

Source: Merrill Lynch.

With the upgrade of Poland's Brady bonds to investment-grade in 1996, U.S. corporate, Asian, and European investors became interested as well. The subsequent upgrades of Mexico and Korea to investment-grade in 2000 and 2002 upgraded the asset class still further, with substantial high-grade investors then comfortably crossing over into emerging markets debt. *Higher returns play a key role as well.* Emerging markets outperformed, with a 41% return in 1996, bringing in more investors.

After the Asian financial crisis of 1997 and the Russian debacle in the summer of 1998, capital flows to emerging markets diminished drastically. Investors quickly reduced their willingness to assume risk (flight to quality) and deserted higher-yielding assets for safer, more liquid bonds. The fear of contagion only worsened the financial crisis because developing countries were unable to raise new financing in the international capital markets. With global markets under severe pressure, the hedge-fund community collapsed and was forced to liquidate, resulting in massive price declines.

In succeeding years, however, the market has matured, as evidenced by the increase in the quality of the investor base and of the issuer base. Liquidity has improved, and volatility has declined. In addition, despite the size of Argentina's default, most of the countries "decoupled" from contagion during the year prior to its collapse, lending confidence to investors that some crises can be avoided.

As U.S. interest rates reached 45-year lows toward the middle of the 2000 decade, demand for emerging markets assets appeared from more conservative investors. A broader range of insurance companies and pension funds, in search of higher yields and diversification, began investing in emerging markets. With relatively low financing costs and many newly formed hedge funds offering the potential of levered returns, the demand for assets grew even greater.

In addition, crossover investors are motivated by the composition of the indexes against which they are benchmarked. The increasing use of broader indexes that include the BBB or better emerging markets sovereign bonds, such as the Merrill Lynch U.S. Broad Market Index or the Lehman Aggregate or Universal indexes, has brought crossover investors into emerging markets.

Since the end of the stock market bubble in 2000, pension and insurance portfolio managers have sought greater diversification. This has taken the form of nontraditional investments, such as emerging markets debt and equity, hedge-fund investments, real estate, and commodities. The wider distribution of investors provides further support for emerging markets as an asset class.

EMERGING MARKETS DEBT PERFORMANCE HISTORY

Historical Returns

Emerging markets debt has produced one of the highest returns among major asset classes. The performance of the Merrill Lynch sovereign IGOV index since December 1991 is shown in Exhibit 20–2. For the first 12 years, cumulative returns for the asset class have totaled 368%, far above the average cumulative

EXHIBIT 20–2

Total Return of Merrill Lynch Emerging Market Index as a Percent of Original Investment

Source: Merrill Lynch. The IGOV index was extrapolated to 1990 based on prices of the few Brady bonds that were outstanding before the index was created.

returns of 178% for U.S. high-yield bonds or 125% for U.S. Treasuries over the same time period. In comparison, cumulative returns of U.S. equities were approximately 106%, whereas emerging market equities posted a 6% decline. Over these 12 years, on an annualized basis, emerging markets debt has provided a 13.7% return compared with 8.9% for the U.S. high-yield market (see Exhibit 20–3).

A small part of this return is due to the Treasury rally. From the inception of the indexes, U.S. Treasury rates have fallen less than 300 basis points, or less than 25 basis points per year for the first 12 years. This accounts for about 1% of the annual return.[2] The remainder of the return can be attributed to the coupon income and price appreciation (due to spread tightening and the steady aging of low-priced bonds as they accrete to par). The end of this period came with Treasury yields reaching historic lows and emerging markets spreads simultaneously touching historically *tight* levels, providing annualized returns that could not be replicated over the subsequent 12 years.

2. A spread tightening of 25 basis points would increase the index value by 1%.

EXHIBIT 20–3

12-Year Total Return, Volatility, and Sharpe Ratio (Annualized)

	Total Return	Volatility	12-Year Sharpe Ratio
EM debt	13.7%	16.0%	0.58
U.S. high-yield	8.9%	6.4%	0.70
U.S. Treasury	7.0%	4.6%	0.57
U.S. corporates	8.0%	4.8%	0.76
U.S. mortgages	7.0%	3.0%	0.88
Equity			
S&P equity	10.7%	14.7%	0.43
Europe equity	7.7%	17.4%	0.19
EM equity	5.9%	23.1%	0.06

Note: Equity indexes with dividends.

Source: Merrill Lynch, Bloomberg. Sharpe ratio is excess return over a risk-free return divided by volatility.

Volatility and Sharpe Ratios

Periodic crises in emerging markets have brought volatility along with high returns. Over the long term, while emerging markets debt has provided an annualized 13.7% return, it has come with a 16% annualized volatility (see Exhibit 20–4). Higher risk should come with a higher return. A risk-adjusted return measure, the Sharpe ratio, is used often for equity investments. It is measured as the ratio of the return in excess of the risk-free rate divided by the volatility.

The Sharpe ratio for the last 12 years in emerging markets debt is about the same as that of U.S. Treasuries owing to the high emerging markets volatility. Mortgages have had the highest Sharpe ratio. From a Sharpe ratio perspective, emerging markets debt would have been a better investment than European or emerging markets equity, the latter two having historically high volatility and low returns.

Correlation with Other Asset Classes

Emerging markets debt has had a weak correlation with U.S. Treasury bonds, as well as with U.S. corporate bonds and mortgages (see Exhibit 20–5). The highest correlation is with the U.S. high-yield market (0.52). Low correlations give emerging markets an important role in a global portfolio. Until late 1997, emerging markets debt was very highly correlated with U.S. Treasuries. But the flight to quality during the Russian debt crisis ended that relationship. Since the Russian crisis, emerging markets returns have been far less correlated with those of the U.S. Treasury market.

EXHIBIT 20–4

12-Year Annualized Return versus Volatility

Note: Equity indexes with dividends.

Source: Merrill Lynch.

EXHIBIT 20–5

Intermarket Correlations after the Russian Crisis

	EM Debt	U.S. High Yield	U.S. Treasuries	U.S. Corpo-rates	Mort-gages	S&P Equity	Europe Equity	EM Equity
Emerging markets debt	1	0.52	0.09	0.34	0.17	0.47	0.47	0.61
U.S. high yield		1	–0.07	0.34	–0.01	0.46	0.37	0.57
U.S. Treasury			1	0.85	0.82	–0.35	–0.46	–0.37
U.S. corporates				1	0.76	–0.08	–0.26	–0.10
Mortgages					1	–0.25	–0.31	–0.31
S&P equity						1	0.85	0.75
Europe equity							1	0.72
EM equity								1

Note: Equity indexes with dividends; period from 1999–2003.

Source: Merrill Lynch, Bloomberg.

Liquidity

Average trading volume of emerging markets debt is usually about US$16 billion per day. There have been exceptions, with a temporary decline in the year following the Russian crisis to only US$9 billion per day and another drop in 2002 when global equities declined and risk appetite was low.

Many high-yield bond portfolios include some emerging markets debt, and thus high-yield managers represent an important source of "crossover" investors. Important to many fund managers is the debt in benchmark indexes. While the Global Emerging Market External Sovereign Plus Debt Index (IP00) is less than half the size of the Global High Yield Index (HW00), the liquidity is better in emerging markets. There are fewer but larger issues in emerging markets debt indexes; the average issue size is over four times larger, making pricing more transparent and bid/ask spreads narrower. Thus emerging markets debt plays a key role in high-yield portfolios, offering greater liquidity when needed.

BRADY BONDS

In 1989, the Brady Plan was introduced, named after former U.S. Treasury Secretary Nicholas Brady. It provided debtor countries with debt relief through restructuring their commercial bank debt at lower interest rates or allowing them to write it down, enabling them to exchange that debt for tradable fixed income securities. In return, the developing countries agreed to adopt macroeconomic reforms. Banks were given the choice of mainly debt (face) or debt-service (interest) reduction options. By the late 1980s, many banks had provisioned as much as 60% of the face value of their commercial loans to less developed countries (LDCs). Since some commercial banks at that time held these assets at face value, an equal face exchange enabled these banks to participate in a restructuring in which the LDC obtained some formal debt relief.

The Brady Plan grew out of the LDC debt crisis of 1982–1988. In the early 1980s, sluggish growth of industrial countries, rising global interest rates, and falling commodity prices triggered a significant economic contraction in developing countries. As a consequence, isolated from the international capital markets and lacking the level of domestic savings needed to service external obligations, most developing countries began to experience severe debt-servicing problems. The first strategy adopted to address the crisis was a program of new lending by commercial banks and multilateral organizations combined with structural adjustment efforts by the debtor countries. By 1988, it had become clear that this strategy was less than successful; the LDCs were not emerging out of the debt crisis, and a new strategy involving "debt relief" was necessary.

A total of 17 countries took advantage of the program from 1989 to 1997, issuing a cumulative face value of US$170 billion of Brady bonds.[3] The majority

3. Russia is often considered part of the collection of Brady bonds because it was restructuring defaulted debt during the era of Brady restructurings. It did not, however, conform to the actual Brady Plan.

EXHIBIT 20–6

Original Brady/Exchange Issue Amounts (US$ billion) and Multilateral Debt Relief Agreements with Commercial Banks

Country	Total Brady Debt Issued	Percent of All Bradys	Official Debt and Debt Service Reduction Agreement Date	Debt Forgiveness in Exchange Agreement	Moody's Update	Standard & Poor's Update
Latin America						
Argentina	25.45	15.0%	Apr-93	35%	Default	Default
Brazil	50.66	29.9%	Apr-94	35%	B2	B+
Costa Rica	0.59	0.4%	May-90	na	Ba1	BB
Dominican Republic	0.52	0.3%	Aug-94	35%	B2	CCC
Ecuador	6.13	3.6%	Feb-95	45%	Caa2	CCC+
Mexico	36.90	21.7%	Mar-90	35%	Baa2	BBB–
Panama	3.22	1.9%	May-96	45%	Ba1	BB
Peru	4.87	2.9%	Nov-96	45%	Ba3	BB–
Uruguay	1.07	0.6%	Feb-91	na	B3	B–
Venezuela	18.55	10.9%	Dec-90	30%	Caa1	BB–
Non-Latin America						
Bulgaria	5.13	3.0%	Jul-94	50%	Ba2	BB+
Poland	7.90	4.7%	Oct-94	45%	A2	BBB+
Ivory Coast	1.33	0.8%	May-97	50%	NR	NR
Jordan	0.74	0.4%	Dec-93	35%	Ba2	BB
Nigeria	2.05	1.2%	Jan-92	na	NR	NR
Philippines	4.21	2.5%		na	Ba2	BB
Vietnam	0.55	0.3%	Dec-97	50%	B1	BB–
Russia	26.0	na*	Dec-97	0%	Baa3	BB+
TOTAL	169.88	100%				

Source: World Bank, Global Envelopment Finance, 1999 Analysis and Summary Tables, Merrill Lynch.
*Russia was not technically a Brady structure but was similar and is often included in the amount of global debt issued in the 1990s in exchange for defaulted bank loans from the 1980s.

of Brady debt was issued by Latin America, with Brazil, Mexico, Argentina, and Venezuela representing 78% of all issued Brady bonds (see Exhibit 20–6). Almost all countries with defaulted commercial bank debt from the 1980s exchanged that debt for Brady bonds or restructured loans. Since then, most countries have been able to improve their financing budget and subsequently have been able to raise more funds in the Eurobond market. The notable recent exceptions are Argentina, Ecuador, Ivory Coast, and Uruguay. The first three countries defaulted, whereas

Uruguay conducted a successful restructuring of its debt at a time of distress without having to default. The well-known default of Russian restructured debt in 1998 was not issued under the Brady Plan but was noteworthy because of the short period that the restructured debt paid coupons (less than two years), the size of the default, and the disastrous impact it had on global markets.

Types of Brady Bonds

The term *Brady bond* refers to a series of sovereign bonds issued by these developing countries in exchange for their rescheduled bank loans. The Brady market is unique in several respects. First, yields always have been higher than on non-Brady bonds. Second, some issues were extremely large and liquid, especially compared with typical sovereign Eurobonds. Third, since the goal of restructuring the debt was to give the sovereign debt service relief in the early years, no bond was a simple fixed-rate bullet bond with all principal paid in a single maturity year. Instead, every bond had at least several combinations of features, including step-up coupons, floating-rate coupons, amortizations, long grace periods before principal began to be repaid, capitalizations, and principal and interest collateral.

Typically, in a Brady exchange for the illiquid defaulted loans, the banks were given several options, one of which included an exchange of defaulted loans for partially collateralized "discount bonds," also known as "principal-reduction bonds." These bonds required 35% to 50% forgiveness on the face value of the defaulted loans, thus providing the sovereign with debt relief (in terms of the principal amount, or "stock of debt"). They offered a "market" coupon rate of LIBOR+13/16, although a true market coupon would have been hundreds of basis points higher. "Par bonds" were issued at "par," in exchange for the original face value of the rescheduled loans, but carried a fixed, below-market interest rate. In addition, investors were given a "past-due-interest bond" whose face value was the amount of past-due interest that had accrued between the payment prior to default and the exchange date.

As each successive Brady exchange took place, the terms typically progressed more in favor of the sovereign. "Haircuts," or forgiveness (the reference to the reduction of principal due to restructuring), crept higher, collateral decreased, and creative ways were used to implicitly reduce the past-due interest calculation.

The particular bond types were chosen by creditors to provide debt and debt-service relief to the sovereign issuer. During the negotiations, creditors were presented with a choice of possible debt restructurings and were given several months in which to choose. At the time of the presentation, all options were equally attractive and produced roughly the same net present value. In their selection, some creditors were constrained by their own internal accounting requirements, whereas others were able to select the bond that provided the highest present value. Typically, these decisions were influenced mainly by the expectation of the sovereign's spread risk and movements in the U.S. Treasury market. A description of the types of Brady bonds that were issued can be found in the Appendix to this chapter.

Exchanges from defaults in the post-Brady era also have included significant haircuts. Investors have had fewer choices, and pressure to participate has been great for a variety of reasons addressed later. Exhibit 20–6 lists the Brady countries with their respective exchange dates, debt forgiveness, and current credit rating.

Brady Bond Valuation

Because almost all restructured bonds offered lower debt service in the early years, no Brady bond was a simple fixed-rate bullet bond with the principal paid entirely in a single maturity year. To account for the complicated features, emerging markets investors need to be more bond-structure-savvy than comparable investors in the high-grade or high-yield markets.

For example, a bond with collateral requires a somewhat different method of assessing value rather than merely calculating yield-to-maturity based on price. Investors value collateralized bonds by "stripping out" the collateral, giving rise to the terms *stripped yield* and *stripped spread*. Similarly, valuation of amortizing or capitalizing bonds requires a more sophisticated approach because the timing of any cash-flow is crucial in determining its value. A description of the most common methods for bond valuation can be found later in this chapter.

Retirement and Exchanges of Brady Bonds

Since the issuance of the first Brady bond in 1989, many countries have implemented economic reforms sufficiently to enable them to access the capital markets in the form of Eurobonds and global bonds, which are issued and sold to international investors. Simultaneously, many countries have made a concerted effort to retire their expensive Brady debt through various forms of buybacks. The Brady bonds that were retired through exchanges typically had lower coupons and lower prices but higher spreads than the Eurobonds that replaced them, thereby offering the sovereign net present value (NPV) savings, important economically as well as politically.

Most of the retirements were made possible by the regained confidence of the international capital markets. This enabled investors to exchange complicated structures of Brady bonds with a tainted history for clean, simple global bonds. After describing the main mechanisms for positive exchanges, we discuss in detail several distressed exchanges—as well as exchanges out of default—since 1999. The details of these exchanges are instructive in that they set precedents for future exchanges.

Public exchanges, which began on a small scale with Argentina in 1995 and on a much larger scale with Mexico in 1996, offered specific Eurobonds in exchange for one or more Brady bonds. Most of the exchanges, while keeping market capitalization fairly constant, replaced Brady bonds priced much below par with new Eurobonds priced close to par, resulting in smaller face of the new issue. These exchanges had the added benefit of reducing the total stock of debt (face) outstanding. The exchanges produced large multi-billion-dollar issues that are liquid and actively traded, led by the Brazil 2027, Mexico 2026, and Venezuela 2027.

Since issuance, sovereign issuers of Brady bonds have been able to retire Brady debt through several main approaches:

- The issuer may exercise the call option on the bond, as Mexico has done with all its Brady debt and Poland with much of it. All Brady bonds are callable at par, usually on coupon payment dates. If the bonds are called, they must be retired.
- The sovereign country may discreetly buy back their Brady bonds in the open market, as did Argentina, Brazil, Mexico, Panama, and Poland.
- A sovereign issuer may initiate a formal Brady exchange program, whereby a price or spread is preset, and bids are solicited for an exchange into a new Eurobond issue. In 1996, Mexico was the first sovereign country to participate in a large-scale Brady-to-Eurobond exchange. At that time, emerging markets were providing extremely high returns, spreads were consistently tightening, and investors were glad to have an opportunity to exchange their collateralized Mexican par and discount bonds for a noncollateralized global issue that would outperform if spreads continued to tighten. This set the tone for subsequent formal exchanges that included Argentina, Brazil, Mexico, Panama, Uruguay, Venezuela, and the Philippines.
- The issuer may offer a formal exchange into local debt. Argentina swapped numerous external bonds for local debt, with a commitment to pay the debt service from tax revenues.
- The sovereign may agree to a private exchange, whereby two to four holders of a sizable block of Brady bonds would agree to an exchange for a reopening of an existing sovereign Eurobond.
- The sovereign may accept Brady bonds as payment in certain privatizations, particularly in Brazil.
- The sovereign may default on the bonds (Argentina, Ecuador, Ivory Coast, and Russia, although the Russian default was on debt that was not technically part of the Brady Plan).
- The issuer pays amortizing principal on schedule. Most amortizing Brady bonds have been repaying large amounts of principal. In 2001, Brazil's IDU (Interest Due and Unpaid) bond became the first Brady bond to actually mature.

This trend of replacing Brady bonds for global or Eurobonds has been favorable to investors because the new bonds are far less complex than the Brady bonds they replaced, thus appealing to a wider audience.

At the beginning of 2004, only about 25% of the original $170 billion Brady bonds remain outstanding. Simultaneously, most countries have issued global bonds and Eurobonds as one of their main sources of external funding, overtaking the Brady debt as the most liquid bonds in emerging markets debt.

DEFAULTS, EXCHANGES, RESTRUCTURINGS, WORKOUTS, AND LITIGATION

Successful Distressed Debt Exchanges

Any exchange in an emerging market can set a precedent for future exchanges. This includes both distressed debt, prior to and averting a default, as well as defaulted debt exchanges. Just as each new Brady exchange offered terms that may have been less beneficial to the bondholder, each successive defaulted global bond restructuring is likely to get similar or less favorable treatment than the restructurings before it. Below is a description of the major distressed and defaulted restructurings since 1999.

Pakistan, 1999: Orderly Exchange Avoided Default

Pakistan, which did not have Brady debt, was current on its external bonds prior to its 1999 voluntary exchange. At that time, it rescheduled over US$600 million in external global bonds. It exchanged three bonds maturing over the next three years for new securities maturing in six years. About 90% of the bonds were exchanged. Investors were concerned about Pakistan's ability to make the next debt-service payment. The bond exchange was part of a larger restructuring of US$3 billion in debt, including that from government and development bank creditors, increasing the likelihood that bondholders would get paid. The bond offer prompted Standard & Poor's to downgrade the nonexchanged bonds to a default rating (D) because the exchange prevents the existing debt from being repaid on time. It was the first time Standard & Poor's had downgraded a country to the default level.

Ukraine, 2000, and Moldova, 2001: Avoided Default

Both the Ukraine and Moldova proposed a reasonable restructuring prior to payment default. Both countries had only a very small amount of global (non-Brady) debt, which was not widely held. Both countries were cash-poor, and investors were pessimistic regarding any solution to the sovereign crisis without international support, despite the fact that this support included the extension of external principal payments for several years.

Uruguay, 2003: Orderly Exchange Avoided Default

Uruguay was current on its debt service prior to its 2003 voluntary exchange, but there was great concern that the spillover effect from the contraction in neighboring Argentina was making it impossible for Uruguay to maintain its fiscal accounts because Uruguay's primary trading partner is Argentina. Prior to Argentina's default, Uruguay had an investment-grade rating. Uruguay exchanged US$4.9 billion of Brady and global debt for new securities that mature later and pay lower interest, stretching out debt payments. The exchange gave Uruguay a fiscal surplus and enabled it to draw on IMF loans, regaining investors' confidence in its ability to pay debts and revive the economy. Over 95% of the eligible bonds were exchanged, one-third of which were issued under local law.

Standard & Poor's called the swap a default and rated the nation's long-term foreign currency debt at about five levels below investment-grade after investors received the new bonds. The rationale was that the new bonds, with both a longer maturity and a lower coupon, were worth less than the old bonds in NPV terms.

Unsuccessful Distressed Debt Exchange

Argentina, 2001: Exchanges Not Sufficient to Avoid Default

In the year preceding its December 2001 default, Argentina conducted two large exchanges of debt in an effort to reduce near-term debt service by extending maturities and lowering cash coupon rates. In June of 2001, Argentina conducted its "megaswap," exchanging close to US$30 billion of local, external global and external Brady debt, much of it coming due in the near future. It swapped that debt for four external bonds, most of which paid no cash coupon for five years but instead capitalized and then stepped up to a high 12% coupon (Exhibit 20–7). Some investors, mostly local investors, hailed the exchange as the solution to Argentina's debt problem. Others were less optimistic, fearing the country's borrowing costs would soar after 2006.

Argentine local banks and pension funds were active participants in that exchange. The attractive feature for Argentina was that it significantly reduced debt service for close to five years. Yet investor confidence did not rise sufficiently, and Argentina's continued funding needs could not be sustained. In November it subsequently exchanged Brady and Eurobond debt for local loans. This exchange originally was only open to local investors, but participant restriction eventually was relaxed. The exchange was viewed as coercive; Standard & Poor's downgraded all eligible bonds to a default rating (D). Within a month, the sovereign declared a moratorium on the payments of US$95 billion of external debt, the largest sovereign default in history.

EXHIBIT 20–7

Argentina's "Mega" Exchange, June 2001

Face	Maturity	Currency	Initial Coupon	Step-up Coupon
US$11.5 billion	2008	USD	7%	15.5%
US$7.5 billion	2018	USD	Capitalizing	12.5%
US$8.5 billion	2031	USD	Capitalizing	12.0%
ARP0.9 billion	2008	Peso	10%	12.0%

Source: Merrill Lynch.

Restructuring after a Default

Below is a summary of the large Russian and Ecuadorian defaults and subsequent restructurings, together with a description of the much larger and more complex Argentine default in late 2001.

Russia, Ecuador, Ivory Coast, and Argentina defaulted on their restructured debt in 1998, 1999, 2000 and 2001, respectively. Russia's debt was not formally under the Brady Plan, but it was restructured debt that was current for only slightly over a year. Ecuador was the first country to default on Brady bonds. In 2000, both countries restructured their US$40 billion defaulted debt into US$27 billion of Eurobonds. Ivory Coast defaulted in 2000, but creditors did not vote to accelerate the bonds, likely because the size was small, as was their ability to pay.

Russia Defaulted Debt Characteristics

Russia defaulted on local debt and US$32 billion in two external debt obligations from the Soviet era Vnesheconombank, a loan and a bond, neither of which cross-defaulted to Russian federation external bonds. Russia did not default on any of its Russian-issued Eurobonds. The principal debt obligation was a participation loan that traded as low as $6.

Ecuador Defaulted Debt Characteristics

Ecuador was more diverse, with six bond issues totaling US$7.7 billion face. The PDIs (Past-Due Interest Brady bonds) were the only liquid, noncollateralized Brady bond. The Ecuador 2002 was an extremely illiquid global bond issued in 1997 and held primarily by banks. The only other global bond outstanding never traded. In the end, the two global bonds received preferential treatment, but the time frame in which investors could address inequities was too short to allow them to act on it. The "haircuts" for all but the IEB bond were determined in a consistent fashion—all cash-flows of defaulted debt of these bonds were discounted at 11.25% (the rate of the most recently issued fixed-rate Eurobond). Investors received new bonds whose face value was based on this NPV.

The IEBs (Interest Equalization Bonds) had differential treatment. Since over 50% of the IEBs were held by a single investor, in order to encourage participation in the exchange, the bond received better terms than the other Brady bonds. For the new bonds, nonfinancial terms were used as leverage to encourage participation. In addition, investors were caught by surprise with only about two weeks between the exchange offer announcement and the date in which to accept the offer. A minimum participation rate was specified. If there was a failure to meet the minimum participation rate, additional past-due interest would accrue, and the structure would no longer be viable. This forced investors to act rather than to argue over inequities.

In addition, if Ecuador defaults on this new debt, bondholders can revert to their original claims (higher face value) that existed before this exchange took place, thus offering further protection.

EXHIBIT 20–8

Status at the Time of Default (US$ billion)

Country	Argentina	Russia	Ecuador
Debt stock at time of default	$148	$171	$17
Defaulted stock of debt	$95	$25 external $40 local	$6.4
Debt/GDP shortly after default	113%	63%	124%
Debt/exports shortly after default	416%	241%	313%

Source: Merrill Lynch.

Argentina Defaulted Debt Characteristics

While the agreements of the Russian and Ecuadorian exchanges offer a guide to investors on how the next restructuring might unfold, the Argentine restructuring is more complex for several reasons. First, the size and disparity are enormous—US$95 billion total face defaulted external debt obligations cover over 80 individual external bond issues in eight legal jurisdictions and in multiple currencies. Second, there are many more disparate parties with their own agendas coming to the negotiating table. Many of the investors are original or early holders, who need a less negative return on their investments. They thus may push hard to get better terms than those of the recent Russian exchange. The Russian debt originated from Soviet loans and had a tumultuous history, having been through a default, a restructuring, and another default. Most of the debt had turned over and, at the time of the restructuring, was held by investors who bought it at extremely depressed prices. Restructured values in Argentina likely will be lower than those in Russia. A comparison of Russia, Ecuador, and Argentina's debt ratios at the time of default is shown in Exhibit 20–8. Defaulted bonds do trade, although far less than paying bonds. A view of bond prices after default is shown in Exhibit 20–9. A description of the new bonds and the terms of the exchanges from defaulted debt to new bonds is found in Exhibits 20–10 and 20–11, which describe the important precedent-setting terms for future exchanges. An indication of spreads of new bonds after an exchange is given in Exhibit 20–12. At the end of 2003, Argentina owed multilaterals (such as the IMF and World Bank) US$30 billion and subsequent to the default had issued a sizable amount of senior local market U.S. dollar–denominated debt (over US$20 billion).

Exchanges typically have three components: principal, past-due interest, and cash. *Principal* often has a "haircut," or reduction in face, and is replaced with a long bond. *Past-due interest* typically is treated better than principal, with part of it paid on exchange in the form of *cash,* little or no haircut, and with exchange bonds that are typically intermediate bonds rather than the longer principal bonds.

EXHIBIT 20–9

Defaulted Bond Prices Immediately Following Default (Day 0 = Default Date)

Source: Merrill Lynch.

Because of its complexity and depth, the terms of the Argentine restructuring could be worse than in prior exchanges. As an example, Argentina suggested 75% forgiveness of debt, which was unprecedented by historical standards. Argentina also suggested total forgiveness of past-due interest. With an average coupon of 10% and likely three years between default and restructuring, investors who expected to get $30 face of an intermediate bond for every $100 face of defaulted debt immediately rejected the suggestion.

Several lawsuits were brought on the payment of the currently outstanding debt. This sovereign bankruptcy on bonded debt marked the first time many disparate foreign bondholders united in an organized committee in the United States and another in Europe, with strong objections to the framework proposed by Argentina.

Foreign and local investors have different objectives. Argentine pension funds were allowed and even encouraged to invest up to 50% of their assets in sovereign debt, thus ensuring large demand for the many global bonds that were issued in the 1990s. During most of that time, Argentina's peso was pegged one-for-one with the U.S. dollar. One month before Argentina defaulted on its external debt, most of the pension fund holdings of external debt were exchanged for local loans that were senior to the external debt, although the coupons were lower and the maturities had been extended. The focus of the Argentine restructuring is equitable burden sharing.

EXHIBIT 20–10

Description of Newly Restructured Bonds

	Date of Default and Years to Restructure	Principal Bond	Past-Due Interest Bond
Russia	1998	30-year (Russia 2030)	10-year (Russia 2010)
	1.9 years to restructure	US$18.4 billion	US$2.8 billion
		Amortizing	Amortizing
		Step-up coupon 2.25% to 7.5%	8.25% coupon
		Noncallable	Noncallable
		Obligation of Russian Federation, though PRINS were Soviet obligations	Obligation of Russian Federation, though PRINS were Soviet obligations
Ecuador	1999 default	30-year (Ecuador 2030)	12-year (Ecuador 2012)
	1 year to restructure	US$2.5 billion	US$1.25 billion
		Step-up coupon 4% to 10%	12% coupon
		Callable at par	Callable at par
		Sovereign must pay down principal on a schedule through par call or open market	Sovereign must pay down principal on a schedule through par call or open market

Source: Merrill Lynch.

The Role of the IMF

The Western nations established the International Monetary Fund (IMF) and the World Bank after World War II as "permanent machinery" to anchor the Bretton Woods system. When developing countries began experiencing debt problems in the late 1960s, the Paris Club was formed to restructure debt from export credit agencies. A decade later, the London Club was formed to deal with workouts of commercial bank debt. After the decade of the 1990s, during which countries had a significant amount of outstanding bonds rather than loans, restructuring defaulted debt required a new process. The IMF and the U.S. Treasury have played significant roles in proposing a permanent mechanism to deal with defaulted bonded debt.

A sovereign default can have global implications. Sovereigns issue their own currency and indirectly backstop the banking system. Sovereign debt is a more important asset in a country's financial system than the debt of a company,

EXHIBIT 20–11

Summary of Terms of Ecuador and Russia Foregiveness and Features

	Bond	Principal Collateral (PV)	Price 1 Month before Default	Price 2 Months before Restructuring	Principal Haircut of Face	Amount PDI and Past Due Principal	PDI Foregiveness	Cash Payment
Ecuador	Par (principal Brady)*	23.5*	37	35	60%	5.0	0	4.1
	Disco (Principal Brady)*	23.5*	42	38	42%	8.2	0	4.7
	PDI (Brady)	0	29	21	22%	5.5	0	2.0
	IEB (Brady)†	0	NA	NA	0	23.5	0	22.2
	2002 (Eurobond)	0	NA	NA	0	15.7	0	12.0
	2004 floater (Eurobond)	0	NA	NA	0	15.0	0	11.3
Russia	PRIN (principal restructured loan)	0	8.75	31.125	37.5%	10.7	0	1.0
	IAN (restructured interest arrears note)	0	10.4	30.625	33%	9.1	0	0.9
Argentina	80 different bonds		43–50	Under 30 by1/04		20–25 by 1/04		

*Principal collateral was paid in cash at approximate market price; description of Brady bonds is in Appendix to this chapter.

†Majority held by a single investor.

Source: Merrill Lynch.

EXHIBIT 20–12

Sovereign Spreads (Basis Points) Just after Issue

	Time After Exchange		
	1 Week	**1 Month**	**1 Year**
Russia			
PDI (2010)	882	1043	883
30-year bond	925	1083	981
EM IGOV index	578	619	758
30-year spread over index	347	464	223
Ecuador			
PDI (2012)	1343	1202	1428
30-year bond	1309	1286	1405
EM IGOV index	645	620	753
30-year spread over index	664	666	652

Note: Merrill Lynch IGOV index consists of emerging markets sovereign bonds rated BBB or below and denominated in U.S. dollars.

Source: Merrill Lynch.

and it plays an important role in the banking system. The IMF can provide a means of providing new money in the absence of any established or enforceable system of priorities. Historically, the condition for receiving IMF support is that a sovereign must not only adhere to IMF targets for inflation, fiscal deficits, and exchange-rate controls, but also the sovereign *must* repay the IMF. There has never been IMF debt forgiveness, except in the case of some highly indebted poor countries (HIPCs), such as Nicaragua or Rwanda.

Consider the case of a sovereign that is having a liquidity shortage, perhaps stemming from fears of the country's solvency. In such a case, the IMF can offer credit, linking the financing to policy adjustments to address fears about solvency. When that support is sufficient, the sovereign can regain investor confidence (e.g., Brazil, Uruguay). At other times, when the support is insufficient or when there is no agreement by the sovereign, a default or moratorium on payments could occur (e.g., Argentina, Russia).

Distressed Debt Market-Related International Litigation

No Bankruptcy Court

There is no bankruptcy court for sovereign defaults, such as that for corporate defaults. Therefore, the outcome of most sovereign defaults is either the resumption

of payments or, in most cases, a distressed exchange. The absence of a formal bankruptcy process clouds sovereign debt restructuring. There is a debate on reforming the international financial system, with a primary focus on the need for a sovereign debt-restructuring process that would limit the risk that litigation could disrupt or delay a debt restructuring. Yet, in many cases, progress is impeded by interference from "holdout" investors. These investors do not participate in the restructuring, yet will demand payment on the original contractual agreement or will negotiate a preferred settlement for themselves through litigation. These investors typically are distressed debt funds that have large enough positions and the means to engage attorneys to sue the sovereign and then to attach assets. Furthermore, no restructuring would be possible if too many creditors did not participate. Therefore, there is a need for making the sovereign debt-restructuring process swift and orderly, reducing the holdout risk. Without a process in place, there is a fear that concerned investors would be inclined to sell their bonds before the event of default, thus actually speeding the decline and preventing the sovereign from constructing a solution.

Pari-Passu Clauses and Sovereign Immunity

Investors have won judgments against a sovereign issuer in default. However, in contrast to corporate defaults, it is very difficult to attach the assets of a sovereign.

There is a more favorable legal climate in continental European law than that in Britain and the United States for attaching assets. In continental Europe, successful litigators have attached the Central Bank's assets of a sovereign whose claims they are holding.[4] In addition, central banks that are incorporated separately for commercial purposes do not enjoy immunity; only the sovereign does. The Foreign Sovereign Immunities Act of 1976 precludes a waiver of immunity of prejudgment attachment of the accounts of a foreign central bank. Since then, a number of common-law countries have adopted similar legislation on sovereign immunity. On the other hand, in continental Europe, foreign central banks generally are treated as entities separate from the foreign state, and as a consequence, the assets of central banks enjoy little or no protection. Deutsche Bundesbank, during one litigation case, considered amending the law (via Parliament) on the nonimmunity provided to a sovereign whose assets are deposited with a German bank.[5]

These laws have an impact on nonparticipants in distressed exchanges. Another avenue open to nonparticipants involves wire transfers. In the United States, an attachment order can only reach wire transfer either before it is initiated or after payment is completed. However, Europe does not have an equivalent law. A distressed investor was able to intercept payments from a sovereign on restructured debt to bondholders in Europe.[6]

4. Cardinal versus Yemen and Leucadia versus Nicaragua.
5. Cardinal versus Yemen.
6. Elliot versus Peru.

Two Well-Known Holdout Cases Have Set Adversarial Precedents

Dart versus Brazil

The Dart family held US$1.4 billion principal claim of defaulted Brazilian loans before the Brady exchange in 1993, for which they had paid about 30 cents on the dollar. The face value-of-claim was US$2.2 billion of principal plus interest. In the litigation, there were no attachments or accelerated payments. The original debt instruments were securitized in a pass-through trust vehicle, and payment is being made in full by Brazil on the original maturity schedule.

Elliot Associates versus Peru

The practices of "vulture funds" that buy cheap sovereign debt in the secondary markets and then sue for full repayment plus interest came to international attention in the case of Peru. Elliot Associates LP, a New York–based hedge fund, purchased pre-Brady loans at a deep discount in 1996 and then actually took the government of Peru to court instead of opting for a restructuring agreement. It won the legal battle, and the Peruvian government eventually paid it more than US$58 million.

This incident is one of the few times a single bondholder has taken a government to court and collected complete repayment of defaulted debt. Elliot's successful litigation was based on an interpretation of the *pari-passu* clause. *Pari-passu* means that unsecured creditors are ranked equally. Therefore, the argument goes, if nonholdouts get their (new) claim, holdouts also should get their original (full) claim. A claim is only as good as the claimant's ability to collect. Unlike corporations, sovereigns generally do not have assets outside the country without sovereign immunity, and thus, even with a judgment, it is difficult to collect.

Elliot located what were technically and legally Peruvian assets in Belgium. This is where the clearing agent, Euroclear, is located and where Brady payments are transferred prior to crediting the bondholders. Elliot went to court to prevent Euroclear from crediting investors with any amounts originating from Peru before Peru paid the Brady bondholders.

Implications from These Cases Caused Ecuador to Be Cautious

As a result of the Elliot versus Peru case, Ecuador decided to become current on payments to the small fraction of original Brady holders who did not participate in the 2000 exchange. These and other litigations have enabled some holdouts to get paid. In some cases, these holdouts have sued for full payment on the nonrestructured debt even after a restructuring has taken place. Uruguay also chose to continue paying the small percentage of investors that did not participate in the exchange, although there was no default. Without the ability to develop a restructuring plan that would be approved by a supermajority of creditors binding on a minority, there is no way to fully protect a sovereign from the risk of holdout litigation.

Changing the Provisions of a Bond

To deal with the holdout problem and encourage maximum participation in an exchange, all contractual proposals seek to change the restructuring process by

changing the provisions found in sovereign debt contracts, allowing a supermajority to vote on restructuring terms.

New York Law Documentation

A standard New York law contract requires the unanimous consent of all creditors to change "key financial terms" (payment dates and amounts). All other terms typically can be amended with the support of one-half or two-thirds of the outstanding bondholders. Some New York law bonds also require that 25% of the bondholders agree before litigation can be initiated.

English Law Documentation

A standard English law contract allows a supermajority of bondholders (typically 75%) present at a meeting that meets quorum requirements to amend all the bond's terms, including the bond's payment dates and amounts. Many English law bonds also have provisions that make it difficult for an individual bondholder to initiate litigation.

Collective Action Clauses

Collective action clauses (CACs) under New York law have begun to be included in many bonds since Mexico introduced them in 2003. A collective action clause defines how many bondholders are needed to agree on a change in the repayment terms of a bond, in order to effect the change and make it applicable for all bondholders. The CACs were introduced to deal with rogue creditors. CACs already exist in bonds sold under the laws of the United Kingdom.

The Mexican terms specify lower percentages required to change both financial and nonfinancial terms of the bonds. The typical structure allows 75% to 85% of bondholders to amend a bond's financial terms, as long as no more than 10% of the bondholders object. Financial terms could include payment dates and amounts. The remaining nonfinancial terms could be amended only with the support of 75% of the bondholders. Also, certain provisions that relate to the ability of creditors to sue to collect on their bonds could not be amended at all.[7]

DERIVATIVES

In addition to cash bonds, active derivatives and repo markets in both Brady bonds and Eurobonds, have given institutional investors leverage and enhanced opportunities to express a view or take advantage of relative mispricings in the market.

7. Issuers use only a few jurisdictions for international bond issuance. New York is by far the largest jurisdiction, followed by England and Germany. German law bonds traditionally also have lacked clauses, but German law is being used less in new issuance following introduction of the euro.

EXHIBIT 20–13

Emerging Market Credit Default Swaps (Over US$1 Billion Volume per Day)

Source: Emerging Markets Traders Association.

Credit Default Swaps

Emerging markets credit derivatives evolved alongside the rapid growth of the corporate credit derivatives market.[8] Credit default swaps (CDS) have grown to play a major role in emerging markets investing and hedging. CDS exposure is similar to the exposure of a floating-rate note investment. Both bond spreads and CDS spreads relate to credit default risk. A CDS offers investors an alternative way of going long or short a particular credit. Exhibit 20–13 shows the distribution by country of the US$1 billion CDS that trade daily. South Korea and Brazil are by far the most actively traded countries.

In some countries, a CDS offers opportunities to short the market that might otherwise not be possible because, for example, the available bonds have long maturities. Shorting a bond in many countries can be difficult or expensive owing to lack of liquidity or lack of a term repo market, but taking a short market position via a CDS is not only easier, but the cost is known. Companies with investments in emerging countries have used the sovereign CDS market extensively to hedge the overall sovereign risk or to determine what return they should target when lending to various private projects or valuing the purchase of a local asset.

8. Credit default swaps are discussed in Chapter 68.

Creating a long position via an emerging market CDS almost always offers higher returns than investing in a cash bond. Other uses are to obtain exposure to a maturity in which there is no cash bond, for leveraged investing, for trading strategies on a relative value or curve mispricing basis, and for risk management purposes for emerging market lenders or investors. Furthermore, CDS has offered the market a tool for assessing relative value among bonds.

A CDS is analogous to insurance on the price loss of an investment due to default. In a CDS of a given credit, counterparty A pays counterparty B a periodic payment (CDS spread), which can be thought of as an insurance premium. In exchange, party B agrees to pay par for one of the issuer's eligible bonds should a default occur, which would be akin to making a claim on the insurance policy. The counterparties generally are referred to as the "protection buyer" (who pays a premium) and the "protection seller" (who makes the contingent default payment or buys the eligible bond for par in the event of default). The CDS contracts specify what credit events are considered default, for purposes of making the contingent claim, and what assets are deliverable for par. Dealers use documentation from the International Swap and Derivatives Association (ISDA).

CREDIT-LINKED NOTES (CLNs)

A credit-linked note (CLN) is a common emerging markets asset that offers investors credit exposure to an issuer in a structure resembling a synthetic corporate bond or loan but typically with a higher spread. Similar to a bond, a CLN allows an investor to take credit risk on a bond in return for payment of interest and repayment of par. A common structure is issuance by a special-purpose vehicle (SPV) that holds collateral securities financed through the issuance proceeds. The credit-derivative CLNs are created by embedding credit derivatives in an SPV.

The CLN has three main components: the SPV, the collateral, and the credit default swap. The issuance proceeds from the CLN are used by the SPV to purchase preagreed collateral to fund the CDS. The SPV simultaneously enters into a CDS with a highly rated swap counterparty (such as a dealer), whereby it sells credit protection in return for receiving an ongoing premium. The SPV grants a security interest in the collateral against the SPV's future performance under the preceding default swap. The SPV also may need to enter into an interest-rate swap (or a cross-currency swap) to reduce interest-rate risk and to tailor the required cash-flows of the note. The package is a CLN that performs similarly to a sovereign bond. CLNs are bought by investors who appreciate the increase in yield versus a sovereign bond and do not need liquidity.

Credit Exposure of the Investor

An investor in a CLN has exposure to the CDS reference issuer, credit risk associated with the collateral securities, and counterparty risk associated with the protection buyer or swap counterparty. However, to the extent that the preagreed

collateral is highly rated and also that the swap counterparty is highly rated, most of the emphasis is on the credit risk of the CDS.

Repos

Emerging markets debt tends to be more technically driven than other low-quality markets because of the large issue sizes and liquidity. It is one of the few bond markets in which investors can take either long or short positions. As such, the emerging market repo market developed depth long before the high-grade repo market. When financing rates were high, in the 5% to 7% range, it was common to be able to finance or borrow the more liquid bonds for three- or six-month terms, with financing desks providing liquidity as they traded the financing curve. Bonds that were in high demand from investors' short positions could be borrowed at rates hundreds of basis points below general collateral financing rates. This provided an opportunity for a repo desk to profit from part of the spread of the special rate of the borrowed collateral. Low financing rates close to 1% diminish the activity and liquidity of the emerging market repos.

VALUATION METHODS

Zero Spread

The common approach to valuation in emerging markets is to spread off the zero-coupon curve Every bond's cash-flows are modeled, with projections of future coupons on floating-rate bonds based on the forward LIBOR curve. After the cash-flows are projected, each resulting risky, noncollateralized cash-flow is discounted by a zero-coupon Treasury rate plus a spread. This spread is the "spread over the curve" or "stripped spread." Dealers vary according to the particular Treasury curve they use, and many investors now use the spread over the zero-coupon curve implied by the swap curve. This spread is often called *spread over swaps.*

Modified Cash-Flow

The modified cash-flow (MCF) method offers a way to account for the rolling interest guarantee (RIG) of a bond with interest collateral. The interest payments in these bonds are partially collateralized by amounts sufficient to cover a specified number of coupon payments. The interest guarantee is characterized as a rolling interest guarantee because the guarantee "rolls" forward to the subsequent interest period if not used.

Although the interest collateral does not currently cover the later coupons, these coupons still benefit from the RIG as each interest payment is made. The objective of the MCF approach is to simulate the rolling nature of the interest collateral as each successive coupon is paid. For example, if two semiannual coupons were guaranteed, a coupon that was due in five years would have sovereign risk for the first four years but would have the AA-rated collateral risk during the fifth year.

To reflect this and measure sovereign risk only, the coupons are modified through a continuous manner of discounting and moving forward each coupon by the specified number of periods in which the coupon would be guaranteed if the collateral rolled. This effectively simulates the process of selling each coupon for its present value as soon as each successive interest payment becomes guaranteed.

In this example, at the end of year four, the tenth coupon could be sold at a discount with no sovereign risk. The set of proceeds generated from the sales represents the modified cash-flows. The investor can now calculate an internal rate of return on a collateralized Brady bond using the MCF and a stripped price. The stripped price is the price of the bond less the present value of its principal collateral (discounted at the U.S. Treasury STRIP rate) and the present value of its interest guarantee (discounted using the swap curve to reflect the AA-rated collateral). In the preceding example, the first two guaranteed coupons are discounted to the settlement date and subtracted from both the price and the cash-flows. The stripped yield and stripped spread (the spread over the U.S. Treasury zero-coupon curve) are perceived as a representation of the market's view of that country's level of sovereign risk. Using these calculated risk values, an investor is able to identify relative value between collateralized Brady bonds and noncollateralized bonds.

Valuing Floating-Rate Bonds

Unlike most corporate bonds, many Brady bonds pay floating-rate coupons that reset at six-month LIBOR plus a constant spread for some or all the coupon periods. To value these bonds, investors project coupon cash-flows that are based on forward LIBOR. These forward rates are derived from the LIBOR swap curve or the Eurodollar futures curve. As U.S. Treasury rates rise or fall, forward LIBOR rates also rise and fall. Thus floating-rate bonds are significantly less sensitive to interest-rate movements in the U.S. market than are fixed-rate bonds.

Embedded Options

Aside from the par-call feature of all Brady bonds, certain par and discount bonds carried *value recovery rights* (VRRs) or *warrants*. VRRs give bondholders the opportunity to "recapture" some of the debt and debt-service reduction provided as a result of the exchange if future economic performance and the debt-servicing capacity of the sovereign debtor improve. The rights are a mechanism by which the issuing country shares with its creditors a portion of the incremental revenue generated by, for example, a consistent increase in oil prices (Mexico, Venezuela, Nigeria) or the sovereign's GDP (Bulgaria). Often, these warrants are linked to indexes of oil export prices, the country's oil export receipts (e.g., Mexico, Venezuela, and Nigeria), or the level of a terms-of-trade index (e.g. Uruguay). Mexican VRRs paid holders for over two years due to the high price of oil.

CONCLUSION

The Brady restructurings of the 1990s transformed illiquid commercial bank loans into liquid, globally traded bonds. The issuance of Brady bonds transformed emerging markets debt into an asset class in its own right.

As the asset class has evolved, defaults have occurred on external bonds since 1999, and the restructurings of those defaulted bonds have not been part of the Brady program. However, the concept has been similar in its efforts to forgive debt and reduce debt service going forward, which provides the sovereign an opportunity to rebuild its economy.

Emerging markets debt has evolved into a sophisticated market with global investors ranging from pension funds to hedge funds. It has grown tremendously over the last 12 years as it has opened its doors to international investment. While it has had well-known market shocks, it has weathered each of them as investors return to the market for its generous returns compared with other asset classes. Emerging markets debt has taken its place as a viable asset class, with product choices as extensive as those in the corporate debt markets.

APPENDIX 20

Types of Brady Bonds

COLLATERALIZED BRADY BONDS

Two principal bonds, pars and discounts, were 25- to 30-year registered bullet bonds and were the largest, most common assets, representing over half the issued Brady market. Issue size ranged from US$90 million to US$22.4 billion and, in some cases, was larger than the most liquid U.S. Treasury securities. Par bonds were issued at "par," in exchange for the original face value of the rescheduled loans, but carried a fixed, below-market interest rate.

Discount bonds, on the other hand, carried a floating interest rate and were exchanged for fewer bonds than the original loan amount but with a higher coupon. At the time of the exchange offers, the par and discount options offered about the same net present value. Most of the par and discount bonds have been retired.

Pars and discounts generally had principal secured by U.S. Treasury zero-coupon bonds,[9] which were funded originally by a combination of International Monetary Fund (IMF) and World Bank loans and the country's own reserves.

9. Collateralized bonds denominated in a currency other than U.S. dollars may have their principal collateral guaranteed by another G10 government issue.

In addition, the interest portion of the pars and discounts was partially collateralized by securities rated at least AA, to cover some of the interest (usually 12 months) on the outstanding principal. The interest guarantee is characterized as a rolling interest guarantee (RIG) because the guarantee rolls forward to the subsequent interest period if not used. Both the interest and principal collateral are maintained by an assigned collateral agent and held in escrow at the Federal Reserve Bank of New York. In the event the country misses an interest payment, the trustee pays the investors out of the interest collateral until the guarantee has been exhausted. Bondholders do not have recourse to the principal collateral until maturity.

NONCOLLATERALIZED BRADY BONDS

The types of bonds included in a given plan were determined during the debt restructuring negotiations between a consortium of creditors and the debtor country. The bonds often have varying coupon schedules and amortizations and sometimes include capitalization of interest. The bonds often were of large issue sizes and typically were referred to by name rather than by coupon and maturity, neither of which was constant throughout the life of the bond.

The most liquid emerging market bond[10] has been the Brazil C-bond, a capitalization bond that paid a portion of the coupon in cash and the remainder of the coupon in more bonds. It was issued in 1994 and did not start amortizing for 10 years. Most of the floating-rate bonds that also had long grace periods, in which no amortization payments were scheduled, have passed the grace period. Amortizations can pay down over 10 years.

As a result of the frequent capitalization or amortization, each bond carries with it a factor reflecting the proportion of the original face (excluding retired bonds) still outstanding. When purchasing a bond, *face* value of the purchase is referred to in terms of the *original* face value of the purchase at the time of issue, but the *price* is referred to in terms of the *current* face. Thus the factor is needed to determine the proceeds, as well as the interest payments.

For example, a purchase of US$10 million of a 7% bond and a factor of 0.6 and a quoted price of $80 on a coupon date would cost US$4.8 million and would pay the investor an interest payment of 7% on US$6 million bonds, or US$420,000 per year. Almost all the floating-rate amortizing bonds currently outstanding have no interest collateral. The most liquid ones are *debt-conversion bonds (*DCBs), *new-money bonds* (NMBs), *eligible interest bonds* (EIs), *interest arrears bonds* (IABs), *front-loaded interest-reduction bonds* (FLIRBs), *past-due-interest bonds* (PDIs), and *floating-rate past-due-interest bonds* (FRBs).

10. The largest and highly liquid emerging markets issue is currently the US$19.6 billion Russia 2030, a bond that emerged from defaulted debt but was not part of the Brady Plan.

CHAPTER
TWENTY-ONE

FIXED INCOME EXCHANGE TRADED FUNDS

MATTHEW TUCKER, CFA
Managing Director
BlackRock

STEPHEN LAIPPLY
Director
BlackRock

Fixed income exchange traded funds (ETFs) are a hybrid investment vehicle. Like a traditional mutual fund, a fixed income ETF is advised by an asset management firm that manages and rebalances the portfolio in accordance with stated investment guidelines. And like an exchange traded futures contract, a fixed income ETF provides investors with exposure that can be traded throughout the day on an exchange.

Fixed income ETFs possess three key attributes:

- *Exchange listing provides transparent, intraday liquidity*. This is in stark contrast to the underlying over-the-counter (OTC) bond market, which can be less transparent and less liquid.
- *A mechanism for creating and redeeming new fund shares*. The number of outstanding shares adjusts to market supply and demand. This differs from closed-end exchange traded funds, which have a fixed number of shares. As a result, fixed income ETFs avoid some of the premium and discount volatility experienced by traditional closed-end funds.
- *Targeted market exposure*. Exchange traded fund managers rebalance the funds and manage cash flows with the objective of providing risk and return characteristics that track (in the case of an index ETF) or seek to outperform (in the case of an active ETF) a published market index.

In this chapter, we discuss the characteristics of fixed income ETFs and how they compare with other fixed income instruments. We will then explore various

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investment applications of fixed income ETFs for individual investors, advisors, and institutions. Finally, we examine the structure and management of these funds as well as their trading behavior.

INVESTMENT CHARACTERISTICS

Exchange traded funds provide several key benefits:

- *Low investment management fees*. ETFs generally have lower fees than open- and closed-end mutual funds. The average management fee is 27 basis points (bps) for a fixed income ETF versus 66 bps for the average fixed income mutual fund.[1]
- *Transparency*. Holdings of most fixed income ETFs are published on a daily basis. This gives investors regular access to the funds' assets and risk exposures.
- *Intraday liquidity*. The ability to trade fixed income ETFs throughout the trading day provides investors with greater visibility into portfolio valuation, even during periods of volatility and illiquidity.
- *Tax efficiency*. The ETF creation/redemption mechanism makes ETFs more tax efficient than traditional mutual funds. When ETF shares are redeemed, the fund delivers securities in-kind (meaning that the underlying securities, rather than cash, are distributed). This in-kind distribution is not considered a taxable event for capital gains purposes. Mutual funds and other vehicles that distribute cash for redemptions must sell securities to raise the cash; in doing so, they potentially realize capital gains (or losses), which are paid to investors in the form of capital gains distributions.
- *Investment breadth*. Exchange traded funds provide exposure to a wide array of sectors for which futures and other exchange traded vehicles do not exist.
- *Risk control*. Because they are exchange traded, and because each fund's underlying securities are held in a separate custodial account, fixed income ETFs have minimal counterparty risk.[2]

Exhibit 21–1 outlines the characteristics of ETFs along with other commonly used fixed income exposure vehicles: individual fixed income securities, futures, and swaps.

1. Information obtained from Morningstar and Bloomberg as of year-end 2010.
2. There are ETFs that rely on OTC swaps to gain market exposure and, therefore, have a higher degree of counterparty risk relative to ETFs that solely hold cash bond positions to achieve their exposures.

EXHIBIT 21–1

Key Characteristics of Bonds, ETFs, Futures, and Swaps

	Bonds	ETFs	Futures	Swaps
Advantages	Highly customizable; can target exposure to any asset class	Priced, traded, and settled like stocks; broad or targeted exposure	Standardization of contracts and electronic trading enable large trading volumes and generally low transaction costs	Highly customizable; can target exposure to multiple sectors
Legal structure	Security	1940 Act Fund	Derivative	Derivative
Round-trip execution costs	Bid/offer spreads	Bid/offer spreads, commissions	Bid/offer spreads, commissions	Bid/offer spreads, possible early termination and other fees
Explicit holding costs	Not applicable	Expense ratios	Contract roll costs	Embedded financing costs
Transparency of costs	Low	High	High	Low
Notional investment	100%	100%	Margin	Collateral (variable amount)
Tracking error	Potentially high, varies by asset class	Generally low	Lower if a single deliverable exists; higher for basket of deliverables (cheapest to deliver option)	Low

(Continued)

EXHIBIT 21–1

Key Characteristics of Bonds, ETFs, Futures, and Swaps *(Continued)*

	Bonds	ETFs	Futures	Swaps
Minimum investment size	Single security	Single share	Single contract	Customized (may be based upon minimum volume criteria)
Expiration	Stated maturity	Both perpetual and end-date liquidation structures exist	Quarterly (usually)	Fixed expiration agreed upon at initiation
Liquidity sources	OTC; multi-dealer model	Exchange; multi-dealer model	Exchange; multi-dealer model	OTC; single-dealer model
Counterparty risk	Minimal	Minimal	Minimal	Significant; can be reduced via collateral arrangements

Fixed income ETFs are used by both retail and institutional investors to obtain fixed income exposure across a broad asset class or a specific sector. Retail investors utilize these funds primarily as core portfolio exposure vehicles. Institutional investors utilize the funds primarily as liquid fixed income access vehicles.

Retail Investors and Financial Intermediaries

Retail investors and financial intermediaries use fixed income ETFs alongside traditional vehicles such as open- and closed-end mutual funds and separately managed accounts, primarily through three strategies:

- *Core exposure:* As with traditional types of funds, fixed income ETFs can be used for core fixed income exposure. A core holding typically provides an investor with broad market exposure. Around this core, exposure to other sectors can be added to satisfy particular risk/return targets. The wide selection of fixed income ETFs enables investors to construct core fixed income exposure either with a single broad market ETF (such as an ETF that is benchmarked to the Barclays Capital U.S. Aggregate Bond Index) or with multiple ETFs that track various government and credit sectors which, when combined, provide broad market exposure.
- *Custom exposure*: Fixed income ETFs can provide targeted exposure to a specific market, allowing investors to tailor portfolios for specific investment objectives or constraints. This application is widely used by individuals and is especially popular among investment advisors, because it allows them to customize fixed income exposure for a large number of individual clients in a scalable way. As an example, an investor who holds a core position in an aggregate bond ETF may wish to periodically overweight exposure to investment-grade credit. The investor may accomplish this by augmenting their core exposure with a tactical allocation to an investment-grade credit ETF. Similarly, an investor may wish to shorten or lengthen the U.S. Treasury duration exposure of their core holding and may do so by blending in shorter or longer duration U.S. Treasury ETFs.
- *Market access:* The ability to target specific fixed income markets with a low-cost, liquid investment vehicle allows investors to gain exposure to market segments such as high yield or emerging markets that can be challenging to access through the underlying bond market. As an example, an individual investor may find a broad emerging market bond allocation difficult (if not impossible) to obtain using individual bond issues. However, there are a number of ETFs on the market today that allow investors to gain access to this challenging fixed income sector instantaneously through an exchange.

Institutional Investors

Institutional investors rely on ETFs' liquidity, transparency, flexibility, and relatively low-cost structure to implement the following commonly used investment strategies:

- *Cash equitization:* Cash equitization involves short-term investments of excess cash to maintain market exposure. Futures are commonly used for cash equitization due to their liquidity and ease of trading. Cash is invested in a money market account, and the futures position serves as an overlay to obtain the desired market exposure. The challenge with futures is that they offer exposure only to money markets or U.S. Treasuries. Over-the-counter swaps (e.g., index total return swaps) may provide precise, customized exposure to a variety of fixed income sectors, but may exhibit less liquidity and potentially result in higher transaction costs relative to exchange traded instruments, are subject to counterparty risk, and can be opaque and operationally intensive. Conversely, fixed income ETFs provide access to a wide range of fixed income sectors through an exchange traded vehicle.

  As an example, a manager benchmarked to a broad index—such as the Barclays Capital U.S. Aggregate Index—would ideally employ a cash equitization instrument to minimize cash drag and maintain exposure to the index. While U.S. Treasury futures are liquid, they have a very high tracking error versus the Aggregate index, due to the differences in sector exposure and the presence of the delivery option in the futures contract. A number of fixed income ETFs exist that would allow the manager to invest excess cash efficiently and cost effectively without significantly increasing portfolio tracking error.

- *Transition management:* When investors restructure their portfolios (e.g., due to changes in their manager profile or strategic asset allocation), they risk significant performance gaps and excessive costs. There is a trade-off to be managed with respect to moving assets quickly and potentially incurring higher trading costs, and moving assets more slowly, which can result in performance differences relative to the target exposure. As an example, a pension plan that is moving a significant amount of money into the corporate bond market may find that it takes days or weeks to build the desired exposure through individual bonds. While the bond portfolio is being constructed, the plan is underexposed to any market movements that may occur in the corporate bond market. Futures and OTC swaps can be utilized to quickly obtain market exposure, but the tradeoffs discussed previously would still apply. The pension plan could instead purchase a fixed income ETF to rapidly establish and maintain corporate bond market exposure while it assembles the target bond portfolio.

- *Tactical allocations:* To take advantage of a market opportunity, a tactical investor must be able to move in and out of the market quickly. Individual bonds can provide targeted exposure but are generally difficult to trade in a large, diversified basket format. Futures and OTC swaps can be utilized, but there are tradeoffs, as discussed previously.

  Fixed income ETFs combine the liquidity of futures and the diversified exposure of index total return swaps. For example, an investor favoring the wide level of credit spreads in 2009 could have purchased a corporate bond ETF far more quickly and efficiently than buying an equivalent portfolio of individual securities. Investment advisors often use fixed income ETFs for tactical plays across a large number of accounts to implement market views more rapidly and cost effectively than they could otherwise through the underlying bond market.

- *Portfolio rebalancing:* Investors typically establish a portfolio-level strategic asset allocation based on their investment objectives and risk tolerance. Once this policy is set, the challenge is to maintain these target allocations, especially in fast-moving and illiquid markets. It can be difficult to access liquidity through managed vehicles and individual securities without incurring significant transaction costs.

  Index ETFs are often used by pension plans to address these challenges as part of a core liquidity component within the broader portfolio. The ETF investment represents a portion of the exposure to each asset class. In this way, it complements, rather than replaces, the core plan holdings. The ETF portfolio provides a liquidity sleeve around the overall portfolio that can be accessed as needed to effect rebalancing. This approach allows the pension fund to maintain a strategic asset allocation without the need to continuously access the less-liquid portions of their portfolio. It is especially valuable in fixed income markets, in which bid/offer spreads in individual securities can be significant and liquidity can be discontinuous.

Advanced Applications

In addition to the more conventional applications discussed above, tactical investors may also employ fixed income ETFs in more advanced strategies involving options, short selling, and vehicles that contain packaged leverage.

- *Options:* As the market for fixed income ETFs has grown and developed, exchange traded options have been listed on a number of the funds. Trading strategies using these options can be structured in a manner similar to those employed in futures options or OTC fixed income options. Options on fixed income ETFs allow investors to

access leveraged market exposure and pursue a variety of strategies such as call or put spreads, and directional volatility bets through straddles. Because they are exchange traded, options on fixed income ETFs may be attractive relative to OTC fixed income options in terms of cost, transparency, and operational ease.

- *Short selling:* Investors who wish to short a specific fixed income sector may find that such a strategy is easier to implement through a fixed income ETF rather than through the underlying bond markets. Like stocks, shares in fixed income ETFs may be borrowed and sold short. The cost varies with supply/demand conditions in the market for the ETF and helps shape an investor's decision on whether to use the ETF or an alternative strategy to short the market. Additionally, dislocations in the cost to borrow a fixed income ETF can create investment opportunities.

  As an example, a relative value hedge fund may find that the borrow cost in a particular high-yield ETF has increased from 1% to 5%, due to a significant level of short interest. The hedge fund may choose to take advantage of this situation by purchasing the high-yield ETF and *lending* it out at a rate of 5%. (Note that borrowing and lending spreads vary.) This would allow the hedge fund to achieve the return of the high-yield ETF plus 5%. Furthermore, the hedge fund may find that the high-yield beta exposure can be hedged by shorting a basket of correlated securities. If the cost of shorting the correlated basket of securities is less than 5%, then the hedge fund earns a spread for as long as the dislocation persists. In this example, the hedge fund must also price in the potential basis risk between the ETF and the correlated basket.

- *Leveraged and inverse ETFs:* There are a growing number of ETFs that provide investors with the ability to gain leveraged long and short exposure to fixed income markets. These funds have attracted interest from investors who seek to implement short-term tactical strategies on the direction of the targeted fixed income sector and who are comfortable with the mechanics and implications of leverage. These funds typically achieve their target exposure and leverage synthetically through OTC total return swaps or exchange traded futures.

  Investors considering these investments should be aware that the majority of leveraged and inverse funds reset leverage to a target level on a daily basis. Since the benchmark itself is not levered, the use of fund leverage coupled with the impact of market path dependency and return compounding can potentially distort fund returns relative to levered benchmark returns over longer periods of time.

FIXED INCOME ETF MANAGEMENT

Because fixed income ETFs are managed funds, an investment advisor is charged with overseeing the portfolio and delivering on its investment objective in accordance with a published prospectus and Statement of Additional Information (SAI). The manager has full investment control of the positions and transactions in the portfolio. There are two primary types of funds in the marketplace—index funds and active funds.

Index ETFs

The majority of fixed income ETFs are index funds, which seek to match the performance of a published benchmark. Many fixed income securities have discontinuous liquidity, making it virtually impossible to fully replicate a broad market benchmark. For this reason, most fixed income index ETFs employ a set of techniques to sample from the broad market. These approaches, the most common of which are optimization and stratified sampling, involve creating a portfolio that contains a subset of the securities from an index that match the major risk characteristics of that index. In constructing and maintaining a portfolio, the manager must balance available security liquidity and transaction costs with the objective of creating a diversified portfolio to reduce idiosyncratic risk and better track benchmark performance.

Active ETFs

In 2008, the first active fixed income ETF was launched, nearly 20 years after the first index ETF. Like their index counterparts, active ETFs also have a stated benchmark. But unlike index funds, their objective is to outperform the benchmark. Active ETFs are not typically used by investors as liquid exposure vehicles in the same way that index ETFs have been used, as they do not have the same targeted market exposure. What active ETFs do offer is a managed alpha vehicle that can be accessed and traded throughout the day.

Managers of active fixed income ETFs employ an array of investment strategies to achieve outperformance including security selection, asset allocation, and duration management. This is similar to the management of a traditional open- or closed-end mutual fund.

As with index ETFs, active fixed income ETF providers publish their holdings on a daily basis, which creates challenges for a portfolio manager when holding concentrated positions or investing in illiquid markets. For this reason, the active fixed income ETFs that have entered the market to date are those that invest in more liquid asset classes or that hold securities until their maturity. This minimizes the chances of the manager being taken advantage of by opportunistic investors because of their posted holdings.

FIXED INCOME ETF CHARACTERISTICS AND MECHANICS

Fixed income ETFs typically provide daily transparency of holdings and pay income through monthly distributions. The liquidity provided by fixed income ETFs is supported by two complementary markets—the primary market, in which fund shares are created and redeemed, and the secondary market, in which existing shares are traded throughout the day on a stock exchange.

Holdings Transparency

A differentiating factor of fixed income ETFs is that their holdings are disclosed more frequently than mutual funds. The majority of fixed income ETF providers publish holdings on a daily basis, providing investors with continual transparency into the fund's risk profile. The exceptions are ETFs that represent share classes of mutual funds as well as those ETFs that have received specific regulatory exemptions.

Fund Distributions

As 1940 Act mutual funds, fixed income ETFs are required to distribute earned income to investors. This income reflects accrued interest earned by the fund and includes the amortization and accretion of securities purchased at a price other than par as well as securities lending income and fund management expenses. Typically, fixed income ETFs distribute income monthly. Earned income may be generally defined as:

$$\text{Earned Income} = \text{Accrued interest} + \text{bond accretion} - \text{bond amortization} + \text{securities lending income} - \text{fund expenses}$$

It is important to note that income is earned at the fund level but distributed at the share level. As a result, changes in the number of shares outstanding in a given month can result in a change in the size of the distribution on a per share basis paid to investors. Value is neither created nor destroyed, however. Any perceived surplus/deficit in per share distributions is offset directly in the net asset value (NAV). For established funds with moderate flows, this tends to result in small shifts in distributed income on a monthly basis; for smaller funds and those that experience extreme flows, the impact can be greater. Note that this income distribution mechanism is not unique to ETFs. Investors should be aware that it applies to other mutual fund structures as well.

Fixed income ETF distributions are an important attribute for investors who invest in bonds for income purposes. Distributions create a future stream of cash flows that an ETF holder will receive, in much the same way that an individual bond provides a future stream of coupon payments.

The Primary Market: Creation and Redemption of Fund Shares

Broker-dealers who create or redeem ETF shares are known as authorized participants (APs). Authorized participants generally work with both investors and ETF providers to maintain liquidity in the market.

Investors purchase and sell shares of ETFs on an exchange, trading them in exactly the same way as a listed stock. Each share represents partial ownership of the portfolio of securities held by the fund, much like shares in a traditional open-end mutual fund represent partial interest in the underlying fund holdings. What differs is the ETF's creation/redemption mechanism.

On a daily basis, the ETF provider publishes the holdings of the ETF along with the lists of securities that can be delivered for the creation or redemption of shares. When there is strong buying demand for an ETF on the exchange, market makers can sell out of their available inventory. In order to replenish this inventory, APs will purchase a portfolio of individual securities and then deliver these securities in-kind to the ETF provider in return for new ETF shares. This same mechanism works when there is strong selling pressure for a fund, which results in APs holding additional ETF shares. These shares can be delivered in-kind to the ETF provider in return for a basket of individual bonds that then can be sold. This market-driven ETF inventory management mechanism prevents a significant, persistent divergence in the price between the ETF and the underlying fund securities.

During periods of strong demand for an ETF, the price of the shares is bid up in the market. If the ETF price is sufficiently higher than the value of the underlying securities held within the ETF, an arbitrage opportunity may exist. Authorized participants could purchase the underlying fixed income securities, deliver them to the ETF provider in exchange for new ETF shares (i.e., create new shares), and then sell the newly created ETF shares in the market for a profit.

This same dynamic occurs in markets with strong selling pressure. If the ETF trades significantly or persistently below the value of the securities in the fund, APs could purchase the ETF shares in the open market (at a discount), deliver them to the ETF provider in exchange for the underlying bond holdings (i.e., redeem these shares), and then sell these bond holdings at a net profit. Arbitrage pressure keeps the ETF price in line with the value of the underlying securities.

Note that one need not be an AP in order to close an arbitrage opportunity in an ETF. As an example, if an ETF is trading at a discount relative to the value of its underlying securities, then a market participant (such as a hedge fund) may act to close the valuation gap by buying the ETF and selling short against it a basket of correlated securities or derivatives. The correlated basket could consist of individual bonds, interest rate swaps, or credit default swaps. The hedge fund would wait for the values of the ETF and the correlated basket to converge. At that time, all positions would be unwound for a net profit.

All creations and redemptions must be done at a value equal to the fund's NAV. This ensures that the value of the securities passing into or out of the fixed income ETF matches the value of the shares issued by or taken back by the fund. In this way, existing shareholders of fixed income ETFs are protected from any potential transfers of wealth during the share creation/redemption process.

Additionally, investors entering or leaving the fund transact at the *market price* of the fund, as opposed to the NAV. Market price execution is an important point of differentiation for a fixed income ETF relative to traditional open-end fund structures. In an ETF that utilizes the in-kind creation/redemption process, each investor incurs the transaction costs created by their specific transaction through the market price of the ETF (i.e., the market price should reflect the cost of share creation) and existing investors are unaffected. Conversely, in a mutual fund structure, investors enter and leave the fund at the fund's net asset value, as opposed to market price, and transaction costs are shared by all investors in the fund. Note that it is customary to value fixed income securities on the *bid* side of the underlying bond market for NAV calculation purposes, while investors typically purchase fixed income securities on the offered side of the market. As a result, a new investor may enter a mutual fund at the NAV, but the securities purchased as a result of this investor's entry may ultimately cost more than the bid side prices that were implied by the NAV. This differential is paid for by existing investors in the fund.

Such a dynamic is generally beneficial for the transacting investor but not the existing investors. An investor's choice of whether to use an ETF or a mutual fund depends, in part, on their desire to incur isolated or mutually shared costs.

The Secondary Market: The Exchange Liquidity Layer

One of the characteristics that differentiate fixed income ETFs from other managed vehicles is that the shares are listed and traded on a stock exchange. Unlike the OTC bond market, the exchange format provides for a high level of visibility into trading volumes, two-sided market levels (both bid and offer), and transaction costs. It also provides investors with the ability to control market execution by using equity trading strategies such as limit orders and stop loss orders, and employ shorting strategies by borrowing ETF shares and selling them into the market.

The level of intraday liquidity and market visibility offered by ETFs is in sharp contrast to the underlying OTC bond market where trades are negotiated directly between parties by phone, e-mail, or other medium. The OTC market creates a number of challenges for an investor. First, it is difficult to determine best execution. An investor can solicit market bids or offers from a selection of dealers, but that investor has no way of knowing whether they executed at the best available price in the market. Second, OTC markets generally provide either the bid or offer price for a transaction, whereas two-sided markets allow the investor to explicitly observe their transaction costs through the spread between the bid side and offer side prices.

One of the central benefits of ETFs is that they develop their own independent exchange liquidity layer through the secondary market as trading volume and shares outstanding grow. Secondary market activity accounts for the majority of ETF trading volume, as most transactions occur without the need to create/redeem shares and access the underlying market. This secondary market liquidity is a key benefit of ETFs in general and fixed income ETFs in particular. The liquidity layer essentially decouples the ETF liquidity from that of the underlying OTC bond market and allows investors to trade in the ETF without having to create or redeem shares. The ability to trade a fixed income ETF within the exchange liquidity layer can result in the ETF trading at a much tighter bid/offer spread than the underlying bond market. When trading demand outstrips available exchange liquidity, the market price action of the fixed income ETF may motivate dealers to access the underlying bond market in order to square orders with inventory.

Accordingly, the level of liquidity available for a fixed income ETF is not driven by the level of observable exchange liquidity alone. A large purchase or sale in a fixed income ETF may potentially absorb the existing level of exchange liquidity, which would then necessitate the creation or redemption of shares by an AP in order to balance the market. The AP would do this by accessing the underlying bond market (i.e., purchasing bonds to facilitate share creation or selling bonds to facilitate share redemption). Accordingly, the total available liquidity of a fixed income ETF is a function of not only the observable exchange liquidity but also liquidity of the underlying bond market (which is substantial in most fixed income sectors).

A fixed income ETF's total available liquidity may be thought of as the sum of:

1. Observable exchange liquidity (i.e., the average daily volume),
2. Contingent exchange liquidity that may be unlocked through the use of limit orders, etc. (which is provided by existing fund shareholders who are willing to transact at a price that is more favorable to them than what is currently available in the market), and
3. Underlying bond market liquidity that may be accessed through the creation/redemption process.

Through careful execution designed to maximize observable and contingent exchange liquidity, market participants are often able to transact in fixed income ETFs at several times the average daily volume with minimal market impact. Exhibit 21–2 illustrates the layers of liquidity of fixed income ETFs.

Exhibit 21–3 presents observed bid/offer spreads for trades on some of the largest fixed income ETFs relative to spreads in the respective underlying market. Note that, because of the robust exchange liquidity in these ETFs, their bid/offer spreads are a fraction of the underlying bond market bid/offer spreads. This is particularly pronounced in the more esoteric sectors such as high yield and emerging markets.

EXHIBIT 21–2

Fixed Income ETF Liquidity Layers

EXHIBIT 21–3

Sample ETF and Market Bid/Offer Spreads

Data obtained from the following sources: Barclays Capital and NYSE Arca. Thirty-day average, as of 12/31/2010. Funds represented: iShares Barclays Capital Aggregate Bond Fund (AGG), Vanguard Total Bond Market ETF (BND). iShares iBoxx $ High Yield Corporate Bond Fund (HYG), SPDR Barclays Capital High Yield Bond ETF (JNK), iShares JPMorgan USD Emerging Market Bond Fund (EMB), PowerShares Emerging Markets Sovereign Debt Portfolio (PCY), iShares S&P/Citigroup International Treasury Bond Fund (IGOV), SPDR Barclays Capital International Treasury Bond ETF (BWX), iShares iBoxx $ Investment Grade Corporate Bond Fund (LQD) and Vanguard Intermediate-Term Corporate Bond ETF (VCIT).

TRADING BEHAVIOR: A CLOSER LOOK AT PREMIUMS AND DISCOUNTS

The price at which an ETF trades is primarily a function of the value of the underlying securities in the portfolio and is also influenced by market flows, liquidity, and market volatility.[3]

When an ETF trades at a price above the NAV, it is said to be trading at a premium; when the ETF is trading below the NAV, it is said to be trading at a discount. Because the convention in fixed income markets is to value securities using bid-side prices, the NAV of a fixed income ETF is calculated using the bid side of the underlying bond market. Under most market conditions, a fixed income ETF will trade at a premium to this bid-side NAV.

The level of premium or discount for a fixed income ETF is a function of the bid/offer spread of the underlying bond market, the balance of ETF flows, and the level of market volatility and execution risk that a market participant takes on in executing the creation/redemption or arbitrage activity.[4]

The market price-to-NAV relationship of a fixed income ETF can be summarized conceptually as:

$$\text{Fixed income ETF premium/discount} = (\text{creation cost} \times \text{flow factor}) + \text{execution risk adjustment}$$

Where

Creation cost equals the bid/offer spread in the underlying market,

Flow factor is a scalar between 0 and 1, representing the balance of ETF flows in the market (0 = all sell orders; 1 = all buy orders), and

Execution risk adjustment equals the cost of basket execution and intraday hedging to facilitate creation/redemption.

Creation Cost

Creation cost is the cost of originating new fixed income ETF shares and is generally the largest driver of fixed income ETF premiums. The creation cost reflects the cost of acquiring bonds in the underlying market, and its magnitude varies according to the liquidity and level of transaction costs in the underlying bond market. Because the creation cost impact on the ETF premium is incurred only by new investors (i.e., those paying the market price to acquire shares on the exchange), existing investors in the fund are not affected.

3. For more detail on these market dynamics, see Matthew Tucker and Stephen Laipply, "Understanding Bond ETF Premiums and Discounts: A Conceptual Framework," *Journal of Indexes* (September/October 2010), pp. 40–48.
4. A timing effect may also arise, given that fixed income markets close at 3:00 p.m. ET while equity markets continue to trade until 4:00 p.m. ET. The timing effect is excluded from this discussion as it distorts the measurement of the premium but is not a driver of its level.

EXHIBIT 21–4

TIPS ETF Premium versus 10-Year TIPS Bid/Offer Spread

Data obtained from TradeWeb and Bloomberg, as of 12/31/10.

As bond market liquidity changes through time, so does the level of transaction costs. This leads to changes in the creation cost and, as a result, the level of the ETF premium. This dynamic was clearly observed during 2009 when there was a significant shift in market liquidity. Exhibit 21–4 depicts the premium on a Treasury Inflation Protected Securities ETF (the iShares Barclays Capital TIPS Bond Fund) versus the bid/offer spread in the underlying TIPS market during 2009. As TIPS market liquidity improved, and the bid/offer spread on TIPS declined, the creation cost of the ETF (as reflected in the premium) also declined.

Some fixed income ETFs facilitate the creation of new shares either entirely or partially by receiving cash rather than an in-kind basket of individual securities. The fund itself (rather than the AP) acquires bonds in the open market, thereby directly incurring the cost of execution, which is absorbed by existing fund investors rather than the marginal investor. These funds generally trade at a lower premium than funds that utilize an in-kind creation/redemption methodology, as the cost of new share creation is borne by existing investors and is not reflected in the ETF price.

The Flow Factor

The balance of ETF flows in the market, known as the flow factor, drives how much of the total creation cost is priced into the ETF and *where* the ETF bid/offer spread resides within the underlying portfolio bid/offer spread. The flow factor is a scalar between 0 and 1 that represents the percentage of purchases versus sales

EXHIBIT 21–5

ETF Trading Behavior in a Balanced Market

of the fund relative to the available exchange liquidity. A flow factor near a value of 1 indicates a high level of net purchases relative to the available exchange liquidity, and may result in share creations. In this case, the market price of the ETF likely reflects the offer side of the underlying bond market. Conversely, a flow factor near a value of 0 indicates a high level of net sales relative to the available exchange liquidity and may result in share redemptions. In this case, the market price of the ETF likely reflects the bid side of the underlying market.

Exhibit 21–5 represents the dynamics of the ETF liquidity layer in a balanced market and the impact of the flow factor on creation cost. The dark gray area represents the underlying bond portfolio bid/offer, or the full creation cost for an in-kind creation fund. The shaded area represents the ETF bid/offer. In markets where secondary trading flows are balanced, the flow factor will be roughly at the midpoint (approximately 0.5), and the ETF bid/offer will rest near the midpoint of the underlying portfolio bid/offer, all else being equal.

Execution Risk Adjustment

An ETF's execution risk adjustment represents the execution and liquidity risk that broker-dealers bear when executing trades and aggregating bond portfolios to facilitate share creation and redemption. Because the execution risk adjustment is a measure of execution risk, its magnitude is driven by the level of volatility and overall liquidity conditions in the market, while its direction is driven by whether the broker-dealer is creating or redeeming ETF shares (generally positive for creation, generally negative for redemption).

EXHIBIT 21–6

ETF Market Price at a Discount to NAV

Recall that the NAV represents a weighted average of the underlying bond bid-side prices and *does not* reflect the economics of a simultaneous basket execution. In less liquid or less transparent markets, the theoretical bid/offer for a given bond can be highly tenuous and may only apply to a very narrow size of execution. Accordingly, broker-dealers may encounter difficulty in sourcing or selling bonds to satisfy a specified creation or redemption basket for a certain size of transaction. The level of the execution risk adjustment reflects the uncertainty around price discovery and liquidity. In highly stressed markets, the execution risk adjustment may be significant, allowing for larger-than-normal premiums or discounts.

Exhibit 21–6 shows a situation in which market pressures have pushed the price of the ETF to a discount. Note that the ETF bid/offer is less than the theoretical bid side of the portfolio, indicating that the broker-dealer has determined that the true liquidation value received when redeeming shares lies below the theoretical bid side of the portfolio. The distance between them (the white area) is the execution risk adjustment.

KEY POINTS

- Fixed income ETFs combine many of the attributes of individual bonds, mutual funds, swaps, and futures to provide transparent, liquid, efficient, and cost-effective exposure for investors.
- Retail and intermediary investors use fixed income ETFs primarily for core or custom exposure and market access; institutional investors use these instruments for cash equitization, transition management, tactical allocations, and portfolio rebalancing.

- In the primary market for fixed income ETFs, authorized participants help maintain liquidity by increasing shares of the ETF (when demand increases) or decreasing shares of the ETF (when demand decreases). Arbitrage pressure keeps the ETF price in line with the value of the underlying fixed income securities.
- In the secondary market, investors trade ETF shares on a stock exchange. This added liquidity layer may provide significantly tighter bid/offer spreads relative to those observed in the underlying bond market.
- Fixed income ETF pricing behavior is driven primarily by movements in the underlying bond market, but is also affected by ETF fund flows and the level of market volatility.

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CHAPTER
TWENTY-TWO

COVERED BONDS

VINOD KOTHARI
Financial Consultant and Visiting Faculty
Indian Institute of Management Calcutta, India

As financial intermediaries create and hold financial assets, they search for a variety of ways to refinance them. Corporate bonds are the most traditional form of capital market-based refinancing. However, corporate bonds are a direct exposure on the issuer and are directly affected by the financial strength of the issuer. The issuer's rating determines the rating of corporate bonds. Obviously, over a period of time till maturity, these bonds are affected by the changes in the rating of the issuer, as also is the probability of default.

A country's financial system may, for a variety of reasons, want financial instruments that are either unaffected or less severely affected by the credit and rating of the issuer. Assume an issuer is creating or holding standard financial assets, such as prime mortgage loans. If a system of refinancing these mortgages allows investors legal access to the portfolio of assets, investors will prefer a claim over a pool of healthy assets over a claim over the issuer. From a policy perspective, if an issuer is allowed to issue bonds that are either solely based on the strength of the asset pool, or at least derive from the same, the issuer may hopefully issue better rated bonds, and therefore, raise relatively cheaper financing to be able to create and hold the pool of assets in question. If an issuer had to depend on corporate bonds, a low-rated issuer would not be able to raise cheaper financing, and therefore, hold healthy assets. This leads to a self-sustaining cyclicality whereby a weaker bank must hold inferior quality assets, and therefore, remain weak or become weaker.

In the world of fixed income securities, markets have been searching for instruments that are asset-backed, rather than entity-backed. Mortgage-backed and asset-backed securities are instruments that seek to detach completely from the rating of the issuer and depend entirely on the quality of the pool of assets and the structural credit enhancements, mostly to reach highest ratings. Covered bonds, the subject of this chapter, are alternative instruments that may be perceived as midway between corporate bonds and mortgage-backed securities, in the sense that they depend both on the quality of the issuer and the quality of the assets underlying the funding.

COVERED BONDS: FROM EUROPE TO THE REST OF THE WORLD

In an environment of institutional investing that is so heavily reliant on ratings of investment options, both mortgage-backed securities and covered bonds are devices to uplift the rating of the instrument above the rating of the issuer. In case of mortgage-backed securities, under an assumption of complete independence of the funding from the risks of the issuer, the securities often get highest ratings. These ratings, and the strength of the security that they evidenced, came under acute challenge during the subprime crisis of 2007–2008, making mortgage-backed securities at least periodically unpopular. The search for an alternative ended at covered bonds, which have been used in Europe over decades. Covered bonds do not have the fascination of mortgage-backed securities, but in the environment prevailing during and after the subprime crisis, the historical strength of covered bonds was far more appealing than the attractiveness of mortgage-backed securities.

Covered bonds, as an instrument of mortgage funding, have a long history. They are first said to have been issued in Germany, then Prussia, in 1769. The first issuance in Denmark happened in 1797 after the fire of Copenhagen in 1795. They are known by variety of names over Europe—pfandbriefe in Germany, realkreditobligationer in Denmark, obligations fonciers in France, and pantbrev in Spain, for example. Covered bonds have been essentially a European instrument, mostly backed by specific laws, until recently when countries outside Europe either started enacting legislations to promote covered bonds, or structurers used combination of securitization-type structuring devices using common law to create covered bonds.

In the United States, Washington Mutual became among the first to come up with U.S. covered bonds in September 2006, followed by Bank of America in the next year. Post the subprime crisis, then-U.S. Treasury Secretary Paulson came out with the Treasury's plan to promote covered bonds, including a statement of best practices. This created a promise that the United States, with its vast and unarguably the world's largest mortgage finance market, would join the list of countries that use covered bonds. Later, in March 2011, a Covered Bond Act of 2011 was presented as HR 940. Other countries too have taken legislative or regulatory measures to promote covered bonds include, for example, Australia, New Zealand, and Canada.

UNDERSTANDING COVERED BONDS

There is no uniformity in the structure of covered bonds—there are reasons why these differences exist. Before we come to the nuances of their structure, let us understand the philosophy behind covered bonds. Corporate bonds, whether secured or unsecured, have the probability of default dictated by that of the issuer. If the issuer defaults, even secured bonds will default, though one may expect a significantly higher recovery rate based on the value of the collateral.

Mortgage-backed securities, on the other hand, are presumably structured to insulate the pool of assets from the risk of bankruptcy of the issuer. Mortgage-backed securities typically attain highest ratings on the basis of credit enhancements sized up to absorb the losses of such insulated pool, to an extent that justifies the highest rating.

Covered bonds borrow from securitization framework, as also from the age-old secured bonds. Secured corporate bonds are the obligation of the issuer, and are backed by security interest in the collateral. To what extent this collateral is available in the event of bankruptcy of the issuer, and what are the prioritized or parallel claims on this collateral, is a function of bankruptcy law that differs from country to country. In the case of securitization, the presumption is that the collateral pool will remain completely aloof from the issuer and be unaffected by the bankruptcy of the issuer, thus allowing investors undeterred access to its full value. Covered bonds strike an "approximate" midway by creating a structure that combines at least the following:

- A recourse both against the issuer and the collateral pool, such that, like corporate bonds, the bond is still the obligation of the issuer, yet backed by a claim over a collateral pool that is expected to withstand competing or overriding claims in the event of bankruptcy of the issuer; therefore, there is no complete isolation of the collateral from the issuer as in case of securitization, yet there is a structure that will protect the collateral and preserve it for payment to covered bonds investors on a first-priority basis.
- The presence of credit enhancements that are expected to absorb losses, at a stress level to attain the best ratings, is common in covered bonds too. However, the credit enhancement structures used in covered bonds have traditionally been simpler than they are in securitization.
- Thus, covered bonds lean both on the credit of the issuer as also the strength of the asset pool.

STRUCTURE OF COVERED BONDS

Covered bonds are on–balance sheet securitizations. If by "securitization" is meant the transfer of a pool and its transformation into securities, then covered bonds are not securitization: They are closer to a secured bonds issuance. In a mainstream secured bonds transaction, there is no transfer of the assets to a *special-purpose entity* (SPE). On the other hand, the assets are identified, and collateral rights are created on the assets as per local secured lending law, and are placed as a security for the bonds. In the event of bankruptcy of the mortgage originator, a general secured lending law or a special law relating to the assets grants the bondholders recourse against the pool of assets, over which security interest had been created. More often than not, there are overriding and parallel claims, arising out of bankruptcy laws or other laws that erode a part of the value of the assets attributable to payment to the secured bondholders. In addition, there

would invariably be a disruption in payments to the bondholders, as once the issuer is in distress or bankruptcy, the payments thereafter would only come through the process of legal enforcement of claims over the secured assets. In other words, the secured assets are prone to the bankruptcy risk of the issuer.

Securitization structures intend to eliminate this risk by relying on "true sale"—the asset pool itself is sold using a legally defensible sale, generally to an SPE. The SPE itself is, in legal presumption, bankruptcy remote; that is, it is so structured as to be free from risk of being called into bankruptcy. Thus, securitization transactions may be taken to have insulated the asset pool from the bankruptcy risk of the issuer. That having been done, the only risk to be concerned about is the risk of credit losses in the asset pool. If there are credit enhancements present to absorb that risk to a sufficient degree, the resulting securities may attain highest rating.

The need for securitization structures to depend on isolation or true sale resulted into some consequential features. One of the most significant consequences is the correlation between the cash inflows from the asset pool and the cash outflows to repay investors. This is commonly known as the *pass through* nature of the transaction, implying that what is received, and whenever it is received, is paid out to investors. The pass-through feature leads to several implications:

- The maturity of the mortgage (or asset) backed securities is the same as that of the asset pool. For example, if the mortgage pool pays off in 20 years, the last dollar to flow to the securities will also take 20 years. There are, of course, several modifiers that come into play; for example, there may be tranches of securities, with some tranches paying before others. There may also be a *clean up call option* that allows the seller to complete the redemption once outstanding pool value becomes insignificant. However, on a holistic basis, there are no asset/liability mismatches in the transaction—the repayment of the liability, the bonds, is driven by the repayments on the assets.
- As the mortgage loans prepay, the investors get prepaid too. Therefore, the much-discussed prepayment risk gets completely shifted to investors. Once again, reallocation devices that differentially reallocate the prepayment risk to different classes of investors may be used.
- The repayment of the liabilities flows from a static pool. *Static pool* refers to the mortgages that were there in the pool when it was sold to the SPE. Hence, the mortgage backed securities will be affected by the expected behaviour of a static pool—behavior of key variables, such as prepayment rate, default rate, average rates of return, as a function of time to maturity.
- Since securitization is based on true sale of the asset, questions arise to whether what is sale in law is also a sale in accounting parlance—leading to questions of off–balance sheet treatment of the assets, and if sale treatment is attainable, there is obviously related question of acceleration of the profit/loss and upfront recognition thereof.

Let us now take the case of covered bonds. Given the fact that covered bonds are the obligations of the issuer, they do not have to exactly derive the cash flows from those of the asset pool. In other words, covered bonds are not passed on pass-through cash flows of the asset pool. There may be mismatches (however, within limits as discussed further below) in the cash-flow structure. As such, all the consequential features of securitization depending on the pass-through nature of the transaction can be avoided, or at least mitigated, in the case of covered bonds.

But here comes the key question. If covered bonds are nothing but obligations of the issuer, then what is the difference between secured corporate bonds and covered bonds? As discussed, the genesis of covered bonds lies in giving to the bondholders bankruptcy-proof access to the assets. Hence, covered bonds have to create a legal structure that may allow investors to use the collateral assets, even if the issuer goes into bankruptcy. The basis of this bankruptcy-protected right lies in either a legislation granting them a special privilege, or in the design/structure of the transaction. Accordingly, covered bonds structures, based on nature of jurisdictions, may be classified into legislative covered bonds and structured covered bonds.

Legislative Covered Bonds

A legislative covered bonds structure is one in which a special legislation gives bankruptcy protection to the investors. This goes with the very genesis of covered bonds—they were created to allow investors in the bonds to have the strength of the assets, not just the strength of the issuer. In most European jurisdictions, covered bonds legislations grant a special immunity to the assets backing the covered bonds—that the bankruptcy trustee shall not take over these assets.

Take, for instance, the German pfandbriefe. Under German law, pfandbriefe can be issued only by banks, also on the strength of a specific license issued on satisfaction of several conditions. These pfandbrief issues are expected on a regular and consistent basis, rather than on an opportunistic or sporadic one.

There are several different types of pfandbriefe permitted by the German Pfandbrief Act—mortgage pfandbriefe, public pfandbriefe, ship pfandbriefe, and more recently, aircraft pfandbriefe, each backed by the type of assets that the name implies. Public pfandbriefe are those backed by claims against public sector authorities.

The key feature of pfandbriefe is "covered assets," the collateral backing up the pfandbriefe. Depending on the type of pfandbriefe, the covered assets should be qualifying mortgages, public sector financial claims or mortgages on ships. In addition, within specific limits, claims against central banks, credit institutions, and derivatives transactions are also recognized as covered assets.

The key to the bankruptcy remoteness of pfandbriefe lies in Sec. 30 of the Pfandbrief Act. This section provides that if insolvency proceedings are opened in respect of the Pfandbrief bank's assets, the assets recorded in the cover registers shall not be included in the insolvent estate. The claims of the Pfandbrief

creditors must be fully satisfied from the assets recorded in the relevant cover register; they shall not be affected by the opening of insolvency proceedings in respect of the Pfandbrief bank's assets. Pfandbrief creditors shall only participate in the insolvency proceedings to the extent that their claims remain unsatisfied from the covered assets.

There are independent administration provisions for the covered assets. Section 30.2 provides that the court of jurisdiction shall appoint one or two natural persons to act as administrators, whereupon the right to manage and dispose of the covered assets shall be transferred to the administrator. Thus, the administrator either continues to collect cash flows from the assets or dispose it off and pay down investors at once.

Similar provisions exist in other legislations dedicated to covered bonds. Thus, in legislative covered bonds jurisdictions, the protection from the bankruptcy risk of the issuer is attained by special provisions of the legislation.

Structured Covered Bonds

There are several covered bonds jurisdictions that do not have any specific laws to supply the bankruptcy protection. In these countries, issuers have been using a combination of SPEs and a transfer of the assets, presumably to attain bankruptcy proofing. These may be called *structured covered bonds jurisdictions*.

The parties involved in a structured covered bond are

- Originator: the bank/entity that wanted to raise funding.
- SPE: the special purpose entity that is interposed in the picture, to hold legal title over the pool of assets and provide bankruptcy protection. The SPE should be so structured as to be free from the risk of consolidation with the originator.
- Cover pool monitor: an entity to ensure that the cover pool satisfies the minimum credit enhancement required by the transaction.
- Administrator or trustee: an entity that will take over the assets in the event of bankruptcy of the originator.
- Bond investors.

A typical structure of a structured covered bond is shown in Exhibit 22–1. The mechanics of a typical structured bond can be described in the following steps:

- Step 1: A structured covered bond typically has an independent SPE that holds title to the assets or the cover pool. Note the significant difference—in normal securitization structures, the bonds are issued by the SPE. In case of structured covered bonds, while the collateral or cover pool is legally sold to the SPE, the issue of bonds is done by the originator or the bank that wanted to raise funding. Hence, the bonds are the direct and unconditional obligation of the originator.

EXHIBIT 22–1

Structure of Structured Covered Bonds

The bonds are usually unsecured obligations of originator, as security interest is created by the SPE (see next). The role of the SPE is to provide a secondary recourse. Hence, in structured covered bonds, the SPE is typically a guarantor.

- Step 2: The proceeds raised through the issue of covered bonds will be on-lent to the SPE. In turn, the SPE uses these proceeds to purchase from the originator the cover pool on a true sale basis.[1] Thus, the SPE becomes the legal owner of the pool. In other words, from a legal perspective, the sale from the originator to the SPE must satisfy the legal features of a true sale. The sale, however, is not a sale from accounting viewpoint—see the discussion that follows. Also, note that the loan given by the originator to the SPE is subordinated to the obligations of the SPE to the bondholders.
- Step 3: Backed by the cover pool, the SPE provides a guarantee to covered bondholders for the payment of interest and principal on the covered bonds, which becomes enforceable if the issuer defaults. The guarantee represents an irrevocable, direct, and unconditional obligation of the SPE and is secured by the cover pool. That is, the SPE creates a security interest on the collateral pool in favor of the trustees.

1. As an alternative, the SPE buys the assets but the price for the same is kept unpaid—by way of a deferred purchase price.

- Step 4: The originator continues to collect and service the cash flows from the mortgage loans. As there is a mismatch between the payments from the mortgage pool and the payments on the bonds, the originator is allowed to (a) retain the collections from the pool; and (b) make payments toward the bonds in excess of collections from the pool. In legal sense, the originator having sold the collateral pool to the SPE now becomes the servicer. However, the cash flows collected from the collateral pool, after external expenses, are allowed to be retained by the originator as repayment of the inter-company loan given by originator to SPE. Thus, as the originator would have collected cash from the collateral pool, the inter-company loan and the purchase of assets by the SPE are squared off; that is, the SPE's obligation to repay the inter-company loan is taken to have been satisfied. On the other hand, as the covered bonds are the direct obligations of the originator, the same may be repaid by the originator periodically.
- Step 5: Although the originator holds the collateral pool and may use the collateral pool's cash flows, and may replace assets in the collateral pool or add new assets in place of those amortized or prepaid, the originator needs to ensure that the credit enhancement levels are maintained at all times. Usually, an independent cover pool monitor monitors the compliance with this requirement.
- Step 6: While the originator may add further loans to the collateral pool, or withdraw loans from the pool, the aggregate amount of collateral "sold" to the SPE must have a minimum amount of credit enhancement.
- Step 7: If originator bankruptcy event takes place, the SPE's guarantee to the bondholders kicks in. At this stage, the SPE attaches the collateral lying with the originator, and passes it on to the administrator.
- Step 8: The claims of the bondholders are paid from the cover assets. In case of a deficiency, the bondholders will have an unsecured receivable from the issuer.

COVER ASSETS AND CREDIT ENHANCEMENTS

Because covered bonds rely both on the asset pool and originator credit, it is important to ensure that the credit risk of the asset pool is absorbed by credit enhancements. While securitization transactions have used a variety of forms of credit enhancements, covered bonds have traditionally used *over-collateralization*. That is to say, the originator needs to ensure that the "cover" assets over-collateralize the outstanding bonds by the required minimum degree of over-collateralization. For example, if the required over-collateralization is 10%, for outstanding bonds of

$100, there need to be covered assets of at least $110. As the bonds are amortized over time, this over-collateralization ratio has to be maintained at all times.

In addition to this, the cover assets, that is, assets forming part of the cover pool, must also satisfy certain features laid down by either legislation or regulation, for example, the loan-to-value ratio in case of each loan. In other words, the quality of the underlying loans in the cover pool is carefully guarded by regulators.

ASSET/LIABILITY MISMATCHES AND LIQUIDITY RISK

Covered bonds are repaid independent of the cash flows of the cover pool. So, they are paid from the regular cash flows of the originator. Likewise, the cash flows received from the asset pool go and become part of the regular cash flows of the cover pool. This clearly implies an asset/liability mismatch underlying a covered bond.

If this asset/liability mismatch was completely uncontrolled, then the obligation to repay covered bonds would have been no different from an obligation to repay any secured or unsecured bond issued by the originator. Hence, the strength of a covered bond depends on how wide is the asset/liability mismatch. The asset/liability mismatch reflects the liquidity risk of the transaction. If the asset/liability mismatch is too wide, a covered bond leans too heavily on the liquidity strengths of the issuer, and therefore is no different from corporate bonds. If the asset/liability mismatch is negligible, a covered bond leans towards being a mortgage-backed security. Hence, usually, covered bonds issuers keep the asset/liability mismatch under control. The extent of asset/liability mismatch also affects the likely rating upliftment that a covered bond may receive, as discussed below.

Exhibit 22–2 shows a computation of the asset/liability mismatch done by rating agency Standard & Poor's. In this exhibit, column A shows the likely balances in the asset pool, and column B shows the likely balances outstanding of the covered bonds. As one may notice, at the inception, the cover pool value is $120, while the bonds outstanding add to $100, implying an over-collateralization of 20%. There is a mismatch between Column A and Column B, as is apparent. The outstanding balances of the assets are based on the amortization of the mortgage loans, incorporating assumptions of prepayment and default. The outstanding balances of the bonds in column B are based on the contracted repayment of the bonds. This may be seen in column D. It may also be noted that while the asset pool will take several years to fully pay down, the bonds are scheduled to be fully paid down at the end of 10 years.

The gap between the cash inflows and outflows is given in column E. Column F applies a scaling factor, giving more weight to a mismatch in earlier years and less to those in later years. The scaling factor is array of scales used by the rating agency in question.

EXHIBIT 22–2

Computation of Asset/Liability Mismatch in Covered Bonds (S&P)

Year	Performing asset balance (€mil.)	Liability balance (€mil.)	Stressed periodic asset cash inflows (€mil.)	Stressed periodic liability cash outflows (€mil.)	Net stressed periodic cash flows (€mil.)	Scaling factor (%)	Scaled net stressed periodic cash flow (€mil.)	Cumulative scaled net stressed cash position (€Mil.)
	A	B	C	D	E = C – D	F	G = E *F	H = Cumulative of G
Outstanding balance	120.00	100.00	—	—	—	—	—	—
1	114.00	90.00	6.00	10.00	–4	100	–4	–4.00
2	108.30	70.00	5.70	20.00	–14.3	95	–13.585	–17.59
3	102.89	40.00	5.41	30.00	–24.59	90	–22.131	–39.72
							—	
4	97.74	20.00	5.15	20.00	–14.85	85	12.6225	–52.34
5	92.85	20.00	4.89	0.00	4.89	80	3.912	–48.43
6	88.21	20.00	4.64	0.00	4.64	75	3.48	–44.95
7	83.80	20.00	4.41	0.00	4.41	70	3.087	–41.86
8	79.61	20.00	4.19	0.00	4.19	65	2.7235	–39.14
9	75.63	20.00	3.98	0.00	3.98	60	2.388	–36.75
10	71.85	0.00	3.78	20.00	–16.22	55	–8.921	–45.67
Maximum ALMM (€Mil.)								–52.34
								–52.34%

ALMM percentage = maximum ALMM/outstanding liability balance (%).

Finally, in column G we accumulate the asset/liability mismatches, and find the highest level of mismatch. This is defined as the asset/liability mismatch of the transaction. The greater the mismatch, the greater is the transaction's dependence on the issuer's rating.

With the discussion above on asset/liability mismatches, it would be apparent that the maturity of covered bonds may be unconnected with the repayment of the assets. Usually, covered bonds may have *soft bullet maturity;* that is, they have an indicative payment date, but the issuer is allowed an extension of time to repay the bonds after maturity. In the example, column D shows payments to the bonds in five different years. This would most likely not be five payment dates on a single bond, but five different tranches of bonds with single bullet maturity dates each.

RATINGS OF COVERED BONDS

As we have discussed earlier, the desire of a covered bond issuer is to raise funding by an instrument that pierces the rating of the issuer. That is, rating upliftment is a significant objective of every issuer.

All the major rating agencies have come up with criteria to give ratings, in fact, rating enhancements to covered bonds transactions. These criteria have been evolving over time, and as volatility spikes occur within the financial system, rating agencies become more conservative.

We do not intend to discuss the rating criteria of each of the agencies here, but we need to observe that unlike in case of securitization, ratings of covered bonds are not completely detached from the rating of the issuer. In fact, the issuer's rating significantly controls the ratings of covered bonds. Hence, rating agencies typically lay down a matrix of factors, on consideration of which they will notch-up the rating of the covered bonds by specified level of notches.

COVERED BONDS AND SECURITIZATION

As we have stated, covered bonds are though historically grounded into secured bonds, but in the recent past transactions have been enriched by securitization methodology, particularly in countries that do not have specific covered bonds legislation. Hence, they are a hybrid between securitization and secured bonds. The few points of similarity between the two are: both result into creation of securities; both are methods of funding from the capital markets; both involve creation of a pool of assets; both have trustees overseeing the implementation of the transaction covenants, etc. The structure of covered bonds would look very similar to the master trust structure of securitization, particularly if the structure is used in case of residential mortgages. However, there are significant points of dissimilarity, as shown in Exhibit 22–3.

EXHIBIT 22–3

Covered Bonds and Securitization Compared

	Covered Bonds	Securitization
Purpose	Essentially, to raise liquidity	Liquidity, off–balance sheet, risk management, monetization of excess profits, etc.
Risk transfer	The originator/issuer continues to absorb default risk as well as prepayment risk of the pool. To achieve a partial transfer of prepayment risk, there may be a call option embedded in the bonds.	The originator does not absorb default risk above the credit support agreed; prepayment risk is usually transferred entirely to investors.
Legal structure	A direct and unconditional obligation of the issuer, backed by creation of security interest. Assets may or may not be parked with a distinct entity; bankruptcy remoteness is achieved either due to specific law or by common law principles.	True sale of assets to a distinct entity; bankruptcy remoteness is achieved by isolation of assets.
Type of pool of assets	Mostly dynamic. Originator is allowed to manage the pool as long as the required "covers" are ensured. From a common pool of cover assets, there may be multiple issuances.	Mostly static. Except in case of master trusts, the investors make investment in an identifiable pool of assets. Generally, from a single pool of assets, there is only issuance.
Maturity matching	From out of a dynamic pool, securities may be issued over a period of time. Usually, covered bonds are "programs"; that is, series of issuance from out of a dynamic and replenishing mortgage loan pool.	Typically, securities are matched with the cash flows from the pool. When the static pool is paid off, the securities are redeemed.

(Continued)

EXHIBIT 22–3

Covered Bonds and Securitization Compared *(Continued)*

	Covered Bonds	Securitization
Payment of interest and principal to investors	Interest and principal are paid from the general cash flows of the issuer.	Interest and principal are paid from the asset pool.
Prepayment risk	In view of the managed nature of the pool, prepayment of loans does not affect investors, except to the extent of call option embedded in the bonds.	Prepayment of underlying loans is passed on to investors; hence, investors take prepayment risk.
Nature of credit enhancement	The cover, that is, excess of the cover assets over the outstanding funding.	Different forms of credit enhancement are used, such as excess spread, subordination, over-collateralization, etc.
Classes of securities	Usually a single class of bonds are issued. There may be multiple time tranches, each having hard or soft bullet maturity.	Most transactions come up with different classes of securities, with different risk and returns.
Independence of the ratings from the rating of the issuer	Theoretically, the securities are those of the issuer, but in view of bankruptcy-proofing and the value of "cover assets," usually notched-up ratings are given.	AAA ratings are given usually to senior-most classes, based on adequacy of credit enhancement from the lower classes.
Off–balance sheet treatment	Not off the balance sheet.	Usually off the balance sheet.
Capital relief	Under standardized approaches, will be treated as on-balance sheet retail portfolio, appropriately risk weighted. Calls for regulatory capital. Regulations provide investors with lower risk weights.	Calls for regulatory capital only up to the retained risks of the seller.

ACCOUNTING FOR COVERED BONDS

Looking at the structure of covered bonds, particularly in case of structured covered bonds, one may notice the presence of a legal transfer of the cover assets from the issuer to the SPE. Would this have the impact of removing the cover assets from the books of the seller-issuer? Under IAS 39/FAS 140, true sale is not a precondition for off–balance sheet treatment. Transactions that qualify as pass-through arrangements, even if not backed by true sale, may lead to assets being off the balance sheet. Neither does true sale guarantee an off–balance sheet treatment. On the other hand, off–balance sheet treatment is based on the substance of the transaction, that is, risks and rewards from the asset pool. If the seller retains significant risks and rewards, the asset continues to be on the books of the seller, and the funding raised is treated akin to a borrowing.

As we have discussed, several covered bonds transactions rely on true sale to achieve bankruptcy protection. Hence, a question may arise—as the originator sells the pool to an SPE that guarantees the repayment of the bonds, should the assets go off the balance sheet of the issuer? The answer would be clearly no, because the bonds are an unconditional obligation of the issuer. Hence, the making of the true sale does not put the assets off the balance sheet of the issuer.

Accounting rules also provide that what is not off the balance sheet of the seller cannot be on the balance sheet of the buyer. In case of structured covered bonds, the SPE is the buyer and guarantor of the bonds. However, the SPE cannot put the assets on its balance sheet. If the SPE prepares any balance sheet as per accounting standards, it may have to make disclosure of the liability on account of guarantee, but neither the asset nor the loan will as such come as on-balance sheet items for the SPE.

KEY POINTS

- As a capital market device for refinancing mortgages, covered bonds have existed in continental Europe for more than 200 years. However, their recent popularity seems to be emanating from the unpopularity of mortgage-backed securities following the subprime crisis.
- Covered bonds may be viewed as a hybrid between corporate bonds and mortgage-backed securities—in the sense that they are an obligation of the issuer, they are close to secured bonds, but since investors also rely on the assets as a backup, they have features of asset-backed securities.
- The asset-backing in form of cover assets provides dual recourse to investors. How clear is the ability of investors to rely on the assets, immune from the post-bankruptcy claims of other creditors, depends either on the legislation, or the legal structure of the transaction.

- Where the bankruptcy protection comes from legislation, it is called *legislative covered bonds;* where it comes from the legal structure, it is called *structured covered bonds.*
- Structured covered bonds use a special purpose entity that agrees to buy the cover assets, albeit with funding provided by the issuer. The SPE then guarantees the repayment of the bonds.
- The key idea of covered bonds is to provide a rating upliftment, so that the bonds are able to achieve a better rating than that of the issuer. The notches by which rating of covered bonds may go up above the rating of the issuer are based on the quality of the cover asset, extent of credit enhancement, inherent asset/liability mismatch and liquidity risk, etc.
- Credit enhancements in case of cover bonds are mostly in form of over-collateralization.
- While structured covered bond transactions make use of the device of sale of the cover pool by the issuer to an SPE, the sale is done such that it qualifies to be a legal sale but not a sale in terms of accounting standards. Hence, from an accounting viewpoint, covered bonds are not different from secured bonds.

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CHAPTER
TWENTY-THREE

NONCONVERTIBLE PREFERRED STOCK

STEVEN V. MANN, PH.D.
Professor of Finance
Moore School of Business
University of South Carolina

Preferred stock is a hybrid security that combines features of both common stocks and corporate bonds. While preferred stock possesses some debtlike features, it is considered to be an equity security. Preferred stockholders have a claim on the cash dividends paid by the issuing corporation, and their claim is senior to that of common shareholders. Furthermore, cash dividends paid to preferred stockholders are almost always fixed by contract (e.g., a specified dollar amount or percentage of their face value). Accordingly, "plain vanilla" preferred stock is, in essence, a perpetuity. The specified percentage is called the *dividend rate,* which may be fixed or floating. Almost all preferred stock issued today limits the payments to be received by the security holder to a specified amount with the proviso that the cash flows received will never exceed those specified in the contract and may be less.

Failure to make preferred stock dividend payments cannot force the issuer into bankruptcy. If the issuer fails to make the preferred dividend payments as specified in the contract, then depending on the terms of the issue, one of two things can occur. If the issue is *cumulative,* the dividend payment accrues until it is fully paid. Conversely, if the issue is *noncumulative,* missed dividend payments simply are forgone. Failure to make dividend payments also may trigger certain restrictions on the issuer's management. As an example, if dividend payments are in arrears, preferred shareholders may be granted voting rights to elect some members to the issuer's board of directors. This feature is called *contingent voting* because the voting rights are contingent on a missed dividend payment.[1]

Cumulative preferred stock has some debtlike features, namely (1) the cash flows promised to preferred stockholders are fixed by contract, and (2) preferred stockholders have priority over common stockholders with respect to dividend payments and distribution of the assets in case of bankruptcy.[2] However, on a balance

1. By contrast, *blank check* preferred stock contains a provision that gives voting rights to approved preferred shareholders as protection against a hostile takeover attempt.
2. The position of noncumulative preferred stock is considerably weaker.

sheet, preferred stock is classified as equity. When there is more than one class of preferred stockholders, the claims of preferred stockholders to the issuer's assets differ in the event of bankruptcy. For example, *first* preferred stock's claim to dividends and assets has priority over other preferred stock. Correspondingly, *second* preferred stock ranks below at least one other issue of preferred stock.

Almost all preferred stock has a sinking-fund provision, and such provisions usually are structured similarly to those used with corporate bonds. A sinking fund is a provision allowing for a preferred stock's periodic retirement over its life span. Most sinking funds require a specific number of shares or a certain percentage of the original issue to be retired periodically, usually on an annual basis. Sinking-fund payments can be satisfied by either paying cash and calling the required number of shares or delivering shares purchased in the open market. Most sinking funds give the issuer a noncumulative option to retire an additional amount of preferred stock equal to the mandatory requirement. This is called a *double-up option*. Preferred shares acquired to satisfy a sinking-fund requirement usually are called using a random selection process.

Preferred shares offer investors two distinct advantages over debt and other equity investments. Preferred shares offer higher yields on average than bonds or common stock. Moreover, preferred shares provide good diversification benefits owing to their low correlation with stocks and bonds. In order to obtain these benefits, investors in preferred stocks must contend with the risk characteristics of these securities. Preferred share possess limited potential for price appreciation. The reason being is that the lion's share of the total return is due to the stream of dividend payments. Naturally this raises the specter of default risk meaning a breach in the contract with the preferred stockholder like omission of a dividend. According to Moody's, out of the 1,802 preferred shares rated over the period 1983–2008, 118 issues experienced a dividend omission which means it was not declared in either the amount or at the regular dividend date specified in the prospectus.[3] Some preferred shares are callable which exposes the investor to reinvestment risk. Finally, preferred stocks tend to be less liquid than common stocks.

PREFERRED STOCK ISSUANCE

Corporations use three types of securities—debt, common stock, and preferred stock—to finance their operations. In terms of total dollars issued, preferred stock ranks third by a large margin. There have been two fundamental shifts in the issuance pattern of preferred stock since the early 1980s. Since the mid-1980s, the major issuers of preferred stock are financial institutions and insurance companies, whereas before this time, public utilities issued a majority of preferred stock. Second, most of the preferred stock issued today carries an adjustable-rate dividend. Traditionally, almost all preferred stock paid a fixed dividend.

3. Moody's Analytics, Preferred Stock Impairments and Recovery Rates 1983–2008, November 2009.

Types of Preferred Stock

There are three types of preferred stock: (1) fixed-rate preferred stock, (2) adjustable-rate preferred stock, and (3) auction-rate and remarketed preferred stock.

Fixed-Rate Preferred Stock

Prior to 1982, all publicly issued preferred stock paid a fixed dividend rate. As an example, consider some fixed-rate preferred stock issued by Carolina Power and Light issued in 1955. These shares carry a $4.20 annual dividend paid quarterly. The issue is callable in whole or in part on May 26, 2011 at a price of $102 per share.

Adjustable-Rate Preferred Stock

For *adjustable-rate preferred stock* (ARPS), the dividend rate is reset quarterly based on a predetermined spread from the highest of three points on the Treasury yield curve. The predetermined spread is called the *dividend reset spread.* The dividend reset spread is added to or subtracted from the *benchmark rate* determined from the yield curve. The three points on the yield curve are the highest of (1) the 3-month Treasury bill rate, (2) the 10-year Treasury rate, or (3) the 30-year Treasury rate. It is often the case that the dividend reset spread is expressed as a certain percentage of the benchmark rate. As an example, HSBC USA Corp. issued preferred stock in May 1994 for which the dividend rate was 83% of the highest of the 3-month U.S. Treasury rate, the 10-year Constant Maturity Treasury rate, and the 30-year Constant Maturity Treasury rate. In addition, the dividend rate had a cap of 10.5% and a floor of 4.5%. This issue was callable on May 26, 2011, at the issue price of $25 per share. The motivation for linking the dividend rate to the highest of the three points on the Treasury yield curve is to provide the preferred shareholder with some protection against unfavorable shifts in the yield curve.

Auction-Rate and Remarketed Preferred Stock

Most ARPS is perpetual, with a cap and floor on the dividend rate. Because most ARPS is not putable, however, ARPS can trade below par value after issuance if the spread demanded by the market as compensation for the risk of the security is greater than the dividend reset spread. The popularity of ARPS declined when these instruments began trading below their par value. This occurs because when an issuer's credit risk deteriorates, the dividend-rate formula remains unchanged and the preferred stock's value will decline. In 1984, a new type of preferred stock was issued to overcome this problem—*auction-rate preferred stock.* This innovation was particularly well received by corporate investors who sought tax-advantaged short-term instruments to invest excess funds. The dividend rate on auction-rate preferred stock is reset periodically, but the dividend rate is established through a Dutch auction process. Participants in the auction consist of current preferred shareholders as well as potential buyers. The dividend rate that participants are willing to accept reflects current market conditions. Commercial paper rates typically serve as benchmarks.

As an example, Advent Claymoore issued auction rate preferred stock in September 2007 with a par amount of $25,000. The reset frequency is 7 days. This issue is subject to mandatory redemption and is callable on dividend payment dates.

In the case of *remarketed* preferred stock, the dividend rate is determined periodically by a remarketing agent, who resets the dividend rate so that any preferred stock can be tendered at par and be resold (remarketed) at the original offering price. An investor has the choice of dividend resets every 7 days or every 49 days. As an example, consider some remarketed preferred stock issued by DNP Select Income Fund, a closed-end fund, in December 1988. Note three facts about the issue. First, the dividend is reset every 49 days. Second, there is a mandatory redemption date of December 11, 2024. Third, the issue is callable on any payment date at par (i.e., $100,000) plus accrued dividends.

TRUST PREFERRED

Trust preferred securities are hybrid securities primarily issued by financial institutions with features of both debt and equity. They are treated as debt for tax purposes such that dividend payments are tax deductible and may be deferred up to five years. Conversely, they are treated as Tier I capital for trust preferred securities are senior to both preferred and common stock but subordinate to all debt. These securities possess 30-year maturities allowing for early redemption at the behest of the issuer. Trust preferred shares generally deliver quarterly dividend payments.

In the aftermath of the financial crisis of 2007–08, regulators lamented financial institutions were too highly levered and that more regulation was paramount. These changes in regulation were delivered in two packages—Basel III and the Dodd-Frank Act. Endorsed by the G-20, the Basel III banking standards are to be enacted by member nations through either regulation or statue by January 1, 2013. The Dodd-Frank Act was signed into law and represents the most significant U.S. financial reform since the Depression. Both packages of regulation raise capital standards and phase out trust preferred from Tier 1 capital. Basel III generally gives a much longer phase out period than the three years stipulated by Dodd-Frank. The other important difference in the treatment of trust preferred stock is that Dodd-Frank exempts small banks from the phase out. Basel III contains no such exemption.

PREFERRED STOCK RATINGS

Preferred stock is rated just like corporate bonds. A preferred stock rating is an assessment of the issuer's ability to make timely dividend payments and fulfill any other contractually specified obligations (e.g., sinking-fund payments). The three nationally recognized statistical rating organizations (NRSROs) that rate corporate

bonds also rate preferred stock. The NRSROs are Fitch Ratings, Moody's Investors Service, Inc., and Standard & Poor's Ratings Group. Symbols used by the NRSROs for rating preferred stock are the same as those used for rating corporate long-term debt. It is important to note that the rating applies to the security issue in question and not to the issuer per se. Two different securities issued by the same firm could have different ratings. Standard & Poor's attaches +*s* and −*s*, which are called *notches,* to denote an issue's relative standing within the major ratings categories.[4]

The Dodd-Frank Act requires U.S. regulatory agencies to remove all references to security credit ratings from their rules and regulations. U.S. regulatory agencies are tasked with the development of an alternative to the ratings agencies. As of mid 2011, progress has been scant. It is widely agreed the process will take considerable time and effort to complete.

TAX TREATMENT OF DIVIDENDS

Dividend payments made to preferred stockholders are treated as a distribution of earnings. This means that they are not tax deductible to the corporation under the current tax code.[5] Interest payments are tax deductible, not dividend payments. While this raises the after-tax cost of funds if a corporation issues preferred stock rather than borrowing, there is a factor that reduces the cost differential: a provision in the tax code exempts 70% of qualified dividends from federal income taxation if the recipient is a qualified corporation. For example, if corporation A owns the preferred stock of corporation B, for each $100 of dividends received by A, only $30 will be taxed at A's marginal tax rate. The purpose of this provision is to mitigate the effect of double taxation of corporate earnings.

The tax treatment of preferred stock also differs depending on whether it is classified as *old money, new money,* or *partial money*. Old money refers to preferred stock issued before October 1, 1942. For old money preferred stock, the dividend-received deduction is only 42%. Partial money refers to a very small new set of issues that were classified as both old and new money. Old and partial money comprise only a tiny fraction of the preferred stock outstanding today. In other words, virtually all preferred stock outstanding today is new money.

There are two implications of this tax treatment of preferred stock dividends. First, the major buyers of preferred stock are corporations seeking tax-advantaged investments. Indeed, very few individual investors hold preferred stock in their portfolios. Second, the cost of preferred stock issuance is lower than it would be in the absence of the tax provision because the tax benefits are passed through to the issuer by the willingness of corporate investors to accept a lower dividend rate.

4. Moody's attaches 1s, 2s, and 3s to indicate the same information.
5. An exception to this statement is trust-preferred securities.

KEY POINTS

- Preferred stock is a hybrid security that combines elements of debt and equity.
- Preferred shares offer higher yields on average than bonds or common stock and provide good diversification benefits owing to their low correlation with stocks and bonds.
- Preferred share possess limited potential for price appreciation and are exposed to default risk.
- There are three types of preferred stock: (1) fixed-rate; (2) adjustable-rate; and (3) auction-rate.
- Trust preferred securities are hybrid securities primarily issued by financial institutions with features of both debt and equity. They are treated as debt for tax purposes such that dividend payments are tax deductible and may be deferred up to five years.

PART

THREE

SECURITIZED PRODUCTS

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CHAPTER
TWENTY-FOUR

AN OVERVIEW OF MORTGAGES AND THE MORTGAGE MARKET

ANAND K. BHATTACHARYA, PH.D.
Professor of Practice
Department of Finance
Arizona State University

WILLIAM S. BERLINER
Executive Vice President
Manhattan Capital Markets

Over the last few decades, the mortgage market in the United States has emerged as one of the largest financial asset classes. As of the fourth quarter of 2010, the total face value of one- to four-family residential mortgage debt outstanding was approximately $10.4 trillion, with more than $6 trillion having been securitized into a variety of investment vehicles. As a point of comparison, at the same point in time, the outstanding amount of marketable U.S. Treasury notes and bonds totaled $8.8 trillion. For a variety of reasons, such as product innovation, technological and regulatory changes, and evolving consumer and lender preferences, the composition of the primary mortgage market continues to evolve on a fairly dynamic basis. The mortgage lending paradigm has undergone a number of profound changes over the past decade. Between 2002 and mid 2007, there was a proliferation of product offerings designed to both appeal to changing consumer preferences and broaden the range of borrowers that could qualify for mortgage loans. While this had the effect of increasing the home ownership rate in the United States, it eventually led to a disastrous combination of relaxed underwriting standards and inflated values for residential real estate. The subsequent financial crisis led to the collapse of numerous large financial firms and lenders, as well as Freddie Mac and Fannie Mae, which were placed into conservatorship in 2008. This in turn led to a major retrenchment on the part of lenders with respect to product offerings and underwriting standards, as well as a great deal of uncertainty with respect to the form and regulation of the mortgage lending industry.

The purpose of this chapter is to outline fundamental aspects of the mortgage markets. We will define the terminology and metrics associated with various mortgage products, describe the process by which lenders compute their loan pricing, and discuss the different risks associated with mortgage products.

PRODUCT DEFINITION AND TERMS

In general, a *mortgage* is a loan that is secured by the underlying real estate that can be repossessed in the event of default. For the purposes of this chapter, a mortgage is defined as a loan made to the owner of a one- to four-family residential dwelling and secured by the underlying property. Standard product offerings are level-pay "fully amortizing" mortgages, indicating that the obligor's monthly payments are calculated in equal increments to pay off the loan over the stated term. There are, however, a number of key characteristics that are considered critical in understanding the instruments, and they are differentiated along the following attributes.

Lien Status

The lien status dictates a loan's seniority in the event of the forced liquidation of the property owing to default by the obligor. The overwhelming preponderance of mortgage loans originated have first-lien status, implying that a creditor would have first call on the proceeds of liquidation of the property if it were to be repossessed. Borrowers have often used second-lien loans as a means of liquefying the equity in a home for the purpose of expenditures (such as medical bills or college tuition) or investments (such as home improvements). A second-lien loan also may be originated simultaneously with the first-lien in order to maintain the first-lien loan-to-value (LTV) ratio below a certain level. A fairly common practice prior to mid 2007, this allows the obligor to avoid the need for mortgage insurance, which is required for loans with LTVs greater than 80%.

Original Loan Term

The majority of mortgages are originated with a 30-year term and amortize on a monthly basis. Loans with stated shorter terms of 10, 15, and 20 years also are utilized by borrowers who are motivated by the desire to own their home earlier. Among these mortgages, where the monthly mortgage payment is inversely related to the term of the loan, the 15-year mortgage is the most common instrument. Small numbers of loans are also structured to have so-called balloon payments. The loan amortizes over a 30-year term; however, at a preset point in time (the "balloon date," generally five or seven years after issuance) the borrower must pay the balance of the loan in full.

Interest-Rate Type (Fixed versus Adjustable Rate)

As is indicated by the nomenclature, *fixed-rate mortgages* have an interest rate that is set at the closing of the loan (or, more accurately, when the rate is "locked" by the borrower) and is constant for the loan's term. Based on the loan balance, interest rate, and term, a payment schedule effective over the life of the loan is calculated to amortize the principal balance. Note that while the monthly payment is constant over the life of the loan, the allocation of the payment into interest and

principal changes over time, as we will demonstrate later in this chapter. During the earlier years of the loan, the level-pay mortgage consists mainly of interest, whereas the constant payment is composed mainly of principal in the later years of the life of the loan.

Adjustable-rate mortgages (ARMs) have note rates that change over the life of the loan. The note rate is based on both the movement of an underlying rate (the *index*) and the spread over the index (the *margin*) required for the particular loan program. A number of different indexes, such as the one-year Constant Maturity Treasury (CMT) and the London Interbank Offered Rate (LIBOR) can be used to determine the reference rate. ARMs typically adjust or *reset* annually, although instruments with alternative reset frequencies are originated. Owing to competitive considerations, the initial rate is often somewhat lower than the so-called fully indexed rate. In this case, the initial rate is referred to as a "teaser rate." In any case, the note rate is subject to a series of caps and floors that limit how much the note rate can change at the reset. Structurally, the cap serves to protect the consumer from the payment shock that might occur in a regime of rising rates, whereas the floor acts to protect the interests of the holder of the loan by preventing the note rate from dropping below predefined levels. The vast majority of adjustable-rate loans have 30-year terms.

The most commonly originated type of ARM is the fixed-period or *hybrid ARM*. These loans have fixed-rates that are effective for longer periods of time (3, 5, 7, and 10 years) after funding. At the end of the period, the loans reset in a fashion very similar to that of more traditional ARM loans. Hybrid ARMs appeal to borrowers who desire a loan with lower initial payments (because ARM rates generally are lower than rates for 30-year fixed-rate loans) but without as much payment uncertainty and exposure to changes in interest rates as ARMs without the fixed-rate period.

Amortization Schemes

As noted, mortgages traditionally have been originated as fully amortizing instruments, meaning that some portion of all payments is dedicated toward reducing the loan's balance. Alternative amortization patterns that grew increasingly popular prior to 2007, particularly in the ARM market, were *interest-only loans*. The product's payments are divided into two stages. During the interest-only phase, the borrower's monthly payments consist only of interest, and are calculated as a simple function of the loan's note rate and balance. When the interest-only period ends, the loan is *recast* (i.e., its payments are recalculated) to reflect the loan's remaining term. This means that the loan's payments increase at some point after origination; this phenomenon, called *payment shock*, caused financial problems for borrowers that were unable to make the higher post-recast payments.

A simple example at this point will be helpful. A loan with a balance of $100,000 and a 6% note rate would have a monthly payment of $600 calculated over the normal 360-month term. The same loan with a 10-year interest-only period would have an initial payment of $500 per month for the first 120 months.

In month 121, the loan would recast and require a new monthly payment (calculated at 6% over a 240-month remaining term) of $716. The borrower is therefore allowed to make a lower payment for the first ten years of the loan, but accepts the facts that the loan is not being amortized during the interest-only period, along with the commitment to a larger future payment once the loan is recast.

Another variation that had a brief burst in popularity was the *payment-option* or *negative-amortization* loan. Although the terms of these products were often quite complex, the product basically allowed for payments that were less than the amount required to make the loan's full monthly interest payment. If the payment made was less than the interest amount due in any month, the shortfall was added to the loan's balance, causing its balance to increase and creating the "negative amortization" in the product's name. For a variety of reasons, the product was discredited and, in some states, outlawed entirely.

Credit Guarantees

While our discussion has centered on the basics of mortgage loans, one of the considerations that also distinguishes various mortgages is the form of the eventual credit support required to enhance the liquidity of the loan. While a complete discussion of secondary markets is beyond the scope of this chapter, the ability of mortgage lenders to continually originate mortgages is heavily dependent on their ability to create fungible assets from a disparate group of loans made to a multitude of individual obligors. Therefore, mortgage loans can be further classified based on whether the eventual credit guaranty associated with the loan is provided directly by the federal government, indirectly through quasi-governmental agencies, or by various alternative entities and practices.

One of the dimensions into which loans can be classified is based on the degree of support received from the Federal government. As part of housing policy considerations, the Department of Housing and Urban Development (HUD) oversees two agencies, the Federal Housing Administration (FHA) and the Department of Veterans Affairs (VA), that support housing credit for qualifying borrowers. The FHA provides loan guarantees for borrowers who can afford only a low down payment and generally also have relatively low levels of income. The VA guarantees loans made to veterans, allowing them to receive favorable loan terms. These guarantees are backed by the U.S. Treasury, which provides these loans with the "full faith and credit" of the U.S. government. These loans are referred to under the generic term of *government loans*. Government loans are securitized largely through the aegis of the Government National Mortgage Association (Ginnie Mae, or GNMA), an agency also overseen by HUD.

Loans that are not associated with government guarantees are classified as *conventional loans*. Conventional loans can be securitized either as so-called private-label structures or as pools guaranteed by the two government-sponsored enterprises (GSEs), namely, Freddie Mac and Fannie Mae. The GSEs are shareholder-owned corporations that were created by Congress to support housing activity. Both Fannie

Mae and Freddie Mac were placed into conservatorship by the U.S. Treasury in August of 2008. As of the end of 2010, the GSEs have received a combined total of more than $150 billion in support from the government, in the form of preferred stock owned by the Treasury (and for which the two firms pay a 10% dividend rate). The very existence of the GSEs, as well as their form and function, remains quite uncertain at this writing; in any case, however, it is likely that they will play a smaller role in housing finance in the future. For as long as they continue to exist, however, the actual choice of the vehicle (GSE versus private label) used to securitize a particular loan depends on a number of factors, such as conformance of obligor credit attributes and property features with GSE loan requirements, the cost of credit enhancement, and loan balance.[1]

Loan Balance (Conforming versus Nonconforming)

As noted earlier, a mortgage's balance often determines the investment vehicle into which it can be securitized. This is due to the fact that the agencies have limits on the loan balance that can be included in agency-guaranteed pools. The maximum loan sizes for one- to four-family homes effective for the following calendar year are recalculated every November. The year-over-year percentage change in the limits is based on the October-to-October change in the average home price (for both new and existing homes) published by the Federal Housing Finance Agency, the GSEs' regulator since 2008. Since their inception, Freddie Mac and Fannie Mae pools have had identical loan limits because the limits are dictated by the same statute. The effective conforming balance for any individual loan was complicated by the financial crisis that erupted in 2007. The statutory limit peaked at $417,000 for a single-family loan in 2006. The Housing and Economic Recovery Act of 2008 (HERA) effectively increased the conforming limit in high-cost areas, based on the area's median home price, to a maximum of $625,500 (or 150% of the statutory limit) for loans on single-family homes. The Economic Stimulus Act of 2008 (ESA) temporarily increased the ceiling in high-cost areas to $729,750, subject to annual renewal. (As of the end of 2010, the limit in high-cost areas was scheduled to be reduced to the HERA limit in September of 2011.)

Loans larger than the conforming limit (and thus ineligible for inclusion in agency pools) are classified as *jumbo loans* and are securitized in private-label transactions (along with loans, conforming balance or otherwise, that do not meet the GSEs' required credit or documentation standards). While the size of the private-label sector is significant it has long been dwarfed by the agency market. Despite the GSEs' difficulties, the market share for loans being securitized as agency MBS was estimated to be in excess of 90% in 2010, largely due to the inability of securities firms to issue non-agency MBS transactions.

1. A note with respect to terminology: throughout this chapter, we will use the term *agencies* to refer to Freddie Mac, Fannie Mae, and Ginnie Mae; the term *GSEs* refers to Freddie Mac and Fannie Mae only.

Loan Credit and Documentation Characteristics

Mortgage lending traditionally has focused on borrowers of strong credit quality who were able (or willing) to provide extensive documentation of their income and assets. These loans are generically referenced as *prime loans*. As we noted in the introduction, the period between 2002 and mid 2007 was characterized by the rapid expansion of product offerings to consumers who had been outside of the traditional credit paradigm. Loans made to borrowers with demonstrably weaker credit are classified as *subprime loans*. This sector grew rapidly between 2003 and 2006; at its peak, it comprised roughly 20% of all issuance, by loan amount, in the United States before declining precipitously after the beginning of 2007.

A category between prime and subprime loans is comprised of so-called alternative-A or *alt-A* loans. This category historically consisted of loans with nontraditional attributes, such as relaxed documentation and occupancy requirements. By 2007, however, the sector effectively became the middle ground for loans that could not be easily categorized as prime or subprime. As a result, its credit profile and performance was wildly uneven, and issuance of loans under the alt-A rubric also dropped dramatically as the product fell out of favor.

The primary factor that enabled the growth of subprime and alt-A lending was the degree of investor acceptance of securities collateralized by these loans. In particular, subprime loans were almost never held in lenders' loan portfolios, making their issuance particularly dependent on securitization as the means of monetizing their production. As a result, the collapse in investor demand for investment products backed by such loans was a primary factor in the demise of these products, as well as many lenders that specialized in their production.

MECHANICS OF MORTGAGE LOANS

As discussed previously, most mortgage loans are structured as immediately and fully amortizing instruments, where the principal balance is paid off over the life of the loan. As noted previously, fixed-rate loans generally have a monthly payment that is fixed for the life of the loan, based on loan balance, term, and interest rate. A fixed-rate loan's monthly payment can be calculated using the following formula:

$$\text{Monthly payment} = \text{original balance} \times \frac{\text{interest rate}\,(1+\text{interest rate})^{\text{loan term}}}{(1+\text{interest rate})^{\text{loan term}} - 1}$$

(Note that the interest rate as used in the formula is a monthly rate calculated by dividing the loan's rate by twelve.) Using this formulation, the allocation of the level payment into principal and interest over time provides insights regarding the buildup of owner equity in the property. As an example, Exhibit 24–1 shows the total payment and the allocation of principal and interest for a $100,000 loan with a 5.5% interest rate (or *note rate,* as it is often called) for the first 60 months.

EXHIBIT 24–1

Payment Analysis for $100,000 30-Year Loan with a 5.5% Rate

Month	Payment	Interest	Principal	Unpaid Balance
1	$567.79	$458.33	$109.46	$99,890.54
2	$567.79	$457.83	$109.96	$99,780.58
3	$567.79	$457.33	$110.46	$99.670.12
4	$567.79	$456.82	$110.97	$99,559.15
5	$567.79	$456.31	$111.48	$99,447.68
6	$567.79	$455.80	$111.99	$99.335.69
7	$567.79	$455.29	$112.50	$99,223.19
8	$567.79	$454.77	$113.02	$99,110.17
9	$567.79	$454.25	$113.54	$98,996.63
10	$567.79	$453.73	$114.06	$98,882.58
11	$567.79	$453.21	$114.58	$98,768.00
12	$567.79	$452.69	$115.10	$98,652.90
13	$567.79	$452.16	$115.63	$98,537.27
14	$567.79	$451.63	$116.16	$98,421.11
15	$567.79	$451.10	$116.69	$98,304.41
16	$567.79	$450.56	$117.23	$98,187.18
17	$567.79	$450.02	$117.77	$98,069.42
18	$567.79	$449.48	$118.31	$97,951.11
19	$567.79	$448.94	$118.85	$97,832.27
20	$567.79	$448.40	$119.39	$97,712.87
21	$567.79	$447.85	$119.94	$97,592.93
22	$567.79	$447.30	$120.49	$97,472.44
23	$567.79	$446.75	$121.04	$97,351.40
24	$567.79	$446.19	$121.60	$97,229.81
25	$567.79	$445.64	$122.15	$97,107.65
26	$567.79	$445.08	$122.71	$96,984.94
27	$567.79	$444.51	$123.28	$96,861.66
28	$567.79	$443.95	$123.84	$96,737.82
29	$567.79	$443.38	$124.41	$96,613.42
30	$567.79	$442.81	$124.98	$96,448.44
31	$567.79	$442.24	$125.55	$96,362.89
32	$567.79	$441.66	$126.13	$96,236.76
33	$567.79	$441.09	$126.70	$96,110.05
34	$567.79	$440.50	$127.29	$95,982.77
35	$567.79	$439.92	$127.87	$95,854.90
36	$567.79	$439.33	$128.46	$95,726.44
37	$567.79	$438.75	$129.04	$95,597.40

(Continued)

EXHIBIT 24–1

Payment Analysis for $100,000 30-Year Loan with a 5.5% Rate *(Continued)*

Month	Payment	Interest	Principal	Unpaid Balance
38	$567.79	$438.15	$129.64	$95,467.76
39	$567.79	$437.56	$130.23	$95,337.53
40	$567.79	$436.96	$130.83	$95,206.71
41	$567.79	$436.36	$131.43	$95,075.28
42	$567.79	$435.76	$132.03	$94,943.25
43	$567.79	$435.16	$132.63	$94,810.62
44	$567.79	$434.55	$133.24	$94,677.38
45	$567.79	$433.94	$133.85	$94,543.53
46	$567.79	$433.32	$134.47	$94,409.06
47	$567.79	$432.71	$135.08	$94,273.98
48	$567.79	$432.09	$135.70	$94,138.28
49	$567.79	$431.47	$136.32	$94,001.96
50	$567.79	$430.84	$136.95	$93,865.01
51	$567.79	$430.21	$137.58	$93,727.43
52	$567.79	$429.58	$138.21	$93,589.23
53	$567.79	$428.95	$138.84	$93,450.39
54	$567.79	$428.31	$139.48	$93,310.91
55	$567.79	$427.68	$140.12	$93,170.80
56	$567.79	$427.03	$140.76	$93,030.04
57	$567.79	$426.39	$141.40	$92,888.64
58	$567.79	$425.74	$142.05	$92,746.59
59	$567.79	$425.09	$142.70	$92,603.88
60	$567.79	$424.43	$143.36	$92,460.53

The exhibit shows that the payment consists mostly of interest in the early period of the loan. Since interest is calculated from a progressively declining balance and the aggregate payment is fixed, the amount of interest paid steadily declines; conversely, the principal component consequently increases over time. In fact, the exhibit shows that the unpaid principal balance in month 60 is $92,460, which means that of the $34,067 in payments made by the borrower to that point, only $7,539 was composed of principal payments. However, as the loan ages, the payment is increasingly allocated to principal. The crossover point in the example (i.e., where the principal and interest components of the payment are equal) comes in month 210. A graphic representation of principal and interest payments, along with the balance of the loan, is shown in Exhibit 24–2.

Loans with shorter amortization schedules (e.g., 15-year loans) allow the buildup of equity in the home at a much faster rate. Exhibit 24–3 shows the

EXHIBIT 24–2

Allocations of Principal and Interest Payments for a $100,000 30-Year Fixed-Rate Loan with 5.5% Note Rate (Total Monthly Payment of $567.79)

outstanding balance of a $100,000 loan with a 5.5% note rate using 30- and 15-year amortization terms. Note that while 50% of the 30-year loan balance is paid off in month 246, the halfway mark is reached in month 151 with a 20-year term and month 107 with a 15-year loan. The chart also shows the outstanding balance for a 30-year loan with a 10-year interest-only period. In the case of

EXHIBIT 24–3

Unpaid Principal Balance for a $100,000 Fixed-Rate Loan at 5.5% for Different Loan Terms and Amortization Schemes

balloon loans, the monthly payments are calculated to amortize the principal balance over a 360-month term. The balloon payment occurs at either month 60 (for a five-year balloon) or month 84 (for a seven-year balloon) and refers to the unpaid principal balance at the balloon date.

For an amortizing ARM loan, the payment is calculated at the initial note rate for the full 360-month term. At the first reset and at every subsequent adjustment, the loan is "recast," and the monthly payment schedule is recalculated using the new note rate and the remaining term of the loan. For example, the payments on a three-year hybrid ARM with a 4.5% note rate initially would be calculated as a 4.5% loan with a 360-month term. If the loan resets to a 5.5% rate after three years, the payment is calculated using a 5.5% note rate and a 324-month term. The following year, the payment would be recalculated again using the prevailing rate (depending on the performance of the index referenced by the loan) and a 312-month term.

In general, mortgage loans can be prepaid at the option of the borrower. When a loan is prepaid, the holder of the loan (either in the form of a loan in portfolio or as part of a mortgage-backed security) receives the prepaid principal at face value. Prepayments take place for a variety of reasons. They may occur when a borrower "refinances" the loan, sells the underlying property, or defaults on the loan. Prepayments (especially those due to refinancing) hurt the holder of the mortgage by calling away the asset and forcing the holder to reinvest the proceeds at lower interest rates. The causes and implications of prepayments are discussed in more depth below.

THE MORTGAGE INDUSTRY

Within the mortgage market, there are a number of different types of financial institutions involved, either directly or indirectly, in the business of making mortgage loans. A number of different classification schemes can be used to distinguish businesses and functions.

Direct versus Third-Party Originations

As indicated by the nomenclature, a direct lender actually underwrites and funds loans. Conversely, a mortgage broker represents clients and typically works through multiple lenders to obtain financing for borrowers. The broker does not, however, either make the underwriting decision or fund the loan in such "third-party" originations or TPOs, but rather serves as an agent linking borrowers and lenders. Many large lenders divide their operations into units or channels that deal with TPOs (generally called the *wholesale channel*) along with those that work directly with borrowers (the *retail channel*). These distinctions are necessary partly because the different channels have differing cost structures, necessitating alternative pricing.

Depository versus Nondepository

Depository institutions (which include banks, savings and loans, and credit unions) collect deposits from both wholesale and retail sources and use the deposits to fund their lending activities. Since depositories have portfolios (for both loans and securities), they have the option of either holding their loan production as a balance sheet asset or selling the securitized loans into the capital markets in the form of mortgage-backed securities (MBS). (In addition, there is a market for nonsecuritized mortgage portfolios among depositories because there are accounting advantages to holding loans on their books instead of securities.) Nondepository lenders (mainly so-called *mortgage bankers*) do not have loan portfolios; virtually all their loan production is sold to investors through the capital markets. (This is sometimes referenced as the "loans-to-bonds" business model.) Depositories that can hold mortgages or MBS in portfolio sometimes can be more aggressive in how they price different products, especially products they wish to accumulate in their loan or investment portfolios (most frequently short-duration assets such as adjustable-rate loans). By contrast, mortgage bankers must price all their production based on capital markets execution. This means that mortgage bankers are at a competitive disadvantage in issuing products for which capital market demand is either weak or nonexistent; they may also find it difficult at times to compete in some product sectors targeted aggressively by banks.

Originators versus Servicers

Loan *originators* underwrite and fund loan production. However, once a loan is closed, an infrastructure is required for collecting and accounting for principal and interest payments, remitting property taxes, dealing with delinquent borrowers, and managing the process of foreclosing on nonperforming loans. Entities that provide these functions are called *servicers*. For providing these services, such entities receive a fee, which generally is part of the monthly interest payment. Servicing as a business is both labor- and data-intensive. As a result, large servicing operations reap the benefit of economies of scale under normal industry conditions (i.e., when delinquencies are relatively low.) However, such large servicers are poorly prepared to deal with large numbers of seriously delinquent loans. During 2010, this led to a serious backlog in the handling of nonperforming loans, as well as controversy surrounding the practices and activities of a number of large servicers.

Servicing as an asset may be classified along several dimensions. Required, or "base," servicing is compensation for undertaking the activities described earlier, and is either dictated by industry guidelines or (in the case of nonagency securities or loans) conditional on the product. For example, as of this writing, lenders must hold 25 basis points of base servicing for fixed-rate loans being securitized into GSE-eligible pools, whereas Ginnie Mae requires either 19 or 44 basis points (depending on the securitization vehicle) for similar loans. The ownership of base servicing also provides the servicer with ancillary benefits, including interest float

on insurance and tax escrow accounts, along with the ability to cross-sell other products using the database of borrower information. "Excess" servicing is any additional servicing over the base amount and is merely a strip of interest payments held by the servicer that allows the loan to be securitized with an "even" coupon, as demonstrated later in the section on execution dynamics. Excess servicing neither requires any activity on the part of the servicer nor does it convey any benefits; it is strictly a by-product of the securitization process.

The Loan Underwriting Process

After the application for a loan is filed, it is considered to be part of the "pipeline," which suggests that there is a planned sequence of activities that must be completed before the loan is funded. At application, the borrower can either lock the rate of the loan or let it float until some point before the closing. From the perspective of the lender, there is no interest-rate risk associated with the loan until it is locked. However, after the loan is locked, the lender is exposed to risk in the same fashion as any fixed-rate asset. Lenders typically track locked loans and floating liabilities separately; they are referred to as the "committed" versus the "uncommitted" pipeline.

There are two essential and separate components of the underwriting process:

- Evaluation of the ability and willingness on the part of the borrower to repay the loan in a timely fashion
- Ensuring the integrity of the property and whether it can be sold in the event of a default to pay off the balance of the loan

There are several factors that are considered important in the evaluation of the creditworthiness of a potential borrower.

Credit Scores

Several firms collect data on the payment histories of individuals from lending institutions and use sophisticated models to evaluate and quantify individual creditworthiness. The process results in a *credit score,* which is essentially a numerical grade of the credit history of the borrower. There are three different credit reporting firms that calculate credit scores, namely Experian (which markets the Experian/Fair Isaac Risk model), Transunion (which supports the Emperica model), and Equifax (which calls its model Beacon). While the credit scores have different underlying methodologies, the scores generically are referred to as "FICO scores." Lenders attempt to obtain more than one score in order to minimize the impact of variations in credit scores across providers. In such cases, if the lender obtains all three scores, generally the middle score is used, whereas the convention is to use the lower value in the case of the availability of only two scores.

Credit scores are useful in quantifying the potential borrower's credit history. The general rule of thumb has traditionally been that a score in excess of 700

represents a "strong" borrower. The problems associated with the financial crisis led to a reassessment of this threshold; a 730 or higher score is currently considered necessary for borrowers to receive the best rates and offerings from lenders.

Loan-to-Value Ratio

The loan-to-value ratio (LTV) is an indicator of a borrower's leverage at the point when the loan application is filed. The LTV calculation compares the value of the desired loan to the market value of the property. By definition, in a purchase transaction a loan's LTV is a function of the down payment and the purchase price of the property (subject to an appraisal). In a refinancing, it depends on the requested balance of the new loan and the appraised market value of the property.[2] LTV is important for a number of reasons. First, it is an indicator of the amount that can be recovered from a loan in the event of a default, especially if the value of the property declines. It also has an impact on the expected payment performance of the obligor because high LTVs may indicate a greater likelihood of default on the loan. While loans can be originated with very high LTVs, borrowers seeking a loan with an LTV greater than 80% generally must obtain insurance for the portion of the loan that exceeds 80%. As an example, if the borrower applies for a $90,000 loan in order to buy a property for $100,000, he or she must obtain so-called mortgage insurance (MI) on $10,000 of the balance. Mortgage insurance is a monthly premium that is added to the loan payment and can be eliminated if the borrower's home appreciates (or the loan is paid down) to the point where the loan has an LTV below 80%.

Another measure used by underwriters is the *combined LTV* (CLTV), which accounts for the existence of any second liens. A $100,000 property with an $80,000 first lien and a $10,000 second lien will have an LTV of 80% but a CLTV of 90%. For the purposes of underwriting a loan, CLTVs are more indicative of the borrower's credit standing and indebtedness than LTVs and therefore a better gauge of the creditworthiness of the loan.[3]

Income Ratios

In order to ensure that borrowers' obligations are consistent with income, lenders calculate debt-to-income (or *DTI*) ratios that compare the potential monthly payment on the loan to the borrower's monthly income. The most common measures are *front* and *back ratios*. The front ratio is calculated by dividing the total monthly payments on the home, including principal, interest, property taxes, and homeowners insurance, by the borrower's pretax monthly income. The back ratio is similar but adds other debt payments (including auto loan and credit card payments) to the total payments. The traditional limits for front and back ratios are 28% and 36%, respectively.

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2. If the new loan is larger than the original loan, the transaction is referred to as a "cash-out refinancing." Otherwise, the transaction is described as a "rate-and-term refinancing."
3. This, of course, assumes that the lender is aware of all loans made on the property; a loan made against a property carrying an unknown or "silent" second lien likely would result in an overly leveraged loan and a higher probability of ultimate principal loss.

Documentation

Lenders traditionally have required potential borrowers to provide data on their financial status and to support the data with documentation. Loan officers typically require applicants to report and document income, employment status, and financial resources (including the source of the down payment for the transaction). Part of the application process routinely involves compiling documents such as tax returns and bank statements for use in the underwriting process. In the period between 2000 and 2007, however, documentation standards were progressively relaxed, leading to the proliferation of limited- and no-documentation loan programs. Popular options included "stated income" loans (which required borrowers to supply an income figure but did not require supporting documentation) as well as programs that required no disclosures of incomes, assets, or employment. (These programs were often labeled "no income/no asset" or "NINA" loans.)

The trend began in the mid 1900s with programs targeted to borrowers whose credit was sound but who had income streams that were either variable or, in the case of self-employed borrowers, difficult to document. This eventually led to the widespread marketing of loans to wage earners who often used the absence of formal documentation to inflate their incomes and evade DTI analysis.

One result of the financial crisis that began in 2007 was the return of rigorous underwriting standards, with full income and asset documentation a key requirement. While this certainly strengthened the credit quality of loans issued under this regime, it unfortunately also served to shut many otherwise strong borrowers out of the mortgage and housing markets due to difficulties in documenting their incomes.

GENERATION OF MORTGAGE LENDING RATES

While it may appear simple on the surface, the determination of mortgage lending rates is a complex interplay between levels in the secondary market for loans (or, more typically, MBS), the value of servicing, the cost of credit enhancement, and the costs associated with generating the loan. In this process, the pricing of different MBS (quoted directly and through the mechanism of intercoupon spreads) is very important in determining the eventual disposition of loans. The MBS market serves to institutionalize the intermediation function by allowing providers of funds (investors) and users of funds (lenders) to interact at the national level. Using the MBS market, lenders make loans, package them into securities, sell them into the capital markets, and use the proceeds to make new loans. While certain lenders may hold some loans and products in loan portfolios (e.g., banks tend to hold short-duration products such as ARMs), the bulk of production is securitized and sold into the capital markets.

While a complete discussion of the MBS market is beyond the scope of this chapter, it is instructive to review the process involved in securitizing loans because of the importance of this process in the determination of lending rates.

For the sake of simplicity, the following discussion focuses on fixed-rate conforming loans securitized through the GSE programs. The coupons on such pools (or "pass-throughs" because they pass principal and interest through to the investor) generally are created in 1/2 percentage point increments, e.g., 5.5%, 6.0%, etc. Loans, by contrast, generally are issued in 1/8 percentage point increments. The creation of pools to be traded as MBS involves the aggregation of loans with similar characteristics, including note rates that are a minimum and maximum amount over the coupon rate, depending on the agency and program. The weighted average of the note rates of the loans in the pool is referred to as the pool's "weighted average coupon" (WAC). The spread between the pool's WAC and its coupon rate (or pass-through rate) is allocated to three sources:

- Required or base servicing, which refers to a portion of the loan's note rate that is required to be held by the servicer of the loan. As noted previously, this entity collects payments from mortgagors, makes tax and insurance payments for the borrowers, and remits payments to investors. The amount of base servicing required differs depending on the agency and program.
- Guaranty fees (or "g-fees") are fees paid to the agencies to insure the loan. Since these fees essentially represent the price of credit risk insurance, there is variation across loan types. In the conventional universe, loans that are perceived to be riskier typically require a higher g-fee for securitization. For Ginnie Mae pools, the guaranty fee is almost always 6 basis points. Note that for Fannie Mae and Freddie Mac securities, g-fees can be capitalized and paid as an upfront fee in order to facilitate certain execution options.
- Excess servicing is the remaining amount of the note rate that would reduce the interest rate of the loan to the desired coupon. This asset generally is capitalized and held by the servicer. Nonetheless, secondary markets exist for trading servicing in the form of either raw mortgage servicing rights or securities created from excess servicing.

A schematic showing how a typical pool issued by the GSEs allocates cash flows is shown in Exhibit 24–4.

A common misconception is that lenders quote rate levels to consumers. In actuality, lenders calculate "discount points" (i.e., an up-front fee paid at closing) for a broad range of note rates. Note that these rate levels can be associated with both positive and negative points. (Negative points can be thought of as a rebate to the borrower in exchange for paying a higher rate.) The process for other products is similar in concept, if not identical in process. Exhibit 24–5 shows a hypothetical matrix of rates and points for 30-year conforming fixed-rate loans.

Given existing market conditions, the process of generating points involves two steps:

- Determining the optimal execution for each note rate;
- Calculating the appropriate amount of points for each note rate.

EXHIBIT 24–4

Cash-Flow Allocation for a 5.5% GSE Pass-Through Pool

EXHIBIT 24–5

Hypothetical Rate/Point Matrix for 30-Year Conforming Fixed-Rate Loans

Rate	Points
4.750%	6.625
4.875%	5.750
5.000%	5.125
5.125%	4.625
5.250%	3.500
5.375%	2.750
5.500%	2.250
5.625%	1.750
5.750%	1.250
5.875%	0.500
6.000%	0.125
6.125%	–0.250
6.250%	–0.625
6.375%	–1.000
6.500%	–1.500
6.625%	–1.625
6.750%	–1.875
6.875%	–2.250
7.000%	–2.250
7.125%	–2.250
7.250%	–2.625
7.375%	–2.875
7.500%	–3.000

EXHIBIT 24–6

Pooling Options for a 6.25% Note Rate Loan Using Hypothetical Prices and Levels

	6.0% MBS	5.5% MBS	Comments
MBS pass-through price	101	99	TBA prices for forward settlement
Base servicing	1.0	1.0	25 basis points in both cases—assumes 4× multiple*
Excess servicing:			
Amount in basis points	0	30	
Excess servicing value	0	1.2	4× multiple for 30 basis points for 5.5s*
Guarantee fee buyup/buydown:			
G-fee buyup/(down) in basis points†	20	0	
G-Fee buydown value	(0.60)	0.00	Assumes 3× multiple for buydown
Proceeds	**101.4**	**101.2**	
Total origination costs (includes allocation of G&A, hedging, and origination costs)	–1.65	–1.65	Assumed same in both cases
Net proceeds	**99.8**	**99.6**	

*For simplicity's sake, the multiples for base and excess servicing are assumed to be the same in this example. In addition, the value placed on servicing is a function of the different remittance styles used by Freddie Mac and Fannie Mae. As a result, the choice of remittance method may also affect the optimal pooling decision.

†The example assumes a 20 basis point g-fee. Note that the g-free buydown is paid to the GSE and therefore is treated as a negative value.

Loans can be securitized in pools with a wide range of coupons (e.g., a conventional loan with a 6.5% note rate can be securitized in Fannie Mae or Freddie Mac pools with coupons ranging from 4.0% to 6.25%). To maximize their proceeds, the optimal execution is calculated regularly by the originator and is a function of the levels of pass-through prices, servicing valuations, and guaranty fee buydown proceeds.[4] Exhibit 24–6 shows two possible execution scenarios for a loan with a 6.25% note rate. Note that execution economics generally dictate that loans are pooled with coupons between 25 and 75 basis points lower than the note rates; creating a larger spread between note rate and coupon normally is not economical. In the example, securitizing the loan in the 6.0% pool is the best execution option because it provides the greatest proceeds to the lender.

4. Guaranty fee buydowns are the monetized value of the guaranty fee. They are paid by the originator as a fee at the time of funding.

Once the optimal execution is determined for each note rate strata, the associated points are then calculated. As with the execution calculation, the calculation of points is based on market prices for pass-throughs and prevailing valuations for servicing and g-fee buydowns. Exhibit 24–7 shows a hypothetical calculation of points for loans with 6.25% and 6.625% note rates, assuming that the best execution for both rates would be securitized as part of pools with a 6.0% coupon rate. The calculated points are shown at the bottom as the difference between the net value of the loan after pricing all components and its par value. While the example

EXHIBIT 24–7

Sample Calculation of Points Given a Lending Rate (All Levels Hypothetical)

	6.25	6.625	Comments
Optimal pass-through coupon*	6.0	6.0	
MBS pass-through price	101	101	
Servicing values:			
Base servicing†	1.0	1.0	25 basis points, assuming a 4× multiple
Excess servicing (net of guaranty fee)†	0.0	0.7	Assuming 20 basis points of guaranty fee, there is no excess servicing for the 6.25% note rate, and 17.5 basis points for the 6.625% note rate—example assumes 4× multiple.
Guaranty fee buydown	–0.6	0	For 6.25% note rate, 20 basis points of g-fee must be bought down at a 3× multiple. No buydown is required for 6.625% note rate, since 20 basis point g-fee can be paid out of the note rate after base servicing.
Total value of servicing and buydowns	0.4	1.7	
Gross value	**101.4000**	**102.7000**	MBS price plus servicing value plus origination income
Total costs (including origination, administrative, and hedging costs, as well as an allocation for a targeted profit margin)	2.0	2.0	
Net value	99.4000	100.7000	Gross value less costs
Gross points	**0.6000**	**–0.7000**	100.00 less net value

*Determined by the methodology described in Exhibit 24–6.

†For this example, the assumed multiples are the same for both note rates. In practice, the multiples might be different due to different valuations placed on the servicing of the two note rates.

does not show it, points generally are rounded to the nearest one-eighth. In practice, points are calculated simultaneously for many rate levels and are subsequently posted in a rates/point matrix similar to the one shown in Exhibit 24–7.

Note also that the costs shown in Exhibit 24–7 include an allocation for the lender's targeted profit margin. Margin requirements change in line with market conditions, most notably based on the levels of lending volumes and the industry's price competitiveness at that time.

In the event that the loan is perceived to be riskier as a result of factors that may include a lower credit score, less documentation, and/or a higher LTV, it would be assigned a higher guaranty fee by the GSE. As a result, the loan would be more costly to the borrower. As an example, assume that the 6.25% note rate loan shown in Exhibit 24–7 was assigned a 30-basis points guaranty fee. At the 3× multiple, the guaranty fee buydown cost is 0.9. The incremental 0.3 cost of credit enhancement means that the loan's net value is 99.1; the 6.25% loan would therefore be priced to have 0.9 points. Therefore, the lending paradigm called *risk-based pricing* means that the higher costs (in the form of points at a given note rate strata) associated with riskier loans represent greater credit enhancement costs that are being passed on to the borrower.

As mentioned, the examples show the calculation for a loan that is eligible to be securitized in a pool issued by one of the GSEs. If the loan were ineligible for such securitization, the cost of the guarantee fee is replaced by the cost of alternative credit enhancement needed to securitize the loan. The most common form of credit support in nonagency transactions is called *subordination*. Briefly, this means that bonds created within the deal are prioritized with respect to how they will receive principal and interest cash flows, as well as how they will accrue losses suffered by the transaction's collateral pool. (Higher-priority or more *senior* bonds have the highest priority for receiving cash flows, and are the last to suffer writedowns.) As a result, the cost of credit enhancement to the transaction is a function of two elements:

- The relative size of the subordinate or *junior* classes of bonds;
- The price at which they can be sold to investors.

The size of the subordinate classes has traditionally been assigned by the rating agencies. Their primary role is to determine how large the subordinates need to be in order for the senior bonds to receive a triple-A rating. In turn, the size of the subordinate classes is a function of the perceived riskiness of the loans backing the transaction. The level at which the subordinates trade in the new-issue market is dictated by the price at which investors feel they can garner attractive risk-adjusted returns. Subordinates typically trade at large price discounts to the more senior bonds in order to account for their greater risks and/or reduced protection from losses.

Therefore, the cost of credit support in non-agency or private-label transactions is expressed by the weighted average price at which the subordinate classes can be sold. Riskier collateral thus has higher credit enhancement costs, since the

amount of subordination is higher and/or the overall price at which the subordinates can be sold is lower.

Risk-based pricing is accomplished in two ways. Lenders often create separate loan programs that reflect a set of attributes, and price the program based on the loans' credit enhancement costs. This was reflected in the proliferation of different lending programs prior to the financial crisis. In cases where creating a separate program is inefficient or undesirable, attributes are priced using "add-ons," or points added to the discount points calculated in the manner described previously. Add-ons (often called *Loan-Level Price Adjustments*, or LLPAs) are fees calculated to account for the incremental cost of credit enhancement for a loan. Similar to discount points, such fees are quoted as percentage points of the loan's face value. For example, a 30-year fixed-rate conforming-balance loan with a 5.875% note rate may be associated with 1/2 point. However, a borrower may seek a loan with an LTV higher than that specified by the program's guidelines. If the add-on in this case is 1 1/2 points, the loan then becomes a 5.875% loan with 2 points.

However, the disinclination of many borrowers to paying large amounts of money at closing necessitates a recalculation of the rate, given some targeted amount of points and the rate/point structure prevailing at that time. In the preceding example, suppose that the borrower only wishes to pay 1/2 point after the effect of the add-ons. Referring to Exhibit 24–5, note that a loan with 1/2 point is associated with a 5.875% note rate, whereas a loan with negative 1 point has a note rate of 6.375%. Therefore, the borrower in the example could obtain a loan with a rate of 6.375% with 1/2 point. This methodology indicates how the expense, calculated in terms of points, of "alternative" loans is translated into incrementally higher note rates.

COMPONENT RISKS OF MORTGAGE PRODUCTS

Holders of fixed income investments ordinarily deal with interest-rate risk, which is the risk that changes in the level of market interest rates will cause fluctuations in the market value of such investments. Mortgages and associated mortgage-backed securities, however, have additional risks associated with them that are unique to the products and require additional analysis. (In the following discussions, mortgages and MBS are collectively referred to as *pools* for the sake of clarity.)

Prepayment Risk

In a previous section we noted that obligors generally have the ability to prepay their loans before they mature. For the holder of a mortgage asset, the borrower's prepayment option creates a unique form of risk. In cases where the obligor refinances the loan in order to capitalize on a drop in market rates, the investor has a high-yielding asset payoff, and it can be replaced only with an asset carrying a

lower yield. Prepayment risk is analogous to "call risk" for corporate and municipal bonds in terms of its impact on returns, and it also creates uncertainty with respect to the timing of investors' cash flows. In addition, changing prepayment "speeds" owing to interest-rate moves cause variations in the cash flows of mortgage pools, strongly influencing their relative performance.

The importance of prepayments to the mortgage sector has created the need for the measurement and analysis of prepayment behavior. Prepayments occur for the following reasons:

- The sale of the property;
- The destruction of the property by fire or other disaster;
- A default on the part of the borrower (net of losses);
- Curtailments (i.e., partial prepayments); and
- Refinancing.

A useful nomenclature is to divide prepayments into "rate-sensitive" and "rate-insensitive" categories. Rate-insensitive prepayments traditionally have been comprised of housing turnover, which normally consists of home sales, along with equity extraction through the vehicle of cash-out refinancings. The spike in delinquencies and credit problems after 2007, however, meant that credit-related prepayments also needed to be taken into account in assessing prepayment speeds. (Since mid 2010, for example, the GSEs are forced to buy seriously delinquent loans out of pools. Such buyouts are treated as prepayments in agency pools. As we will discuss, credit-related prepayments are treated differently in private-label securities.)

Rate-sensitive prepayments primarily consist of refinancings for which borrowers do not monetize their homes' equity, and are also called "rate-and-term" refinancings. This activity is dependent on borrowers' ability to obtain a new loan at a lower rate, making this activity highly sensitive to the level of interest and mortgage rates. In addition, the amount of refinancing activity can change greatly given a seemingly small change in rates. The paradigm in mortgages thus is fairly straightforward. Mortgages with low note rates (that are "out-of-the-money," to borrow a term from the option market) normally prepay fairly slowly and predictably, whereas loans carrying higher rates ("in-the-money") can see spikes in prepayments when rates drop, as well as significant volatility in prepayment speeds.

The measurement of prepayment rates is, on its face, fairly straightforward. A metric referred to as *single monthly mortality* (SMM) measures the monthly principal prepayments on a mortgage portfolio as a percentage of the balance at the beginning of the month in question. (Note that SMM does not include regular principal amortization.) The *conditional prepayment rate* (CPR) is simply the SMM annualized using the following formula:

$$\text{CPR} = 1 - (1 - \text{SMM})^{12}$$

While CPR is the most common term used to describe prepayments, other conventions are also used. Logic suggests, for example, that prepayment behavior is not constant over the life of the loan. Immediately after the loan is funded, for example, a borrower is unlikely to prepay his mortgage; however, the propensity to prepay (for any reason) increases over time. This implies that prepayments adhere to some sort of "ramp," where the CPR increases at a predictable rate. The most common ramp is the so-called PSA model, created by the Public Securities Association (now called the Securities Industry and Financial Markets Association, or SIFMA). The base PSA model (100% of the model or 100% PSA, to use the market convention) assumes that prepayments begin at a rate of 0.2% in the first month and increase at a rate of 0.2% per month until they reach 6.0% CPR in month 30; at that point, prepayments remain at 6% CPR for the remaining term of the loan or security. Based on this convention, 200% PSA implies that speeds double that of the base model (i.e., 0.4% in the first month ramping to a terminal speed of 12% CPR in month 30.) Exhibit 24–8 shows a graphic representation of the PSA model.

The PSA model depends on the age of the loan (or, in a pool, the weighted-average loan age). For example, 4.0% CPR in month 20 equates to 100% PSA, whereas 4.0% CPR in month 6 represents 333% PSA. Conversely, the usefulness of the PSA model (or other ramps that are similar in nature) depends on how quickly prepayments move toward a terminal rate (or, to put it differently, how quickly they "ramp up"). It is generally understood that prepayment ramps have shortened since the model was derived, reflecting the lowering of refinancing barriers and costs. In turn, this arguably has distorted the reported PSA speeds for loans that are 30 months old or less, making the PSA model less useful as a measure of prepayment speeds.

While a full discussion of prepayment behavior and risk is far beyond the scope of this chapter, it is important to understand how changes in prepayment rates affect the performance of mortgages and MBS. Since prepayments increase as bond prices rise and market yields are declining, mortgages shorten in average life and duration when the bond markets rally. As a result, the price performance of the mortgage portfolio or security tends to lag that of bonds without prepayment exposure when interest rates decline. Conversely, prepayments tend to slow when market yields are rising, causing the average life and duration of the mortgages or MBS to increase. This phenomenon, generally described as *extension*, causes the price of the mortgage or MBS to decline more than comparable fixed-maturity instruments (such as Treasury notes) as the prevailing level of yields increases.

Owing to changes in prepayment rates, mortgages and MBS exhibit price performance that is generically referenced as "negative convexity." Since prepayments increase when rates decline, MBS shorten in average life and duration at precisely the time when their performance would benefit from extending. Conversely, when the bond market sells off, mortgage average lives and durations lengthen. This behavior causes the price changes in mortgages and MBS to be decidedly nonlinear in nature and to underperform those of assets that do not exhibit negatively convex behavior. Exhibit 24–9 shows a graphic representation

EXHIBIT 24–8

The PSA Model

of this behavior. Investors are generally compensated for the lagging price performance of MBS through higher base-case yields. However, the necessity of managing negative convexity and prepayment risk on the part of investors dictates active analysis and management of their MBS portfolios.

EXHIBIT 24–9

Performance Profile of Hypothetical Fixed-Maturity Bond versus MBS

Credit and Default Risk

Analysis of the credit exposure in the mortgage sector is different from the assessment of credit risk in most other fixed income instruments because it requires:

- Quantifying and stratifying the characteristics of the thousands of loans that underlie the mortgage investment;
- Estimating how these attributes will translate into performance based on standard metrics and the evaluation of reasonable best-, worst-, and likely-case performance;
- Calculating returns based on these scenarios.

In a prior section, some of the factors (credit scores, LTVs, etc.) that are used to gauge the creditworthiness of borrowers and the likelihood of a loan to result in a loss of principal were discussed. Many of the same measures are also used in evaluating the creditworthiness of a mortgage pool. For example, weighted-average credit scores and LTVs are calculated routinely, and stratifications of these characteristics (along with documentation styles and other attributes) are used in the credit evaluation of the pool. In addition to these characteristics of the loans, the following metrics are also relevant for the *a posteriori* evaluation of a mortgage pool.

Delinquencies

Delinquency measures are designed to gauge whether borrowers are current on their loan payments or, if they are late, stratifying them according to the seriousness of the delinquency. The most common convention for classifying delinquencies is one promulgated by the Office of Thrift Supervision (OTS); this *OTS method* classifies loans as follows:

- Payment due date to 30 days late: *Current*
- 30–60 days late: *30 days delinquent*
- 60–90 days late: *60 days delinquent*
- More than 90 days late: *90+ days delinquent*

Defaults

At some point in their existence, some delinquent loans become current (or cure) because the condition leading to the delinquency (e.g., job loss, illness, etc.) resolves itself. However, some portion of the delinquent loan universe ends up in default. By definition, default is the point where the borrower loses title to the property in question. Default generally occurs for loans that are 90+ days delinquent, although loans where the borrower goes into bankruptcy may be classified as defaulted at an earlier point in time.

It is important to note that the treatment of defaults in agency and nonagency securities is different. As noted in the previous section, seriously delinquent loans

are bought out of agency pools. Since the agency in question is responsible for the repayment of the full amount of principal to investors, buyouts are prepayments for all practical purposes. No such mechanism exists for private-label securities; principal is only paid to investors once it is recovered through the foreclosure process (or through some alternative mechanism, such as a short sale.) Moreover, only the recovered amount of principal is returned to investors, with the transaction absorbing the resulting losses.

Therefore, defaults in private-label transactions must be treated and quoted separately from refinancings, turnover, and other types of *voluntary prepayments*. Rates for *involuntary prepayments* are generally measured by the *conditional default rate*, or CDR. CDRs are calculated in a fashion similar to CPRs, in which the face value of loans going into default in any given month is divided by that month's initial value. The resulting *monthly default rate* (or MDR) is then annualized in the same fashion as SMMs.

Severity

Since the lender has a lien on the borrower's property, some of the value of the loan can be recovered through the foreclosure process. *Loss severity* measures the face value of the loss on a loan after foreclosure is completed. Severities are often heavily influenced by the loan's LTV (since a high LTV loan leaves less room for a decline in the value of the property in the event of a loss). However, in the event of a default, even loans with relatively low LTVs can experience significant losses, generally for several reasons:

- The appraised value of the property may be high relative to the property's actual market value.
- The value of a property may have declined since the loan's origination due to changes in the real estate market.
- There are costs and lost income associated with the foreclosure process.

In light of these metrics, the process of evaluating the credit-adjusted performance of a pool involves first understanding the expected delinquencies, defaults, and loss severities of the pool based on its credit characteristics and attributes. Subsequently, loss-adjusted yields and returns can be generated.

KEY POINTS

- Mortgage loans can be categorized using a number of different factors, including: lien status; original loan term, interest-rate type, balance classification, amortization type, and borrower credit and documentation standards. Loans can also be categorized by the type of credit support they receive, i.e., guarantees directly from the U.S. government, through Freddie Mac or Fannie Mae, or some form of private credit enhancement.

- The payments on a fixed-rate fully amortizing mortgage remain fixed for the term of the loan. Early in a loan's life, the bulk of the payments are classified as interest. However, the portion directed to repay principal grows as the loan ages.
- Mortgage underwriting is a complex process that takes into account borrowers' ability and apparent willingness to service their loans. These are judged using metrics such as credit scores, loan-to-value ratios, and income ratios. The accurate documentation of income, employment, and assets has also proved to be important in assessing borrower creditworthiness.
- Mortgage lenders calculate their pricing in the form of the discount points required or rebated for a series of note rate strata. Consumer mortgage pricing is computed through a complex process that incorporates MBS levels, servicing values, and the cost of credit support.
- Securities backed by residential mortgages have a variety of risks. In addition to interest rate risk, mortgage-backed securities are exposed to prepayment risk, as well as credit risk if the securities in question do not have explicit or implicit government backing.

CHAPTER
TWENTY-FIVE

AGENCY MORTGAGE-BACKED SECURITIES

ANDREW DAVIDSON
President
Andrew Davidson & Co., Inc.

ANNE CHING, CFA
Senior Analyst
Andrew Davidson & Co., Inc.

EKNATH BELBASE, PH.D.
Senior Consultant
Andrew Davidson & Co., Inc.

Agency mortgage-backed securities (MBS) are a large and important asset class. They represent a core fixed income sector with substantial liquidity, and as reinforced by the financial crisis of 2007–2009, they have to date had essentially no credit risk and are preferred investments from the standpoint of capital requirements and regulatory treatment. Yet at the same time, they pose risks to investors that are often difficult to grasp and measure. This is due to the uncertainty of prepayments on the underlying mortgages, the complexity of borrower prepayment behavior, and the interplay between the credit risk of the underlying mortgages and prepayments on agency pools. In this chapter, we provide an overview of the distinguishing characteristics of *Agency MBS*, securities issued by *government-sponsored enterprises* (GSEs), and provide an analytic framework for evaluating the risk and relative value of these complex securities.

MORTGAGE LOANS

Residential mortgage loans are the building blocks of MBS, and as of year-end 2010, were the largest category of debt in the U.S. economy. In order to develop an understanding of how MBS work, one must first become familiar with the structure and characteristics of mortgages.

A *mortgage* is a loan that is secured by real property. A borrower or mortgagor is under legal obligation to repay the loan or risk forfeiture of the property backing the loan. A mortgage loan consists of two parts: the mortgage deed or deed of trust and the promissory note. The mortgage deed describes the real estate

used as collateral against the repayment of the note. The promissory note represents the personal promise to repay the loan, which also stipulates the financial terms of the loan, including the rights of both the borrower and lender.

Mortgages are generally categorized by time to maturity, interest-rate type, amortization structure, and loan size. A fixed-rate mortgage, as the name implies, has a fixed-rate of interest for the length of the loan. Loan terms are typically 15 years or 30 years, with other terms (20, 25, and 40 years) much less common. The most common type of fixed-rate mortgage is a constant payment (also known as level-pay) fully amortizing mortgage. This means that the principal is fully amortized over the length of the loan and each monthly payment is the same dollar amount. In other words, the principal is repaid gradually over the term of the loan in contrast to U.S. Treasury securities and other bonds in which the principal is generally repaid in one lump sum at maturity; each constant payment is a changing mix of interest and principal, with the amount of interest decreasing over time and the amount that is principal rising, as shown in Exhibit 25–1.

Other types of amortization structure include balloon loans and interest-only period loans. A *balloon loan* requires a full repayment of remaining principal at a future date. For example, a 30-year fixed-rate loan with a balloon at 10 years requires all remaining owed principal to be repaid at month 120. An *interest-only period loan* allows the borrower to make smaller payments, consisting of only interest, for an initial period (such as 5 or 10 years), followed by larger payments after that date due to the shorter remaining amortization period.

EXHIBIT 25–1

Constant Payment Mortgage

Finally, *negative amortization mortgages* allow an initial period in which borrowers are allowed to make payments less than the interest due, resulting in increasing loan balances.

Adjustable-rate mortgages (ARMs) have variable rates of interest. Lenders sometimes offer ARMs at below market "teaser" rates for an initial period of time. After the teaser rate period has expired, the coupon resets off a specified index. Typically, the index is tied to a comparable term U.S. Treasury bill or other market cost of funds such as the London Interbank Offer Rate (LIBOR) or Eleventh District Cost of Funds Index (COFI). An acceptable index from a regulator's point of view is one that is not susceptible to market manipulation by the lending institution and is driven by market conditions. Typically the contract interest rate resets once a year subject to cap limitations. Periodic caps limit the rate increase at reset date, while lifetime caps limit the upper bounds of a coupon during the life of the loan. As a result, monthly payments adjust up or down as interest rates move.

Hybrid ARMs blend the features of both fixed-rate and adjustable-rate mortgages and began to be increasingly popular beginning around 2002. Hybrid ARMs are initially fixed-rate loans that convert into adjustable-rate loans after a predetermined period—typically 3, 5, 7, or 10 years—and then reset annually at a specified spread to an index over the remainder of a 30-year term. Other salient features of hybrid ARMs include cap structures and indices. Hybrid ARMs are subject to initial, periodic, and lifetime caps. The initial cap limits the amount the contract rate of interest can rise at the first reset date. The periodic cap limits the increase in the contract rate at each subsequent reset date. The lifetime cap establishes a ceiling on the amount the contract rate can increase over the life of the loan. The most common cap structures for hybrid ARMs are presented in Exhibit 25–2. In addition some 5/1 hybrids have a 2/2/5 cap structure.

Hybrid ARMs have been issued with a variety of indices, with the 1-year Constant Maturity Treasury (CMT) as the most prevalent index prior to 2001. There has been a recent trend toward LIBOR-indexed hybrids, which reflects liquidity concerns with respect to the disappearance of the 1-year Treasury bill. Additionally, LIBOR-based MBS provides a closer match between bank assets and liabilities, reducing basis risk between LIBOR-based liabilities and ARMs.

EXHIBIT 25–2

Typical Hybrid ARM Cap Structures

Hybrid Type	Initial Cap	Periodic Cap	Lifetime Cap
3/1	2%	2%	6%
5/1	5%	2%	5%
7/1	5%	2%	5%
10/1	5%	2%	5%

In 2003, Fannie Mae introduced a LIBOR-indexed 5/1 hybrid program as a way to create more uniformity and liquidity in the market for LIBOR-based hybrid products.

While interest-only periods are available with fixed-rate loans, in the mid-2000s they became increasingly associated with hybrid loans. Meanwhile, balloon loans all but disappeared as hybrid loans became more popular. Finally, while negative amortization loans are theoretically possible with fixed-rate loans and a single amortization change date, negative amortization loans originated in the 2000s have tended to be adjustable-rate or hybrids, with the "Option-ARM" product gaining the most notoriety during the housing boom and aftermath of 2004 through 2010.

Another distinguishing feature of a mortgage loan is the absolute size of the loan. For example, as of 2011, a loan for a single-family home which is less than $417,000 is considered a conforming loan size, with other, higher limits for higher cost geographic areas. A loan whose size is greater than the conforming loan cut-off is called a jumbo loan. This limit has been adjusted annually based on national house price growth. Approximately 80% of mortgages in the United States meet the conforming loan size.

Exhibit 25–3 provides a list of various mortgage products available as of March 2004. Notice that the first two products are both 30-year fixed-rate mortgages. However, the contracted rates of interest differ because the first product requires two percentage points of the loan amount paid upfront by the borrower

EXHIBIT 25–3

Mortgage Products and Rates Available on March 5, 2004

Program	Rate (%)	Points	APR (%)
30-yr fixed	5.25	2	5.45
30-yr fixed	5.75	0	5.77
20-yr fixed	5.38	0	5.41
15-yr fixed	4.50	2	4.84
15-yr fixed	5.13	0	5.16
30-yr fixed jumbo	5.75	0.25	5.79
15-yr fixed jumbo	5.25	0	5.28
30-yr adjustable	3.13	0	3.95
3/1 ARM	3.25	2	3.73
5/1 ARM	4.50	0.125	3.97
7/1 ARM	4.75	0	4.19
30-yr fixed FHA/VA	4.75	0	6.54

APR = annual percentage rate.

Source: Countrywide Mortgage.

at the time of loan origination. The second 30-year loan does not require a payment of points. Points (sometimes referred to as *discount points*) are paid to the lender to reduce the overall interest rate of the loan. Borrowers who plan to live in a dwelling for a long period of time tend to pay points up front to lower their interest rate and thus monthly mortgage payment. Analysts consider the choice of borrowers to pay "points" to be predictive of the length of expected tenure.

Further down Exhibit 25–3 the interest rates of two fixed-rate jumbo mortgages (30- and 15-year) generally command higher interest rates than their conforming counterparts. This is both because jumbo loans tend to have more ruthless exercise of the borrowers option to refinance (more on this in our prepayment section) and because jumbo loans do not qualify for the agency loan programs, resulting in lowered liquidity for jumbo-backed securitizations. Over time, the spread between jumbo loans and agency-eligible loans has fluctuated, depending on factors such as the liquidity premium commanded by agency MBS, credit concerns and the general level of credit spreads, and the price of prepayment risk. The ARM products listed have lower interest rates than fixed-rate products because these mortgages are fully adjustable after the initial fixed period has expired, and as of the date shown in the table, the yield curve was relatively steep. Over time, the ARM/FRM difference primarily varies as a function of the slope of the yield curve, and on the demand for ARMs as investments relative to the demand for ARMs by borrowers.

Exhibit 25–3 also quotes the annual percentage rate (APR), which is higher than the original contract rate and accounts for all costs including interest, such as any origination fees, discount points and private mortgage insurance that may be part of the loan agreement.

HISTORY OF SECONDARY MORTGAGE MARKET

The Federal National Mortgage Association (Fannie Mae) was established in the 1930s in order to purchase and sell FHA-insured loans and eventually VA loans (1948). Prior to the 1950s, the secondary mortgage market consisted exclusively of the sale of whole loans to investors. Mortgage banks and thrift institutions would originate mortgages and sell them to life insurance companies, pension funds, and other financial institutions. The explicit government guarantee of FHA and VA loans facilitated the active trading of whole loans in the secondary mortgage market.

For much of its life, Fannie Mae operated as a national savings and loan in the sense that it gathered funds by issuing its own debt and buying mortgages that were held in its portfolio until 1968 when it was divided into two entities. A new GSE, which retained the same name, Fannie Mae, was created as a shareholder-owned government-sponsored enterprise (GSE). Ginnie Mae (GNMA) was also created to continue to provide a secondary market for government-insured loans. In 1970, Ginnie Mae issued its first mortgage pass-through security, in which the timely payment of interest and principal were guaranteed to investors as well as

the full repayment of principal even in the event of a default. At this point, Fannie Mae shifted its focus from government-guaranteed mortgages to non-FHA/VA mortgages, known today as conventional mortgages.

In 1970, the U.S. government chartered the Federal Home Loan Mortgage Corporation or Freddie Mac in response to credit shortages for single-family mortgages, which accounted for the largest share of the residential mortgage originations. The government's objective was to provide a secondary market for thrifts and other originators of conventional mortgages. Freddie Mac was also authorized to purchase FHA/VA loans. At the same time, Fannie Mae was given the authority to purchase conventional mortgage loans, which would allow both GSEs to compete for all residential mortgages below the conforming loan limit.

MBS issuance remained relatively steady in dollar terms for Ginnie Mae from the mid 1980s through 2000; meanwhile, the volume of Fannie Mae and Freddie Mac issuance began to grow significantly in the late 1990s and early 2000s, resulting in a diminishing GNMA share until the financial crisis of 2007–2009. At that point, the non-agency securitization market (also called the "private-label securities," or PLS, market), which had been supplanting the GNMA share, ceased to function, while the FHA increased loan volume significantly to help ameliorate the shortage in credit. This led to an increase in GNMA issuance for 2008–2010.

A distinguishing characteristic of agency MBS is the implicit or explicit guarantee they carry. For example, Ginnie Mae guarantees the timely payment of principal and interest on all Ginnie Mae pass-through securities backed by the full faith credit of the United States government. Therefore, in the event that a borrower defaults on a mortgage in the underlying collateral pool, investors will continue to receive the timely payment of principal and interest.

In the case of Fannie Mae and Freddie Mac, MBS investors are also guaranteed the timely payment of principal and interest whether or not payments are made by mortgagors. However, the Fannie Mae and Freddie Mac guarantees constitute corporate guarantees and are not backed by the full faith and credit of the U.S. Government. Yet despite the lack of a formal government guarantee, Fannie Mae and Freddie Mac MBS have traditionally been viewed by the financial markets as having credit status better than triple-A bonds (often referred to as the *implicit guarantee*). The source of this perception is generally attributed to the close ties between the government and the GSEs. The close ties include the history of the GSEs as government agencies, the unique regulatory structure of the GSEs, a largely symbolic line of credit to the Treasury and the presence of presidential-appointed board members for the GSEs.

The guarantees on principal and interest repayment, together with the large issuance this has allowed and a special forward delivery/repo mechanism that we discuss later, have made GNMA and GSE securities by far the most liquid asset-backed security, with significantly greater liquidity than corporate bonds, and at times even greater liquidity than certain U.S. Treasury issues.

The notion of an implicit government guarantee for the GSEs was severely tested during the financial crisis of 2007–2009. Fannie and Freddie began to suffer significant delinquencies in their guarantee portfolios, which were generally expected to result in losses greater than the guarantee premiums they had charged to bear this risk as well as their capital buffers; additionally, they had built up sizable positions in the AAA-rated tranches of nonagency securities, which began to suffer significant price declines as a liquidity crisis hit this market. As many investors began to question their continued solvency, the GSEs ability to rollover their short-term debt came into question, and in an emergency action, the secretary of the Treasury directed their regulator to take them into *conservatorship,* effectively making the guarantee on agency MBS and senior debt securities explicit. As of writing in early 2011, the ultimate fate of the GSEs is being re-thought, especially the government guarantee. Nevertheless, we expect agency MBS to be a major fixed income asset class for the foreseeable future.

AGENCY POOL PROGRAMS

The GSEs rely on a network of lenders that originate loans in order to create mortgage pools backing their mortgage-backed securities. Qualified lenders typically sell mortgage loans to the GSEs through one of two channels: flow and bulk; lenders are qualified if their origination and servicing practices have passed the GSEs requirements. The flow channel allows volume to fluctuate based on the lenders ability to originate, but with guarantee fees set in advance (prior to 2006, these were set annually, but subsequently have been set quarterly). The guarantee fees are set according to loan-level variables that determine credit quality. The flow channel can be viewed as the most liquid forward market. The bulk channel involves spot sales of loan packages with guarantee premiums negotiated on a per-package basis.

While loans in a pool may share broad similarities, differences do exist. For example, not all borrowers may be paying the same coupon. The loans may not be the same age when they were bundled. In recognition of these differences, aggregate pool characteristics or indicatives are calculated to provide investors with the starting point of their analysis. The standard terminology used to describe a typical agency pass-through can be found in Exhibit 25–4, which contains information about a specific Freddie Mac pool.

Gross weighted-average coupon (gross WAC) refers to the actual dollar weighted average coupon of the mortgages in the underlying loan pool, while the net WAC represents the gross WAC less any servicing fee paid for processing the loan. The WAC of the Freddie Mac pool in Exhibit 25–4 is 8.0%. The proceeds from a mortgage pass-through can be stated on a gross or net basis. The net WAC for this pool is equal to the net coupon of 7.5%. In this particular example, the servicing fee is 50 basis points, which is standard for Freddie Mac pass-throughs.

EXHIBIT 25–4

Freddie Mac Pool C00875

Issue date	October 1, 1999
Collateral type	30-year fixed
Net Coupon	7.5%
Current Balance	$80,561,443
Original Balance	$992,811,774
Factor	0.00303856
WAM (months)	296
WALA (months)	54
WAC	8.0%
Delay	44 days

Servicing refers to a third party who processes the homeowner's monthly mortgage payment, makes payments to local governments for property taxes, pays the property insurance and mortgage insurance premiums if necessary. The servicer also ensures that timely payments are made by the borrower every month and deals with the borrower in the event of delinquency.

It is important to note that the dispersion of mortgage coupons within the pool is fairly small with limits that depend on the specific agency pool program, which is discussed in further detail in the following. The WAC is important because it not only tells investors about the interest rates of the underlying mortgages, but also reveals the sensitivity of the loan pool to prepayments. When current mortgage rates available to borrowers fall below 1.5% or 150 basis points of the underlying WAC of the loan pool, we would anticipate that the pass-through would exhibit greater prepayment speeds. However, if current mortgage rates were to rise above the WAC of the pool, we would not expect prepayments rates to rise as long as this relationship remained between the WAC and current mortgage rates.

Similar to the WAC, the weighted average maturity (WAM) represents an average maturity weighted by the loan balances of the pool. The WAM is important because it gives investors an idea of how many payments are remaining before the principal of the pool is retired. In this particular example, the WAM of this Freddie Mac pool is 296 months. The weighted average loan age (WALA) is just the converse of WAM and represents the average age of the underlying loans in the pool weighted by their balances. In this example the WALA is 54 months.

The basic characteristics of loans within a mortgage pool have generally been standardized depending on the specific agency and program. The specific pooling requirements for each of the agency programs are summarized in Exhibit 25–5 with outstanding volume through the end of 2010.

Each MBS pool carries a pass-through rate or coupon, which is the interest rate passed onto the investor, usually on the 25th day after the end of the accrual period.

EXHIBIT 25–5

Characteristics of Agency Pool Programs

	Ginnie Mae	Fannie Mae	Freddie Mac
Mortgage Types	FHA/VA/RHS	Conventional/ some FHA/VA	Conventional/ some FHA/VA
Issuer	Ginnie I: single issuers Ginnie II: multiple issuers		
Guarantee	Timely payment of principal and interest	Timely payment of principal and interest	Timely payment of principal and interest
Guarantor	Full-faith credit of U.S. government	Fannie Mae, under conservatorship	Freddie Mac, under conservatorship
Interest Rate on Underlying Mortgages	Ginnie I: Same interest rate except for Manufactured Housing Pools Ginnie II: May vary within 1% range		
Minimum Pool Size	$1,000,000 (single-family)		
Outstanding Volume*	$580 Billion	$2.8 Trillion	$1.8 Trillion
Servicing Spread	Ginnie I: 50 bp Ginnie II: 50–150 bp	maximum of 250 bp	maximum of 250 bp
Delay (Days)			
Stated	45	55	45
Actual	14	24	14

*As of Dec 31, 2010.

Source: Federal Reserve, GNMA.

The pass-through rate is lower than the interest rate on the underlying mortgages in the pool. The interest differential covers the guarantee fee paid to Fannie Mae and the fee paid to the servicing institution.

Ginnie Mae offers several programs: Ginnie Mae I, Ginnie Mae II, and Ginnie Mae Platinum. Each of these programs offers full and timely payment of principal and interest, backed by the full-faith-and-credit guarantee of the U.S. government.

The Ginnie Mae I program issues pass-through MBS where registered holders receive separate principal and interest payments on their certificates. The MBS are based on single-issuer pool. Each pool must consist of a minimum of

three loans totaling a minimum dollar amount of $1 million. The underlying mortgages have roughly the same maturities and interest rates. Only fixed-rate mortgages can be submitted under this program. The single-family pools have a 50 basis point guaranty and servicing fee. Payments are made to the holders on the 15th day of each month.

The Ginnie Mae II program, which was introduced in 1983, allows registered holders to receive an aggregate principal and interest payment from a central paying agent on all of their Ginnie Mae II MBS. The Ginnie Mae II program provides greater flexibility to issuers because it accommodates both multiple-issuer pools as well as single-issuer pools. Smaller issuers who do not meet the minimum dollar pool requirements of the Ginnie Mae I program are able to participate with pool sizes as small as $250,000. The Ginnie Mae II program also allows both fixed- and adjustable-rate mortgages. Coupon rates on underlying mortgages can vary between 50 and 150 basis points above the interest rate on the pool. Ginnie Mae II MBS pay on the 20th day of each month.

Ginnie Mae Platinum securities are issued under the Ginnie Mae Multiclass Securities Program. A Ginnie Mae Platinum security is created by combining Ginnie Mae MBS pools with uniform coupons and original terms to maturity into a single certificate. An interesting feature of the Platinum program is that investors owning several MBS with relatively small remaining balances have the ability to aggregate the MBS. This provides critical liquidity to investors. Platinum pools can also be used by investors as collateral for repurchase agreements and structured financial products.

Fannie Mae MBS pays interest on the 25th day of each month (after the accrual period). The pass-through rate is lower than the interest rate on the underlying mortgages; this interest differential covers the guaranty fee paid to Fannie Mae (as well as the servicing fee paid to the servicer). When the underlying loans are pooled together, Fannie Mae permits the interest rates on the loans to fall within a 250 basis point range.

Freddie Mac also offers a pass-through program that offers full and timely payment of interest and ultimate payment of principal guaranteed by Freddie Mac and not by the full faith and credit guarantee of the U.S. government. The Freddie Gold program, on the other hand, offers full and timely payment of interest and scheduled principal guaranteed by Freddie Mac. The Gold program is very competitive with the Fannie Mae MBS program; hence, it is Freddie Mac's most popular MBS program. The Gold program pays interest on the 15th day of every month. Fannie Mae offers a Mega program and Freddie Mac offers a Giant program that are similar in nature to Ginnie Mae Platinum program as described.

TRADING CHARACTERISTICS

The timing and amount of cash that exchanges hands in a trade involving agency MBS are critical in determining the price and yield of the security. Therefore understanding market trading conventions established for agency MBS is critical

in analyzing the relative value and risk of these securities. The key issues are discussed in the following.

Settlement and TBA

Typically, pass-through MBS trade on a forward basis, in which settlement occurs once per month. Each type of mortgage is assigned a particular day during the month for trade settlement. During any particular calendar month, the active month for which most trades will settle will be the next monthly settlement for that security. For example, during the month of June the active trading month will be for July settlement. By the middle of July, traders will generally shift the active settlement month to August. Secondary collateralized mortgage obligations (CMOs) the subject of Chapter 26, trade on a corporate (T+3) settlement basis unless specified otherwise at trade initiation.

The forward market facilitates the origination of mortgage loans, as originating firms can sell MBS forward, prior to creating mortgage pools. In this way, the originators hedge the rates they have "locked" for borrowers. Active trading in the one-month-forward market also stems from the importance of the CMO market. Among most Wall Street dealers, frequently the biggest trading counter party of the MBS pass-through trader is the dealer's primary CMO desk. The pass-through trader will be responsible for purchasing the CMO collateral needed for any deal. As most CMO deals settle one (or more) calendar month from the pricing date, trading for collateral is most active in the one-month-forward market. This does not preclude other settlement possibilities for investors. Up until two days before the settlement within any particular month, it is still possible for investors to purchase bonds for current-month settlement. Dealers will still make markets for current-month settlement, but not always with the same liquidity as the most actively traded month.

However, there are times when attractive opportunities arise for investors as current settlement approaches. In cases in which a dealer still needs collateral to settle a CMO, he or she may have an aggressive bid for current settlement collateral or be willing to create an attractive spread in the mortgage "roll" market. Investors who roll their mortgage pass-throughs enter into a repurchase agreement in which they sell their MBS today for repurchase at a later date. Exhibit 25–6 shows TBA bid and asks prices for a few FNMA 30s starting with settlement in February 2011 given the trading environment as of January 26, 2011. For example, assuming execution at the mid-point of the bid and ask, rollers of FNMA 4.5s would sell at 101-28.5/32 for Feb settlement and repurchase at a lower price of 101-17.5/32 for March settlement. The difference is referred to as the *drop* and can be thought of as a partial coupon payment received by the lender. The column labeled Drop gives more precise bid/ask levels for the drop. The units are in 32nds, so for example, the Feb/Mar 4.5 coupon drop bid is (10 5/8)/32 which in decimal form is approximately 0.33. Each drop, assuming a particular one month prepayment speed on the underlying TBA, corresponds to an implied financing rate.

EXHIBIT 25–6

Sample of TBA Rolls (Sample Dollar Rolls & Financing Rates)

Market Data: Jan 26, 2001				
Coupon	**Feb Price**	**March Price**	**Drop**	**Rate**
4.5	10–28/29	101–17/18	10 5/8	0.065
5	104–22/23	104–12/13	9 5/8	–0.349
5.5	106–25+/26+	106–18/19	7 3/8	0.088

Source: Bloomberg

These financing rates are shown in the final column. The greater Wall Street's demand for mortgage pass-throughs settling in the nearby month, the greater is the drop. The demand for current production pass-throughs is driven by the need for collateral for CMO production or other investor demand for MBS. The choice of rolling bonds will depend on whether investors can reinvest the proceeds of the sale of their mortgage pass-throughs and earn a return greater than the yield of the bonds. The greater the drop, the greater the implied financing rate of the bonds is.

Although the roll is very similar to a *reverse repo* transaction in other government bond markets, there are some differences worth noting. The investor who sells the bond is not likely to get the same pool back, but one with substantially similar characteristics. In general, the buyer will deliver back the cheapest bond they can find that still matches the coupon and TBA guidelines, so when running a roll analysis, it may be best to assume the most adverse pool will be delivered back to you. Determining the cheapest to deliver bond can be substantially more difficult to anticipate than in the government securities market due to the complexities of prepayments and its drivers.

Settlement Cash Flows and Security Delivery

At the time of the trade, the two counter parties agree to the settlement date, price, and quantity of securities. At the time of settlement, the purchaser will pay the price times the quantity of securities, plus any accrued interest. The interest-accrual period will include the number of days from the first of the month until the settlement date.

Most trades are on a *to-be-announced* (TBA) basis. Mortgage lenders are allowed by the agencies to sell mortgages forward by securitizing the mortgages for purchase in the secondary market. In order to allow lenders to hedge (or fund) their origination pipelines, settlement dates are set between one and nine months from the date on which the transaction is negotiated. This permits lenders to lock in a price for the mortgages for which they are in the process of originating. An interesting feature of the TBA market is that the purchaser does not know

what pools will be delivered until just prior to settlement. The number of pools that will be delivered (and the precise characteristics of the pools) are unknown. Generally, TBAs are analyzed using the *average characteristics of the given mortgage program.*

Trades can also occur on a *specified pool basis*. These trades may reflect special inventory that a dealer holds or that a client needs. Trades on specific pools usually occur at prices above the current TBA quotes due to some valuable properties that the specified collateral has in comparison to TBA, or *cheapest-to-deliver,* collateral. In addition to specific pools, buyers and sellers may negotiate other types of characteristics such as year of origination or number of pools to be delivered.

Specified pool trading occurs for seasoned or WAM bonds, lower loan balance pools (LLB), lower FICO or Alt-A pools, etc. Due to their prepayment characteristics relative to the average pools (generally less sensitivity to interest rate volatility) WAM bonds tend to have greater value than the generic pool and, therefore, sell at higher prices than the TBA price. Wall Street traders also use specified pool trading to obtain pools for structured transactions or reduce back office costs by restricting the number of pools to be delivered.

While specified pool trading has existed throughout the life of the agency MBS market, the proportion grew tremendously between 1995 and 2003, which led to considerable fragmentation of the agency MBS market. The fragmentation is a result of the large range of loan sizes and dispersion of credit quality of borrowers within Fannie Mae and Freddie Mac conventional 30-year loan pools, combined with the disclosure of more borrower variables in more detail over time. The differences in agency pool composition can result in substantial differences in prepayment sensitivity and consequently, investment decisions. During periods of high demand, pools that were purchased on a pool specific basis are often delivered into TBA transactions, thus providing a contingent source of liquidity for the TBA market.

In the past, Fannie and Freddie provided information about loan coupons, remaining term, weighted average loan age, weighted average loan term, original WAM, original loan size, and issuer for each pool. Starting in 2003, they began to disclose additional pool characteristics, which began to impact mortgage trading and prepayment modeling. The additional disclosures include loan purpose, original loan-to-value (LTV) ratio, standardized credit scores of borrowers (FICO score), servicer, occupancy status, geographical distribution (at the state level), and property type. The availability of these additional pool characteristics led to an increase in the choice of specified pools, and has resulted in a greater ability to select cheapest-to-deliver pools that contain more prepayment sensitivity.

Delay of Cash Flows

Nearly all borrowers make their mortgage payments in arrears on a monthly basis. Likewise, investors receive their cash just once a month. The time between

the expected cash payment from the borrower and the ultimate cash flow received by the investor is called the *delay*. The effect of this delay must be treated by the yield calculations performed on MBS because it represents a true loss of economic opportunity. The delay varies slightly among the agencies and GSEs (see Exhibit 25–5).

While the delay factor is meant to cover many of the exigencies that occur when borrowers are late with their payments and the mechanical complications of processing the cash flows, it also provides an important source of income to the financial intermediaries. Both Fannie Mae and Freddie Mac derive significant income from the float earned between the time they collect cash flows and disburse them to investors.

Accrued Interest

The MBS begins to accrue interest on the first calendar day of the month. This corresponds to the same accrual period for the borrower. At the time of settlement, the investor must pay the previous holder the interest through the settlement date. After settlement, the investor is entitled to the entire month's interest.

MBS accrue interest on a 30/360-day basis. That is, accrued interest calculations assume that each month has thirty days and that each year has 360 days. Practically speaking, this means that each month the investor receives 1/12 of the annual coupon. As for calculating accrued interest, the investor receives 1/30 of the monthly interest payment for each day up until settlement. No additional interest is paid for settlement on the 31st of the month. Typically most settlement occurs in the middle of the month, so the extra day is not an issue.

Delivery Standards: Variance and Pools Per Million

In the nuts and bolts of trading MBS, some accommodations are made to smooth the settlement process. Many MBS pools are not originated in round dollars. However, trades between dealers and institutional investors usually take place in even lot sizes of one million dollars or more. To accommodate the anomalies of pool size, the seller has some flexibility regarding the number of pools delivered and principal amount settled.

In settling a trade, the seller can modify the amount of principal delivered. This deviation from the original trade amount is called *variance*. The variance permitted on TBA trades of Fannie Mae, Freddie Mac, and Ginnie Mae securities is plus or minus 0.01% of the dollar amount of the transaction agreed upon by the parties. In the case of specified pool trades, no allowance for variance is permitted. If the variance is not within the 0.01% limit, the pools are not considered good delivery. In a declining market, sellers of MBS will probably deliver as much as possible in a trade, taking full advantage of the upper end of the variance limit. The opposite will occur in a rising market.

In order to keep someone from delivering a large number of low principal dollar pools, the Securities Industry and Financial Markets Association (SIFMA)

limits the number of pools delivered in a trade. Restricting the number of pools to a small number has some operational benefits for the MBS purchaser. Tracking the monthly principal and interest payments can be labor-intensive and costly. Left unchecked, sellers would attempt to unload all of their small pools on someone else. Over time, the delivery requirements have been modified somewhat, allowing for more pools per trade for higher coupon MBS. The increased number of pools reflects the high pay-downs and the resulting low balances. The standard requirements for delivery and settlement of MBS are published in the SIFMA Uniform Practices manual.[1]

PREPAYMENT AND CASH-FLOW BEHAVIOR

Prepayments are the primary distinguishing feature of agency mortgage-backed securities. Without prepayments, mortgages would be extremely easy to analyze. On the other hand, if MBS were so simple, the number and scope of investment opportunities would be severely limited. Prepayments are the double-edged sword of the MBS market. They create opportunity, but they also create risk.

The timing and amount of cash flows received by pass-through MBS are greatly affected by the prepayment behavior of underlying mortgages within the MBS pool. Borrowers generally have the right to prepay their loans at any time without penalty (with the exception of some subprime loans). Borrowers may pay off their loans in full or in part. For a full prepayment, the borrower pays off the remaining outstanding balance of the loan, usually using the proceeds of another loan at a lower rate. Partial prepayments, often referred to as *curtailments,* reduce the balance of the loan, but do not alter the scheduled monthly payments. For individual loans, a partial prepayment shortens the life of the loan. However, for a pool of loans, a full prepayment of one or several loans does not have the same effect as a partial prepayment of an individual loan. Full prepayments of loans within a pool serve to reduce the outstanding balance, but do not reduce the final maturity of the underlying loan pool.

PREPAYMENT CONVENTIONS

Prepayments are defined as the difference between the actual balance of the MBS pool in any month and the balance expected due to normal amortization. The market has developed several approaches to describing the prepayments for a pool of loans. Since MBS pools vary in size, prepayments measured in dollar terms would not make meaningful comparisons. Exhibit 25-7 summarizes three prepayment conventions, which are all expressed as a percentage or rate.

1. The publication is available at www.sifma.org.

EXHIBIT 25–7

Prepayment Conventions

Single Monthly Mortality (SMM)	The SMM measures the percentage of dollars prepaid in any month, expressed as a percentage of the expected mortgage balance.	$\text{SMM} = 100 \times \frac{(\text{Scheduled Balance} - \text{Actual Balance})}{\text{Schedule Balance}}$
Conditional Prepayment Rate (CPR)	CPR reflects the percentage prepayment rate resulting from converting the SMM to an annual rate. The CPR is best understood as the percentage of nonamortized balance prepaid on an annual basis.	$\text{CPR} = 100 \times \left[1 - \left(1 - \frac{\text{SMM}}{100}\right)^{12}\right]$
Public Securities Association Model (PSA)	An industry convention adopted by the Public Securities Association in which prepayment rates, expressed in CPR, are assumed to follow a standard path over time. This path assumes that the prepayment rate for a pool of loans increases gradually over the first 30 months and then levels out at a constant rate. Along the 100% PSA curve, the prepayment rate starts at 0.2% CPR in the first month and then rises 0.2% CPR per month until month 30, when the prepayment rate levels out at 6% CPR.	$\text{PSA} = 100 \times \frac{\text{CPR}}{\text{minimum (age, 30)} \times 0.2}$

Note: The Public Securities Association became the Bond Market Association and subsequently SIFMA after a merger, but the name PSA has not changed for the prepayment convention.

EXHIBIT 25–8

Sample Prepayment Rate Calculations

Scheduled Balance	154,000
Actual Balance	153,000
Age (months)	25
SMM	0.65%
CPR	7.53%
PSA	150.54%

In order to develop a familiarity with the conventions, we will work through some numerical examples.[2] Using information about the scheduled balance, actual balance and age presented in Exhibit 25–8, we can calculate the prepayment rates in SMM, CPR, and PSA formats.

SOURCES OF PREPAYMENTS

Prepayments arise when borrowers move, refinance, or default on their mortgage loans. Prepayments that result from changing residences constitute a base prepayment rate, which is referred to as *turnover*. Employment related relocation, marriage, divorce, children, death of a spouse, and other life cycle changes are factors that directly affect housing turnover. Most conventional mortgages (non-FHA/VA loans) contain a *due-on-sale clause,* which stipulates that the mortgage must be paid in full when the house is sold. In contrast, FHA/VA loans are often assumable, which means they can be transferred to the new homeowner as long as the new borrower meets minimum credit requirements.

Mortgage refinancing represents the largest and most variable source of prepayments. There are several categories of refinancing that can occur. For example, there are high quality borrowers who want to take advantage of lower cost mortgages in a falling interest rate environment. There are also borrowers who refinance in order to borrow more money than the existing loan balance on their property, provided that there is sufficient equity in the home. This type of refinancing activity is called a *cash-out refinance*. Borrowers with previously tarnished credit histories are able to refinance at more favorable rates because of improvements in their credit ratings. This type of refinancing is referred to as *credit curing*.

Defaults are not technically prepayments, but they have the same effect as prepayments in that the principal balance of the defaulted loan is returned to the investor in the case of agency MBS. Because of the guarantee provided by the

2. Formulas for calculating SMM, CPR, and PSA can be found in SIFMA's Standard Formulas section. Many other formulas for MBS valuation can be found there as well.

GSEs, the investor is protected from the credit risk of individual borrowers that compose the pool. Defaults of agency MBS typically represent only a small fraction of monthly prepayments because of the high credit quality of the underlying mortgages, and therefore, generally can be forecast as part of prepayments. Notable exceptions were agency pools composed of Alt-A low-doc loans originated during the period 2006–2008. In such cases, it is critical to forecast defaults separately from prepayments because of the lower quality of the collateral.

The most important factors that impact prepayment behavior include interest rates, aging, loan size, burnout, and seasonality. The primary factor influencing prepayment rates is the level of interest rates, which reflects a borrower's opportunity to refinance. The refinancing incentive can be measured by the difference between the interest rate of the borrower's loan versus the interest rate currently available in the market for new loans. For example, in the Andrew Davidson & Co. prepayment model, current coupon yield (the yield on MBS trading near par) is used as a proxy for the rates currently available to borrowers. Loans in which the difference between the loan coupon and the current coupon yield are greater than zero have a greater incentive to refinance. Exhibit 25–9 demonstrates the effect. As the refinance incentive moves from negative to positive territory, prepayment speeds increase as shown by CPR along the vertical axis. The relatively level prepayment speeds for refinancing incentive less than zero reflect the base turnover rate in the housing market. Such loans, in which the coupon is less than the current coupon yield, are called discount loans because they have prices less than par.

EXHIBIT 25–9

Interest-Rate Effect on Prepayment: GNSF

The response of prepayments to interest-rates is decidedly nonlinear. (Many early prepayment functions used an arctangent function to fit the S-shape we see.) Most academic papers that have attempted to value MBS in simple ways (without using Monte Carlo simulation, which is discussed in the section on valuation) assume a linear response, is makes these academic approaches to date impractical for use by practitioners.

Because refinancing into a new mortgage comes with fixed costs (such as an appraisal, origination fee, etc.), the size of a loan is an additional factor affecting the refinancing incentive perceived by the borrower. All else equal, on a percentage basis, these fixed costs are lower the larger the size of the loan, leading to steeper refinance incentive curves than shown above for Fannie and Freddie loans, which tend to be larger than FHA loans. The refinance incentive curve for prime jumbo loans is even steeper.

Aging is the second most important factor influencing prepayment behavior. Aging reflects the fact that new loans typically exhibit slower prepayment speeds compared with "seasoned" or older loans. The PSA benchmark aging curve was introduced in the mid 1980s to account for the aging pattern typically observed for agency MBS. The base PSA curve or 100% PSA is depicted in Exhibit 25–10 and starts at 0 CPR and rises linearly to 6 CPR by month 30. The PSA curve roughly depicts the prepayment pattern for discount loans but not for premium loans. Because of the variation in aging patterns for different loan types (in particular the substantial variation by refinance incentive), the PSA curve

EXHIBIT 25–10

PSA Prepayment Convention

should be considered an outdated convention. We have included it here for completeness because a number of popular analytical systems continue to include it as an alternative to CPR and SMM.

Exhibit 25–11 shows the aging pattern of Ginnie Mae loans by coupon type. Premium coupon loans are defined as loans whose coupons are greater than the prevailing market rate and therefore have a positive refinancing incentive, while discount coupon loans have coupons less than the current market rates. The exhibit illustrates that newer loans prepay more slowly, regardless of whether they are premium or discount loans. Moreover, the exhibit also shows that not all loans follow the same prepayment trajectory. The premium loans experience higher prepayment speeds and peak sooner compared with the discount loan counterparts in the exhibit. In addition, the prepayment rates of discount loans tend to rise more slowly and peak farther out on the aging curve.

Burnout is another important factor determining the rate of prepayments and probably the most difficult to measure. The concept of burnout is based on empirical observation that refinancing activity within a loan pool declines over time regardless of whether interest rates continue to decline further. The burnout effect can best be understood by viewing an MBS pool as a collection of borrowers, each with different propensities to refinance. As rates fall, the borrowers with greatest propensity do so. The borrowers remaining in the pool face higher refinancing costs, economic and noneconomic. These borrowers tend to repay at a slower rate compared to the first group of borrowers even when later faced with

EXHIBIT 25–11

Prepayment Rate of Discount versus Premium Loans

the same interest rate differential. Because the composition of the pool depends on the path that interest rates and refinancing have taken since the pool was originated, burnout is called a *path-dependent* variable. In addition to the nonlinear response to refinance incentive discussed earlier, this path-dependence presents additional challenges in valuing MBS compared to other asset classes.

Exhibit 25–12 illustrates both the concept of burnout and the difficulty of measuring it using data from the aggregate performance of an FNMA 30-year fixed pool from 2002 with performance from 2002 through the end of 2010.

The bars show the total balance of that vintage over time, the dashed lines show our model forecasts (given an accurate interest rate forecast), whereas the solid lines show actual aggregate prepayment speeds. As we can see, the majority of the balance of the 2002 vintage refinanced during the strong incentives of 2003 and 2004, and the model was largely accurate during that period. Later, with a very changed pool composition, despite rates dropping much lower during the financial crisis (to all-time lows in early 2009), the model forecast much lower prepayment peaks, topping around 50 CPR. Nevertheless, this vintage in aggregate behaved much more burnt out, primarily due to the extremely difficult housing market and credit crunch. (This is discussed in more detail in the paragraph on housing and the general economy influencing prepayments.)

EXHIBIT 25–12

Comparison of Prepayment Speeds, FNMA 30-year 2002 Vintage

Seasonality is another major determinant of prepayment rates. Seasonality reflects the close interaction of prepayments with housing market activity. Historically, prepayments tend to be faster during the summer and slower during the winter months, reflecting increased home turnover during the summer months. Seasonality is more pronounced for discount loans compared with premium loans. Premium loans do not exhibit a large seasonal component because refinancing activity tends to eclipse the seasonality effect. The commonly observed features of seasonality are as follows: Prepayments tend to be highest in May and July with an uptick in December, perhaps reflecting year-end tax strategies and moving during the holidays, especially summer vacation.

House prices and the general economy also influence prepayments. Weak economic activity, declining housing prices and unemployment all tend to depress prepayments. These factors are sometimes regional in nature and can lead to large differences in prepayments across the United States. During the 1990s, home price appreciation strongly affected prepayments because rising home prices resulted in greater homeowner equity, thus increasing financial opportunities available to borrowers for cash-out refinancing. Later, during 2006–2010, as home prices declined nationally, prepayments were dramatically depressed, even at what on paper looked like comparable refinancing incentives. Many borrowers had insufficient equity to allow them to refinance; simultaneously, banks, and the GSEs became much more cautious in their underwriting, and raised the premiums charged for taking credit risk. This resulted in a long period of depressed prepayments relative to the late 1990s and early 2000s, when strong house price appreciation resulted in faster prepayments at given refinance incentives than people had come to believe based on prior experience. This period has led some modelers to include an explicit credit-spread in their measures of refinance incentive.

The shape of the yield curve can also impact prepayments. With the development of a variety of mortgage products such as ARMs, hybrid ARMs, and balloon loans, borrowers can choose products whose prices are derived from different parts of the yield curve. When the yield curve is steep, borrowers may refinance into shorter maturity loans in order to reduce their borrowing costs. When the yield curve is flat, it may be advantageous for borrowers to lock in rates at the long end of the yield curve particularly if they have a long time horizon.

PREPAYMENT MODELS

Evaluation of the investment characteristics of MBS requires estimates of prepayment rates. These estimates can take various forms, from a single assumption based on experience to complex models that rely on loan level details.

These forecasts, regardless of their source, are used to understand the performance characteristics of MBS and determine appropriate valuation of different investments. Prepayment forecasters face a fundamental problem. They seek to estimate future events in a changing world. For example, new loan types are constantly being created and the loan origination process is continually evolving.

In addition, over time, our understanding of the primary variables affecting prepayments and their interactions has continued to evolve. Still, the primary guide to future prepayments is past prepayments. Thus modelers develop models which seek to explain prior prepayments well based on a parsimonious set of variables while retaining some flexibility to allow for changes in understanding that occurs over time. Since the economic and social environment is constantly changing, and prepayments are affected by a host of factors, it is unlikely that any historically based analysis will completely reflect future prepayments. Investing based on prepayment models is a little like driving, while looking through the rear view mirror. It may be hard to stay on the road, but it's better than driving with your eyes closed, especially on stretches where the road does not turn too dramatically.

Good models are ones that are robust and parsimonious. Robust models provide good forecasts under a variety of conditions. That is, they do not need to be adjusted continually in order to reflect changing environments. Models that require constant adjustments probably will not provide accurate forecasts of future prepayments. Parsimonious means that the models are as simple as possible. Parsimonious models capture the major variables that affect prepayments using the fewest number of parameters. They have the advantage that they do not "over fit" the data compared with models with too many factors. The use of complex models with too many parameters may result in an excellent fit to historical data, but may not provide accurate projections. The added variables may reflect a spurious one-time correlation rather than real long-term relationships. Parsimonious models are also easier to incorporate into valuation tools and explain to a wide audience.

VALUATION

A common measure of value quoted among investors is the spread between the MBS and a benchmark U.S. Treasury security. While spread measures are inadequate because they provide only a static view, they are a useful starting point for assessing relative value. Exhibit 25–13 presents various spread measures for Fannie Mae 30-year with coupons ranging from 4.5% to 6.5%.

The first spread measure presented in Exhibit 25–13 is the static spread, which is labeled Spread/Benchmark. It is computed by subtracting the yield of a specific U.S. Treasury security from the yield of the MBS. For newly issued current coupon MBS, the benchmark Treasury is often the on-the-run 10-year Treasury note. Other MBS are compared to U.S. Treasuries with similar average life. The first number represents the spread in basis points and the second number represents the benchmark Treasury. For example, the spread of FNMA 5.0 is 197 basis points over the 3-year Treasury.

A more reliable measure of value than static yield is an interpolated weighted average life spread, which is also shown in the same exhibit as "Spread to WAL Treasury." This measure uses a Treasury benchmark that more closely reflects the

EXHIBIT 25–13

Spread Analysis for Fannie Mae 30-Year, January 14, 2011

							Spread to		
Agency	**Coupon**	**Maturity (years)**	**WAM**	**Price**	**Static Yield**	**WAL**	**Spread/ Benchmark***	**WAL Treasury**	**Zero Curve**
FNMA	3.5	30	356	95.50	4.30	7.1	97/10	212	60
FNMA	4.0	30	355	99.47	4.10	5.2	218/5	232	62
FNMA	4.5	30	347	102.58	3.64	3.7	172/5	253	69
FNMA	5.0	30	338	105.17	3.00	3.0	197/3	218	82
FNMA	5.5	30	326	107.66	2.37	2.5	134/3	155	75
FNMA	6.0	30	330	108.58	2.34	2.6	131/3	152	67

Source: Andrew Davidson & Co., Inc. Prepayment and OAS Models
*Source: 1/Bloomberg LP, 2011.

principal repayments of the MBS. For example, rather than compare the FNMA 4.5 with a 5-year Treasury, we would compare this MBS pass-through with a Treasury with the same WAL of 3.7 years. In order to do this, we interpolate the yield of a Treasury with an average life of 3.7 years. Notice that the interpolated weighted average life spread for the FNMA 4.5 is greater than the static spread. The difference can be attributed to the divergence between the average life of the MBS and benchmark Treasury, which makes the WAL spread more reliable.

The spread to the zero curve or "zero spread" is also presented in Exhibit 25–13, which is a great improvement on static yield and interpolated WAL spread because it incorporates the shape of the yield curve and timing of cash flows. The cash flows of the MBS are discounted by the zero coupon rate plus a constant spread that equates the net present value of cash flows to the current market price. In Exhibit 25–13, the zero spreads are lower compared with the WAL spreads. The reason for this is that lower yield spreads earned on longer dated cash flows have a greater effect on value than the higher spreads earned on earlier cash flows. The flatter the yield curve, the less divergence will be observed between WAL and zero spread measures.

All of the spread measures we have mentioned so far suffer from the deficiency that they are all computed based on a single interest rate scenario. In reality, we are never able to forecast the path that interest rates will take. Therefore, a measure of value that recognizes this uncertainty is needed.

Option-adjusted spread (OAS) is such a measure of value because it takes into consideration the changing nature of underlying cash flows under a multitude of interest-rate scenarios. OAS represents the expected spread over the short-term risk-free rate over a large number of possible interest rate scenarios *after accounting for the prepayment option*. OAS captures the additional yield an investor is expected to earn from the prepayment option component of MBS cash flows. The "expected yield" from an MBS can be thought of as the risk-free return (over the life of the mortgage suitably time weighted) plus option cost plus OAS.[3] In general, OAS calculations from price, or price calculations from OAS utilize *Monte Carlo Simulation*. This is in contrast to the valuation of other, simpler instruments which might be done in closed form (using a "formula") or using *backward induction* (a faster numerical approach than Monte Carlo). The nonlinearity of prepayments as well as path-dependence prevents the use of the first approach, whereas path dependence often prevents the use of the second.

Additional measures such as *effective duration* and *effective convexity* provide insight into the market risk of the security. Effective duration measures the change in price for a 100 basis point change in interest rates, holding OAS constant. Convexity measures the change in duration for a 100 basis point change in rates. *Negative convexity* is a general feature of MBS (or other bonds with embedded optionality), reflecting that the amount of upside price appreciation is limited relative to the amount of downside price risk, as a function of interest rates. The

3. OAS is discussed in more detail in Chapter 26.

reason for the use of the term *effective* is to distinguish these measures from static (single-path based) measures, which happen to coincide for simpler securities (such as noncallable Treasuries) but would give inaccurate results for MBS.

Exhibit 25–14 presents OAS results for various coupon Fannie Mae 30-year pass-throughs. The calculations for the starred line were generated using the Andrew Davidson & Co., Inc. prepayment and OAS models. The OAS values on Fannie Mae pass-throughs on December 17, 2010 range between 5 and 35 basis points using our model. The dashed and triangle lines show the median and mean OAS values, respectively, using a sample of results from five major dealers that publish weekly OAS results. Discrepancies on the order of 20 bps between different models regularly occur, highlighting the difference primarily caused by the use of different prepayment models.

We show a similar comparison of option-adjusted durations (OAD) from the same valuation date in Exhibit 25–15. Similar to the OAS results, variation between different firms' results is primarily attributable to prepayment model differences (with an additional contribution from interest rate simulation models). The exhibit shows that the duration of discount coupons (4 and 4.5s) grows quite large, and at increasing slope, whereas the rate at which duration shrinks in the higher coupons (5.5 through 6.5s) diminishes, with a flattening of the duration curve.

EXHIBIT 25–14

FN30-Comparison of AD&Co and Dealer OAS Pricing Date
December 17, 2010

EXHIBIT 25–15

FN30-Comparison of AD&Co and Dealer OAD Pricing Date
December 17, 2010

This feature is caused by the *negative convexity* of MBS. This means that gains in decreasing interest rate environments will be limited compared to fixed income investments with positive duration, whereas losses in increasing interest rate environments will be greater. The option cost yield premium paid by MBS can be viewed as the compensation paid for this feature of MBS whereas the OAS premium itself can be viewed as the compensation paid for the *prepayment model* uncertainty.

KEY POINTS

- Mortgage-backed securities consist of pools of mortgages with cash flows to investors dependent on underlying mortgage cash flows as well as potential cash flow structuring rules (CMOs). The simplest MBS are pass-through securities.
- The underlying types of mortgages can be a variety of fixed-rate mortgages, ARMs, and hybrid ARMs, with a choice of amortization structures, underlying indices and cap structures. Fixed-rate 30-year amortizing mortgages remain the dominant form of mortgage loan, but hybrid ARMs have also become popular in the last decade.
- Agency MBS are those issued by GNMA, Fannie Mae, and Freddie Mac.

- Prior to the financial crisis of 2007, Fannie and Freddie carried an implicit government guarantee while GNMA has always carried the full faith and credit of the U.S. government. During the financial crisis, Fannie and Freddie entered conservatorship, effectively making the guarantee of agency MBS explicit. Although their ultimate resolution and future form may not be decided until 2012 or later, it is expected that agency MBS will remain a major asset class for many years to come.
- Investors are attracted to agency MBS due to their high credit quality, yield pick-up, and tremendous liquidity.
- The difficulty of modeling prepayments makes the valuation and risk management of MBS challenging, even compared with the analysis of other fixed income instruments with embedded options. In particular, the path-dependence of mortgage pools and CMOs, together with the nonlinearity of prepayment models, makes Monte Carlo simulation the preferred approach for valuation among practitioners.

CHAPTER
TWENTY-SIX

AGENCY COLLATERALIZED MORTGAGE OBLIGATIONS

ALEXANDER CRAWFORD

This chapter provides an introduction to the U.S. agency collateralized mortgage obligation (CMO) market. It begins with the background of the CMO market and explains the difference between agency and nonagency CMOs. The chapter introduces the issuers Fannie Mae, Freddie Mac, and Ginnie Mae, then covers all of the major CMO tranche types in terms of structure and analysis, providing practical examples. It also covers information about option-adjusted spread (OAS) and prepayment models, and how to use that information to hedge CMOs or determine relative value. Coverage of nonagency CMOs is provided in Chapter 31.

THE CMO MARKET

The CMO market has existed since the mid 1980s. Its original purpose was to allow investors to more closely control when they receive principal from mortgage backed securities. With mortgage pass-throughs, principal is received each month throughout the life of a security, often for a full 30 years. In a CMO, the principal is divided up into pieces or "tranches" creating some bonds that receive principal right away (and hence have shorter durations) and bonds that do not, typically resulting in longer durations. The creation of so-called PAC, or planned amortization class bonds took the CMO a step further, attempting to create a corporate bond surrogate.

To create a CMO, a dealer must gather agency pass-through collateral, structure a deal, then pay a fee to Freddie Mac, Fannie Mae, or Ginnie Mae to issue the CMO. Ginnie Mae has the full faith and credit of the U.S. Government, whereas the other agencies have the implicit guarantee of the U.S. Government.

Now, the CMO market has exploded into a myriad array of tranches using different types of collateral. The cash-flow priority of tranches can even jump around based on prepayments. The same financial technology used to create CMOs has been employed to create other securitized products in the world global market.

This chapter was written when the author was an employee of Deutsche Bank.

When comparing nonagency CMOs to agency CMOs, agency CMO analysis tends to be simpler because of more established prepayment models and minimal credit risk. Collateral information disclosure on nonagency CMOs tends to be slightly better, but in general the information gap is marginal for new deals.

THE REASONS WHY CMOs EXIST

Like any security, CMOs exist because there is a market to buy and sell them. From the demand side, there are investors who still want to more closely control the cash flows they get from an MBS investment. In addition, the CMO market has grown to such an extent that many other things are possible using the CMO market than with the MBS pass-through market, such as bonds with coupons that adjust on a monthly basis (floaters). From the supply side, CMO originators continue to operate as long as they can make a reasonable profit in the business. Often, all the CMO tranches are not sold right away, which forces the dealer to hold inventory, and thus take risk.

Size of the CMO Market

Peak issuance of CMOs was over $1 trillion in 2005. CMO issuance dropped to only $191 billion during the financial crisis of 2008, but has since rebounded. For example, CMO issuance in 2010 exceeded $500 billion. Historically, issuance of new CMOs has surpassed that in most other markets, including Treasuries and corporate bonds.

Liquidity

The raw size of the CMO market suggests it should have enormous liquidity. However, liquidity is somewhat hampered by lack of homogeneity in the CMO market. Even the most common tranche types, PACs and sequentials, may have subtle differences that need to be examined and valued. (We will discuss this in detail later.) The liquidity of CMOs is typically less than pass-throughs, but comparable to corporate bonds. Even specialized derivatives, such as interest-only (IO) strips often have relatively tight bid/ask spreads of around an eighth of a point during normal market conditions.

Practical Details

In this section, we cover practical details such as typical payment and settlement structure for CMOs. Rules are generally different for CMOs than for corporate bonds. In some cases, rules are different for certain types of CMO tranches than for pass-throughs.

Bond Settlement

CMOs usually settle in book entry via DTC (Depository Trust Co.). Primary market CMOs may have delayed settlement, similar to pass-throughs. For example, many new-issue CMOs settle in the month after the trade date. New-issue CMOs usually settle at the end of the month, to allow the dealer time to bring in collateral and finish structuring the deal.

Secondary market CMO transactions are typically for corporate settlement, presently T+3 business days. It is possible to trade CMOs for other settlements, such as cash, if necessary.

Monthly Interest and Principal Payments

CMOs pay interest monthly, similar to the underlying pass-throughs. Tranches eligible to receive principal payments will receive them at the same time as the interest payments. Most CMOs have the same number of delay days as the underlying collateral, for example, 55 stated delay days for FNMA pass-throughs. However, certain tranches, such as CMO floaters, may have reduced delay days to facilitate comparison to corporate bonds. The number of delay days for each tranche is available in the prospectus or from electronic sources. Of course, the number of delay days impacts yield, as interest and principal are returned later (and hence reinvestment interest on that interest and principal is foregone) the longer the delay is.

Deal Clean-Up Calls

Some deals may contain clean-up calls triggered when only a small portion of the deal remains. The percentage trigger is typically set between 1% and 10%, inclusive. This feature is typically set up to avoid the burden of high fixed costs for the deal's trustee when a small amount of bonds remains outstanding. We discuss analyzing deal clean-up calls later in this chapter.

New Issue versus Secondary Markets

The new issue CMO market typically settles as much as one or two months in the future, allowing the issuer to gather the requisite collateral for the deal and complete structuring. This structuring period also affords the investor the opportunity to custom design CMO tranches that fit into his portfolio. Most secondary tranches trade for corporate settlement. While the investor cannot change existing tranches, more information about the tranche, such as historical prepayment speeds, can be valuable to the investor.

CMO TRANCHE TYPES

The crux of understanding the CMO market is understanding the different tranche types and how they are structured. Today, CMO deals are very complex, with multiple collateral sources, multiple tranche types, etc. in a complex array for

each CMO deal. It is important to realize that each of these deals is made primarily from two basic flavors.

- A *planned amortization class* (PAC) deal, in which the non-PAC (support or companion) tranches have highly variable cash flows and average lives, while the PAC enjoys relatively stable, prescheduled cash flows.
- A *sequential deal*, where standard sequential tranches have cash-flow priority (i.e., absorb most or all of the principal from the deal) in turn until they are all retired.

These types of deals can be altered or dressed up slightly (such as in a PACquential deal), but there are still two basic flavors. Once the PACs and sequentials are created, they can be divided even further (e.g., into a PAC floater and PAC inverse floater). It is also possible to add other tranches with special features, such as a tranche where interest accrues back into the principal, called a Z-bond (i.e., zero coupon). Nevertheless, to understand the structure of CMOs, one must always start with that first question on which deal type it is, then walk through how an individual tranche was created in order to correctly analyze it.

For each tranche type in this section, we will provide the following: description, example, yield table, and methods of analysis. Note that while we have tried to be as realistic as possible in showing yield table and OAS analysis for CMO tranches, these numbers do not necessarily correspond to anything available in the market currently. These examples have been constructed mainly for learning purposes, not to illustrate relative value or hedging purposes! We also do not identify deal names or CUSIPs on any of these bonds for those reasons.

Sequential

A *sequential CMO*, also historically referred to as a "vanilla bond," deal typically takes the collateral's principal and time tranches it. The first sequential tranche receives all of the prepaid and scheduled principal from the deal until the tranche is retired, then the next sequential in line starts receiving principal. For example, in a simple three-tranche sequential (Exhibit 26–1), the first sequential could be allocated 30% of the deal's principal. All principal cash flows from the underlying collateral would pay down the first sequential tranche to a zero balance. Then, the second sequential would receive its principal, and finally the third. The purpose of this structure is twofold. Investors may want a shorter or longer duration than the underlying collateral. In addition, the period of time before which the second sequential receives any principal is known as *lockout*. This lockout feature may be valuable to some investors who do not want to receive (and possibly need to reinvest) principal for some period of time.

Example

Sequential bonds will have a different duration, average life, and projected cash-flow for each prepayment assumption tested. In many respects, they perform like

EXHIBIT 26–1

Cash Flows from a Three-Tranche Sequential Deal

the underlying collateral of the CMO deal. Increase prepayments, and sequentials shorten their average life and duration. A few differences between sequentials and collateral:

- The window of time principal is returned to the investor in a sequential is narrower than that for collateral.
- A sequential can be locked out from prepayments (i.e., the factor remains 1.0) for some period of time. Pass-throughs start to factor down from 1.0 as soon as they are created.
- The coupon on a sequential (or any other CMO bond) can be different from the underlying collateral. Most commonly, the coupon on the sequential is "stripped down" lower than the collateral in order to create bonds that trade at or below par.

When a sequential coupon is stripped down, a portion of the interest from the collateral is diverted elsewhere in the deal.[1] The purpose of this maneuver is to lower the price of the sequential bond, although typically the yield of the bond will also fall. Nomenclature in the CMO world talks of the *tranche coupon* versus the *collateral coupon*. For example, a 5.0/5.5 sequential would be a bond with a 5% coupon in a deal using 5.5% pass-through collateral.

Exhibit 26–2 compares the yield tables of a full coupon, 5.5/5.5 sequential with a stripped down 4.0/5.5 sequential. Note that the principal cash flows are essentially the same—the principal cash flows on these bonds react in the same way to changes in prepayment rates. However, market performance will likely be

1. Note that the coupon income stripped off these tranches could become an IO/IOette tranche, or could be added to a regular tranche with principal to create a premium tranche, for example, a 6% coupon off 5.5% collateral.

EXHIBIT 26–2

Comparing the Yield Tables of Full versus Stripped Down Coupon Sequentials

Sequential, 4% on 5.5% Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,595	800	225	145	120
Price					
96.625	7.20%	6.03%	4.87%	4.67%	4.61%
97.625	6.20%	5.40%	4.61%	4.47%	4.43%
98.625	5.21%	4.78%	4.35%	4.27%	4.25%
Average Life	1.09	1.76	4.5	6.2	7.05
Libor OAS	25				
OAD	5.26				
OAC	–1.36				

Sequential 5.5% on 5.5% Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,596	823	223	146	121
Price					
101.9375	3.51%	4.23%	5.00%	5.13%	5.17%
102.9375	2.58%	3.63%	4.75%	4.93%	4.99%
103.9375	1.67%	3.04%	4.50%	4.73%	4.81%
Average Life	1.09	1.73	4.54	6.18	7.01
Libor OAS	35				
OAD	3.11				
OAC	–2.27				

Source: DB Global Markets Research.

quite different, due to the longer duration of the 4.0/5.5 tranche. The 4.0/5.5 tranche has a 5.26 option-adjusted duration (OAD) versus a 3.11 OAD for the 5.5/5.5 full coupon sequential in our example. When interest (IO) is removed from a tranche, the negative duration associated with the IO is also removed, extending the duration of the remaining bond.

An intuitive way to think about premium and discount CMO durations is callable corporate bonds. As the price of the bond goes over par, it becomes harder for the price to rise given a drop in interest rates because of the call feature (in the case of MBS, faster prepayments). The duration of a high premium callable bond will be close to the call date because it is likely to be called. However, the duration of a deep discount callable bond is longer, close to the maturity date of the bond, because the bond is unlikely to be called.

Analysis

Analysis of sequentials falls into two broad categories:

- Analysis of short duration sequentials that are currently paying, typically as short duration bonds. They may be compared to short agencies, ABS, hybrid ARMs, other CMOs, etc.
- Longer duration sequentials that are often compared with the underlying collateral. Many characteristics of the sequential and collateral are typically similar: prepayment speeds, duration profile, etc.

For short duration bonds, investors are typically looking at yield and comparing it with similar duration bonds. In addition, investors need to evaluate the extension risk of the sequential to make sure it is not beyond their risk tolerance if interest rates rise, prepayment speeds slow, and the sequential extends.

For long duration bonds, comparison to collateral can be made using OAS or yield analysis, plus potentially a total rate of return analysis that compares expected returns of different bonds under different interest rate scenarios.

Planned Amortization Class

The second basic type of CMO deal is a PAC/support structure. PAC stands for *planned amortization class* and is one of the most stable classes of CMO. It is given a pre-set schedule for its principal pay down. If prepayment speeds were to remain at a fixed speed in a specific prepayment band (the *PAC band*) for the life of the security, the PAC would adhere to its original schedule and behave similarly to a corporate bond with a pro rata sinking fund structure. Exhibit 26–3 shows the amortization schedule for a hypothetical PAC.

EXHIBIT 26–3

Amortization Schedule for a Hypothetical PAC

Source: DB Global Markets Research.

PAC Bands, Band Drift, and Broken PACs

As mentioned, each PAC has a band, expressed in PSA terms. If prepayments remained constantly at that level throughout the life of the PAC, it would adhere to its planned amortization schedule and have the expected average life.

Of course, prepayments do not remain constant from month to month, let alone the life of a security. Therefore, over time, especially in a fast prepayment environment, the *PAC bands* on a PAC can drift, generally growing tighter over time (i.e., less advantageous for the investor).

One example of PAC band drift is in a fast prepayment environment. If approximately one-third of a PAC CMO deal is support bonds and prepayments increase over the top end of the PAC band, at some point, all the support bonds will be paid off. When the supports are gone, the PACs behave like sequential bonds, and are termed *broken PACs* in the marketplace. In reality, a broken PAC will behave like a sequential bond. However, due to the stigma of being "broken," the broken PAC may trade more cheaply than a similar sequential.

Exhibit 26–4 shows an example of a new PAC with a band of 100–250 PSA. Note that as interest rates rise, its average life stays around 5.95 years. However, since all MBS are inherently callable in any given month, very fast prepayment speeds engendered by a drop in mortgage interest rates cause the PAC to break out of its PAC band and shorten its duration significantly.

Exhibit 26–5, by contrast, shows a broken PAC originated a few years ago. All the support bonds in this deal have paid off, so it effectively behaves like a sequential. Note also that its OAS happens to be higher than the sequential bond analyzed earlier in this chapter. This can occur in the market if there is a glut of broken PACs. This bond currently does not have a PAC band left, but originally had a band of 100 to 255 PSA.

EXHIBIT 26–4

Example of a New PAC, Original PAC Band 100–250 PSA

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,665	800	220	143	120
Price					
101.1875	3.99%	4.39%	4.75%	4.75%	4.75%
102.1875	3.30%	3.96%	4.56%	4.56%	4.56%
103.1875	2.62%	3.54%	4.37%	4.37%	4.37%
Average Life	1.5	2.47	5.95	5.95	5.95
Libor OAS	41				
OAD	3.65				
OAC	–1.26				
Vol Duration	0.05				

Source: DB Global Markets Research.

EXHIBIT 26–5

Example of a Broken PAC, no PAC Band Left

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,595	800	225	145	120
Price					
102.9375	0.74%	2.97%	4.57%	4.84%	4.92%
103.9375	–0.74%	2.17%	4.26%	4.61%	4.72%
104.9375	–2.19%	1.38%	3.96%	4.39%	4.53%
Average Life	0.66	1.26	3.52	5.02	5.79
Libor OAS	37				
OAD	1.98				
OAC	–4.07				
Vol Duration	0.03				

Source: DB Global Markets Research.

Analysis

The decision to buy PACs over sequentials or pass-throughs involves a couple of questions. First, is there a reason to buy cash-flow stability?

- Is cash-flow stability cheap via purchasing PACs?
- Is hedging pass-through or sequential cash flows using options or other derivatives expensive or cumbersome from an accounting perspective?
- Does the investor think the bond market is range-bound or could break out of its range?
- What do implied and actual volatility in the market look like and where are they going?

The answers to these questions can guide an investor toward whether to purchase PAC bonds.

Note that broken PAC analysis will be similar to sequential bond analysis. As mentioned, often broken PACs will trade at wider spreads than similar sequentials, creating relative value opportunities.[2]

Like sequentials, PACs can be compared using OAS analysis, yield, total return analysis, etc. with other MBS or even to corporate bonds because of the PACs' stable nature.

2. Broken PACs tend to trade slightly cheaper than sequentials, whether because of the stigma of the "broken" deal or selling by investors who sell them to buy new PACs with intact bands.

EXHIBIT 26–6

Example of a PAC 2, No PAC Band Remaining

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,665	800	220	145	120
Price					
97.875	8.05%	7.06%	6.11%	5.97%	5.84%
98.875	6.63%	6.20%	5.80%	5.74%	5.68%
99.875	5.23%	5.36%	5.49%	5.51%	5.53%
Average Life	0.75	1.27	3.81	5.54	8.78
Libor OAS	36				
OAD	5.37				
OAC	–2.19				

Source: DB Global Markets Research.

PAC 2

In some structures, the effectiveness of PAC classes is enhanced by creating a structure similar to a PAC, but with tighter PAC bands. In the priority of the cash-flow waterfall, the PAC takes priority, followed by the PAC 2 (also referred to as Level II PACs and supports with schedules), and finally the support bonds. If the support bonds are retired and PACs remain, then the PAC 2s effectively become the new support bonds.

In return for the higher cash-flow variability of the PAC 2, it will yield more than similar PACs in the same deal. At the same time, in extreme prepayment environments, the PAC 2 will suffer extension or call risk before the PAC. The PAC 2 bond selected for Exhibit 26–6 has a relatively tight PAC band—so tight we cannot observe cash-flow stability on this bond in the ± 100 bp scenarios.

Analysis

PAC 2 analysis needs to be very careful, as bonds from this class exhibit much more variability of structure, cash flows, and value than the PAC 1 or sequential tranche types. OAS analysis can help an investor make a determination if a bond is attractive. Investors also need to focus on potential duration extension and shortening in radical interest rate scenarios to make sure that duration change is tolerable. In our example bond, duration extension if rates rise is worse than with our example sequential bond.

Support Bonds

The support or companion bonds take whatever principal is left over each month after the PAC bonds have been paid as closely to schedule as possible. If prepayment

EXHIBIT 26–7

Example of a Support Bond

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,595	800	225	145	120
Price					
94.375	44.97%	25.96%	9.44%	6.00%	5.98%
95.375	36.95%	21.93%	8.70%	5.92%	5.90%
96.375	29.29%	18.03%	7.97%	5.83%	5.82%
Average Life	0.16	0.3	1.57	23.95	25.66
Libor OAS	90				
OAD	11.00				
OAC	–16.04				

Source: DB Global Markets Research.

speeds are fast, excess principal will pay down support tranches once planned principal payments to the PACs have been made. On the other hand, if prepayment speeds are very slow, all of the principal may go to the PAC bonds, with the support bonds receiving no principal for that month.

Example

The structuring of the support bond, with approximately 30% of a deal being companions and the balance PACs, makes for highly variable cash flows and a wide variety of performance characteristics. Because of this, companion yields tend to be quite high. Exhibit 26–7 shows how the average life of the bond can vary widely.

Analysis

Structures are very deal specific, and OAS models can help determine relative value among support bonds. Note however, that OAS and hence relative value will be very sensitive to model assumptions. Discount companions are more popular because they can be sold to retail investors more easily. Exhibit 26–7 shows our example companion, with high average life variability, but a big OAS. Note also that the structure and price prevents the yield of the bond from falling much below 6%, even in a rising interest rate environment. The yield can exceed 40% in a dramatic interest-rate rally in our example bond.

Targeted Amortization Class

A *targeted amortization class* (TAC) is similar to a one-sided PAC. The bond has some call protection from adverse prepayment speeds. However, it can have a lot of extension risk if prepayments drop too low.

EXHIBIT 26–8

Example of a TAC

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,595	800	225	145	120
Price					
92.1875	32.71%	20.16%	8.90%	6.33%	6.22%
93.1875	28.78%	18.09%	8.44%	6.22%	6.13%
94.1875	24.97%	16.08%	7.98%	6.12%	6.04%
Average Life	0.32	0.59	2.74	17.94	21.7
Libor OAS	44				
OAD	10.11				
OAC	–2.46				

Source: DB Global Markets Research.

Example

In Exhibit 26–8, we see that our example TAC has a lot of extension risk. Even at reasonable, although slow, prepayment speeds, the bond extends out to 20-plus year durations.

Analysis

TACs are not all created equal. Some behave more like PAC bonds or PAC 2s. Others look more like companion bonds. The defining characteristic of TACs is they should have some call protection. A first cut of analysis should involve looking at the spread of average lives that can occur. In addition, OAS and perhaps total return analysis may be useful.

While the TAC we have chosen does have a high OAS, it clearly has a large amount of risk if rates rise. The TAC is already at a discount dollar price, and its price could plunge further if prepayments slowed and extended the TAC out to a 20Y average life in a steep yield-curve environment.

PACquential

A PACquential blends characteristics of a PAC and a sequential. While a Type I PAC typically has a lower band of 100 PSA, a PACquential has more extension risk, with a lower band more typically around 150 PSA. Nevertheless, a PACquential does have a PAC band and is supported by its own companion bonds. This feature makes it more stable than a standard sequential tranche.

Example

Our example bond has a PAC band of 150 to 360 PSA, within which it has a 5.1 average life (Exhibit 26–9). In this case, the extension risk of the bond down to

EXHIBIT 26–9

Example of a PACquential

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,665	800	220	145	120
Price					
96.75	6.14%	5.26%	4.73%	4.72%	4.65%
97.75	5.42%	4.84%	4.49%	4.48%	4.44%
98.75	4.72%	4.43%	4.26%	4.26%	4.23%
Average Life	1.53	2.7	5.1	5.23	5.85
Libor OAS	37				
OAD	4.48				
OAC	–1.38				

Source: DB Global Markets Research.

120 PSA is minimal. Therefore, the difference between this bond and a regular PAC is not that great.

Analysis

Note that since PACquentials are not that well standardized in the market, each bond must be carefully examined on its own merits. One factor to pay special attention to is extension risk of the PACquential below its PAC band down to as low as 100 PSA. Beyond that, all the standard analysis tools apply: OAS, average life variability, and total return analysis.

Z-Bonds

A bond can have different cash-flow characteristics (PAC, sequential, PACquential). Also, it can have different interest payment features. In the case of a Z-bond, interest accrues and is added to principal initially. This initial phase of a Z-bond's life is similar to a zero-coupon bond. At some point, the Z starts to pay down interest and principal. The characteristic of suspension of interest for some period of time extends the duration of the Z-bond. A Z-bond can be created from any of the fundamental cash flows. Note that the accrued interest taken in from a Z-bond can be used to pay down principal on another CMO tranche. This technique can be used to create bonds with a short legal final maturity, very accurately determined maturity (VADM) bonds.

Example

The companion Z-bond we have chosen for our example (Exhibit 26–10) has a deep discount dollar price, giving it PO-like characteristics, including negative convexity that is pretty close to zero. Note the wide variation in average lives in different scenarios.

EXHIBIT 26–10

Example of a Z-Bond

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,595	800	223	145	120
Price					
84	12.58%	8.75%	6.64%	6.45%	6.39%
85	12.09%	8.36%	6.57%	6.39%	6.34%
86	11.61%	8.16%	6.49%	6.33%	6.28%
Average Life	2.57	6.05	17.36	21.03	22.28
Libor OAS	53				
OAD	19.47				
OAC	–0.09				

Source: DB Global Markets Research.

Analysis

There are a few main differences when analyzing a Z-bond versus a regular tranche of the same variety.

- Is the Z-bond currently a payer? If not, the audience of investors may be reduced.
- The OAD of the Z-bond can swing extremely widely in different interest rate scenarios because of its ability to accrete interest payments into principal.
- The OAD can be much longer than that for collateral.

Standard OAS or total rate of return (TRR) analysis should take these factors into account. On our example bond, the OAD is extremely long, almost 19.5. The fundamental question to ask is whether an investor would prefer to own this bond or a zero-coupon Treasury bond. The two can best be compared using TRR analysis.

Note also that these bonds will be extremely sensitive to small changes in model assumptions. Different models will almost certainly give a wide range of OAS valuations.

Very Accurately Determined Maturity

Very accurately determined maturity (VADM) bonds are structured to have short final maturities. They use accrued interest from Z-bonds to pay off principal (see Z-bond discussed previously in the chapter). In general, the average life of a VADM bond is more stable than a comparable duration sequential bond. They are

EXHIBIT 26–11

Example of a VADM

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,595	800	225	145	120
Price					
103.5	3.44%	4.26%	4.81%	4.81%	4.81%
104.5	2.89%	3.92%	4.61%	4.61%	4.61%
105.5	2.34%	3.59%	4.41%	4.41%	4.41%
Average Life	1.85	3.13	5.95	5.96	5.96
Libor OAS	56				
OAD	3.56				
OAC	–1.20				

Source: DB Global Markets Research.

especially resistant to extension risk, as the short final maturity of the bonds is guaranteed even if prepayments drop to zero, a highly unlikely event.

Example

Exhibit 26–11 shows our example VADM bond, 5.95-year average life even as prepayments drop to 0. Note however, that the premium price exposes the bond to big issues if interest rates drop and prepayments speed up.

Analysis

Investors should primarily purchase VADMs if they absolutely need the guaranteed final maturity—such as in certain mutual funds or other investor situations. Check that the VADM maturity does fit the requirements of the investor. In addition, check what the call risk of the bond looks like, which can vary widely among CMOs.

Floater

As well as the principal cash flows having different types, interest may also be paid in different ways. Most tranches have fixed-rate cash flows, as most collateral for CMOs has a fixed interest rate. However, it is possible to construct tranches with a floating rate of interest, generally tied to LIBOR, but conceptually to any market interest rate. One possibility is to use an interest rate swap to create a floating-rate bond. However, more likely is the division of a fixed-rate tranche into a "floater" and "inverse floater" whose interest rate moves down as the floater's moves up (see Inverse Floater discussed later in the chapter).

Key components for a floater include:

- The index, such as LIBOR. Other indices used are constant maturity Treasury indices, such as 10Y CMT.
- The margin, or spread over the index paid to the investor.
- The cap, or maximum coupon rate that the floater can pay, inclusive of the margin paid over the index.
- The floor, or minimum coupon rate, often equal to the margin.

Example

Our example bond shown in Exhibit 26–12 is a companion floater. The average life is highly variable. The major issue for a bond buyer would be difficulty in hedging the risk of the embedded cap. Thus, higher cash-flow variability will in general push the OAS of a floater lower.

Analysis

Floating-rate bond analysis is similar to fixed-rate analysis in terms of examining cash flows and the bond's OAS. However, the floater has the additional complexity of having embedded caps and floors to value (even if the floor is 0%). It is especially important to make sure the term structure model employed correctly values caps and floors at market values in this type of analysis. Additionally, an investor can price out an actual cap or floor for the expected average life of the security and see if the package of floater plus hedge makes sense.

Discount margin refers to the effective spread over the index once the bond's price and a prepayment assumption are factored in. An investor would look at discount margin as well as OAS to determine value in a floater.

EXHIBIT 26–12

Example of a Floater

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,665	800	220	145	120
Price					
98	6.84%	5.12%	2.74%	2.53%	2.52%
99	2.47%	2.47%	2.56%	3.64%	4.42%
100	2.04%	2.19%	2.39%	2.41%	2.41%
Average Life	0.42	0.7	7.05	21.34	23.56
Libor OAS	19				
OAD	2.58				
OAC	–2.82				

Source: DB Global Markets Research.

Note that a floater's OAD (if uncapped) is effectively limited to the combination of index and index reset. Most of the duration of the floater duration would be due to the duration from the cap.

Inverse Floater

An inverse floater is typically created by dividing a fixed-rate tranche into a floating-rate portion and the inverse floater. The key understanding is that the sum of the parts (floater and inverse floater) must equal the whole (the underlying tranche) in terms of both interest and principal payments. (Also see the discussion later in the chapter dealing with "creation value.")

Example

Our example is shown in Exhibit 26–13, a discount companion inverse floater. These bonds have a lot of duration and are often used as substitutes for POs. Our example has a highly variable average life, but high yields across interest rate scenarios.

Analysis

Inverse floater duration is increased by higher leverage in the inverse floater's coupon formula. In our example bond, the underlying tranche has an OAD of 9.57 and the inverse floater's leverage is 2.75. If the floater had a duration of 0, then the inverse floater's OAD is roughly equivalent to 1 + leverage times the underlying tranche's OAD. In this case, the floater has significant duration (over 2) because of the extension risk along with the relatively low coupon cap of the floater.

OAS analysis is important for analyzing inverse floaters, and as with floaters, inverse floaters have embedded caps and floors. Therefore, the term structure

EXHIBIT 26–13

Example of an Inverse Floater

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,665	800	220	145	120
Price					
84.3125	60.38%	41.89%	19.84%	17.08%	17.04%
85.3125	56.69%	39.75%	19.41%	16.87%	16.83%
86.3125	53.09%	37.66%	18.98%	16.66%	16.63%
Average Life	0.42	0.7	7.05	21.34	23.56
Libor OAS	696				
OAD	28.80				
OAC	–12.45				

Source: DB Global Markets Research.

model is important for evaluation. Also, the prepayment model used to evaluate the inverse floater is critical. As market rates fall, the inverse floater's coupon rises, but faster prepayments (and hence principal paydowns) may eat away the value of this to the bondholder. Effectively, the inverse floater buyer is leveraged to prepayments, and thus must be careful to examine the effect of variations in prepayment assumptions on bond valuation.

Inverse Floater versus Leveraged Collateral

Does OAS analysis work? One way to check is to compare inverse floaters with leveraged collateral positions. While at first glance it may appear that one should simply buy the bond with the highest OAS, in reality, the duration (or OAD) of the two assets being compared also matters significantly. To correctly compare inverse floaters with collateral, the collateral must be implicitly levered (by borrowing money) to the same duration as the inverse floater for the comparison to be fair. (The comparison is still not completely fair because leveraged collateral probably has more liquidity and easier funding than the inverse floater.)

In Exhibit 26–14, we can see that our prepayment model still prefers the inverse floater over a position of leveraged collateral. Levering the collateral involves investing a similar cash amount as for the inverse floater, then borrowing additional cash to buy more collateral until the investor has a similar duration and convexity exposure between the inverse floater and the leveraged collateral. In this example, we have borrowed money equivalent to the 2.75 times leverage of the inverse floater, assuming that we could borrow money at LIBOR flat.

Creation value is another method used to analyze inverse floaters. The value of floaters is relatively easy to determine, as they are relatively liquid and easy to price. Likewise, the underlying tranche for the floater/inverse combination is typically easy to price. Given those two prices, the arbitrage-free creation value of the inverse floater can be determined (Exhibit 26–15). Investors prefer to purchase inverse floaters at or below creation value in the secondary market.

EXHIBIT 26–14

Comparing Leveraged Collateral versus an Inverse Floater

Tranche Type	Security	Price	OAS	OAD
Inverse floater collateral	FNMA 5.5%	100.578125	5	4.7
Leveraged collateral stats	FNMA 5.5% leveraged	2.75 times lvg.	33	17.5
Inverse floater	*	85.31	696	28.8

*See Exhibit 26–13
Source: Deutsche Bank.

EXHIBIT 26–15

Floater + Inverse Floater = Underlying Companion Bond

	Floater	Inverse Floater	Underlying Companion
Collateral	FNCL 5.5	FNCL 5.5	FNCL 5.5
Amount on issue (curr and orig)	25,626,350	9,318,674	34,945,024
Coupon	1ML + 130 bp	17.05–2.75 × 1ML	5.50
Cap	7.50%	17.05%	
Floor	1.30%	0%	
Yield	2.60%	19.41%	7.08%
Price	99.00	85.31	95.35
OAS	19	696	199
OAD	2.58	28.80	9.57
OAC	–2.82	–12.45	–5.39

Source: DB Global Markets Research.
Note: 354 WAM, 5.90 WAC for all bonds.

Trade against Forward Rates

Some investors buy inverse floaters as a trade against forward rates rising as fast as the market would suggest. For example, the yield of our inverse floater at unchanged rates and 220 PSA is 19.41%. The yield assuming this prepayment speed but forward rates is 18.4%. If rates rise more slowly than forward rates suggest, the true yield of the bond will be somewhere in between the two numbers.

Analyzing inverse floaters is complex and can be done in many different ways. They are not as liquid as regular tranches. The reward may be discovering some true value in the bonds, or taking advantage of specific views on the market.

Interest-Only and Principal-Only Tranches

Interest-only tranches (IOs) come in several forms. The primary one we will discuss is "trust IOs," in which collateral is contributed to an IO/PO deal by dealers, a small fee is charged by a GSE or Agency, and IO and PO tranches are returned to the dealers involved in proportion to their collateral contribution. This type of structure gets its own IO/PO trust number, hence the name. An IO can also be created by stripping interest off a CMO tranche or in other ways, which typically result in CMO tranches with IO characteristics. Trust IOs tend to have the most liquidity, as they are large size deals that trade on broker screens, while smaller deals have less price transparency.

IOs typically have negative duration. If interest rates rise, prepayment speeds tend to slow. Slower speeds benefit the IO holder, who wants the collateral factor to stay as high for as long as possible. Once loans prepay, they stop paying

interest beyond the month in which prepayment occurs. An IO investor wants prepayments to be as slow as possible. In the most extremely negative case, an investor could buy an IO and discover the entire tranche has paid off in that month, reported in the following month.

The principal only (PO) is the complement of the IO. It returns only the principal portion of the pass-through. Thus, a PO holder would prefer prepayments to be extremely fast. Under a dollar price of approximately $85-00 (which is typical), POs have positive convexity. This makes them useful for hedging purposes, for example hedging mortgage servicing rights.

Example

Exhibit 26–16 shows an example of an IO. Since trust IO and PO pricing is relatively liquid, most of the analysis for IOs and POs will concern an investor's view of prepayments or interest rates versus the market's (as represented by IO/PO pricing). Nevertheless, IO/PO prices can also fluctuate due to technicals, including short squeezes on certain tranches. Note how the IO in Exhibit 26–16 has a high negative OAD.

Exhibit 26–17 shows an example PO from the same Trust deal. Some investors buy POs for prepayment protection or positive convexity, but others buy them simply to add duration to their mortgage portfolio. As interest rates drop, observe that the PO yield rises significantly due to increased prepayments. Often, as in our hypothetical example, the PO will have a negative OAS in return for its positive convexity. Effectively, an investor is paying a premium to buy call options when they buy a PO.

Analysis

IO/PO analysis using OAS models or other techniques is notoriously complex, and even seasoned traders have lost money due to technicals in the IO market.

EXHIBIT 26–16

Example of an IO

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,665	800	325	150	125
Price					
24.53125	–104.60%	–59.38%	2.13%	12.50%	13.94%
25.53125	–106.20%	–60.62%	1.13%	11.52%	12.96%
26.53125	–107.70%	–61.78%	0.21%	10.61%	12.05%
Average Life	1.12	1.55	4.93	8.71	9.69
Libor OAS	328				
OAD	–24.11				
OAC	–17.02				

Source: Deutsche Bank Global Markets Research.

EXHIBIT 26–17

Example of a PO

Scenario	–200	–100	0	100	200
Prepayment (PSA)	1,665	1,200	325	150	125
Price					
74.9375	28.69%	20.71%	6.58%	3.66%	3.27%
75.9375	27.23%	19.66%	6.24%	3.47%	3.10%
76.9375	25.81%	18.63%	5.91%	3.29%	2.94%
Average Life	1.12	1.55	4.93	8.71	9.69
Libor OAS	–132				
OAD	14.71				
OAC	2.78				

Source: Deutsche Bank Global Markets Research.

As IOs and POs are notoriously sensitive to even small changes in prepayment assumptions, one must be very careful to examine the model used to calculate OASs. Variables such as seasoning and burnout are magnified many times in between analyzing the collateral and the IO/PO derivative.

Creation value can also be used to analyze IOs and POs, similar to the analysis of inverse floater/floater combinations. For Trust IOs and POs, at first the combination (combo) typically trades at a small premium above collateral. The combination cannot trade significantly below the price of collateral, because they may be recombined into collateral for a small fee and sold. However, the combination may trade at a price significantly above TBA collateral for a number of reasons:

- The underlying collateral is valuable, for example it has seasoning worth a pay-up to TBA collateral.
- There is a squeeze or scarcity of the IO or PO, which raises the price of the combination in turn. Sometimes POs get restructured in other deals, potentially leaving them dear.

Historical analysis of IO and PO OAS numbers may be somewhat useful, but ends up being highly prepayment and OAS model dependent.

Premium tranche/IO arbitrage is another way to compare relative value of IOs versus regular classes of CMOs. For example, a PAC IO plus a stripped down PAC should equal the value of the full coupon PAC, or there is an arbitrage. This is similar to the recombination value of an inverse floater. In practice, since many investors are willing to accept tighter spreads for lower dollar price PAC bonds, we can see arbitrage opportunities occur during deal pricings which make the restructuring of a premium PAC tranche into a stripped-down coupon PAC and a PAC IO attractive.

For POs, some investors may be using them to hedge other assets, such as mortgage servicing rights (MSR). In that case, all the above analysis may be

performed, but the investor probably also wants to check how well correlated changes in price of the PO will match changes in price of the hedged asset.

Unusual Features

Note that IOs can be stripped off of any CMO type, for example PACs, creating PAC IOs. This class of bond will behave like a high yielding PAC within the band, but if prepayments speed up, will pay off quickly, perhaps leaving a loss for the investor. Other non-Trust IOs must be examined carefully as to the nature of their cash flows.

Exotics

We now describe a number of exotic CMOs for the sake of completeness, but will not spend a lot of time looking at individual bonds.

Inverse IOs

Inverse IOs are created by stripping the premium portion off an inverse floater. In some respects they behave as an interest rate floor. At times, their pricing has been described in relation to floor prices (e.g., 80%). However, they are more like "knockout" floors because if interest rates fall enough, prepayment rates will speed up and pay down the notional principal of the tranche, reducing the remainder of the investment to zero. Because of their illiquidity, these bonds are difficult to hedge and value even more so than trust IOs.

Inverse IOs are highly levered to one's interest rate scenario and prepayment forecast. It is important to analyze how small variations in prepayment or interest rate assumptions change the potential value of the bond.

Jump Zs

A jump Z reacts to fast prepayments by suddenly shifting from accrual to paying interest and principal (becoming a "payer"). This option can be of great value to the investor if the Z-bond is at a discount price. Note also that some Jump Zs are sticky, meaning once the "payer" trigger has been pulled, they continue to pay even if prepayment rates subsequently drop.

Structured POs

POs themselves can be structured into TAC POs, Super POs (companion POs), etc. Analysis is similar to that for PO analysis, except the bonds will probably be even more sensitive to slight changes in prepayment assumptions.

AGENCY VERSUS NONAGENCY CMOs

While most investors who can buy agency pass-throughs are allowed to buy agency CMOs, certain investors cannot participate in the nonagency CMO market. Here, we describe some of the differences between the two markets (see Exhibit 26–18 for a synopsis). Nonagency CMOs are discussed in more detail in Chapter 31.

EXHIBIT 26–18

Agency versus Nonagency CMO Differences

	Agency CMOs	Nonagency CMOs
Credit support	Agency guarantee of underlying mortgages, primary mortgage insurance	Credit enhancement (e.g., Senior Subordination), underlying mortgages, primary mortgage insurance
Actual delay days	Variable: 0,14, 24	Variable: 0, 24
Collateral types	Agency pass-throughs, conforming Alt-A loans, VA loans	Jumbo or other nonconforming pass-throughs, re-performing loans, Alt-A loans
Prepayment model	Standard agency prepayment model	Specialized model based on collateral
Subject to interest shortfall	No, compensating interest paid by GSEs	On some deals

Source: DB Global Markets Research.

AGENCY CMO ANALYSIS

The following section looks at how investors analyze and use agency CMOs. We also cover term structure and prepayment models briefly.

Analysis for Regular CMO Tranches

CMO analysis depends upon investor needs. While relative value may seem to be one answer, one rule does not necessarily hold for all investors. The definition of relative value can be different for different investors. Other investors have portfolio constraints. For example, an insurance company may need assets that closely match liabilities even if interest rates exhibit large moves.

Investor Goals and Constraints

Investors can have many goals and constraints when purchasing CMOs. For example:

- Insurance companies and banks sometimes have yield levels (bogies) below which they do not wish to purchase bonds.
- Relative value investors may require a certain OAS, or OAS advantage versus collateral.
- Hedge funds may require a certain amount of liquidity in purchases they make, both for bonds and potential hedges (such as cancelable swaps). If liquidity in the bond or the hedges is insufficient, they may decline to do an otherwise attractive trade.

- Funded investors may need to issue debt or raise equity before adding MBS. If the environment is not amenable to such issuance, then CMO purchases may be delayed.
- Banks may have internal maturity or duration restrictions or preferences on bonds for their portfolio.
- Individual or institutional investors may have a top dollar price limit above which they will not purchase bonds.

Perhaps the variability of investors explains why there are so many different kinds of CMOs, some unique. Different requirements and views are what makes a market.

Cash-Flow Analysis

For most regular tranche types, cash-flow analysis consists of testing various prepayment models and static prepayments to determine what the sensitivity of a bond is to changes in interest rates. This analysis would include a comparison of the negative convexity of different CMO bonds.

For some investors, cash-flow analysis becomes more detailed, as they may be trying to hedge their own stream of liabilities, or perhaps they are hedging the CMO with an amortizing swap.

Finally, for nonstandard tranches, it pays to examine the cash-flow waterfall and test various interest-rate scenarios, examining the results in terms of cash-flow streams. It is important to check for bonds that have unusual cash flows. For example, anything that could cause a bond to have a longer-than-expected maturity, or a gap when principal was not paid would be suspect.

OAS Analysis

For most regular CMO tranches, OAS analysis is relatively useful. For similar tranches off similar collateral, it is easy to use OAS to determine relative value of bonds. In addition, comparing OAS numbers for CMOs versus underlying collateral also is straightforward. The more difficult issue is how to compare OAS numbers of tranches of different durations. For example, often longer dated tranches are at higher OAS numbers than similar shorter dated tranches. This structural issue makes it difficult to evaluate relative value of longer versus shorter dated CMOs.

More issues in OAS analysis are presented later in this chapter and in Chapter 41.

Hedging

For normal CMO tranches, OADs are an acceptable way to calculate how to hedge. However, wide window sequentials may require hedging on multiple points on the yield-curve to avoid yield-curve risk, similar to hedging yield-curve risk in the underlying collateral. Exhibit 26–19 shows how the bulk of duration risk may be in the 10-year area for a specific bond, but hedging in the 2 year, 5 year, and 30 year would help reduce yield-curve risk.

EXHIBIT 26–19

Partial Durations of a Five-Year-Wide Window Sequential

Yield-Curve Point	2	5	10	30
Partial Duration	0.685	1.56	2.795	0.17
OAD	4.7			

Issues in OAS Analysis

There are a number of issues in OAS analysis to discuss in order to determine if the OAS received on a bond is truly what the investor seeks to find out: the spread of the mortgage backed security, ex-option cost, versus a benchmark such as swaps. While in the 1980s and early 1990s, the primary variable differentiating OAS numbers was the prepayment model, at this point in the technology, the term structure model has become equally as important. We cover a number of other issues in this section, such as deal call risk, and variations among prepayment models.

Term Structure Model

As mortgages have linked more tightly over time with the OTC derivatives markets (swaps and swaptions), modeling the relationship between these two markets has become critical. When swaps and swaptions are used to hedge MBS (or vice versa), the two markets need to be evaluated using the same term-structure model and the same assumptions, or else different, and perhaps erroneous, results can be obtained.

While a one-factor interest-rate model was used in the past and may work reasonably for pass-throughs, it is clearly not enough if an investor is looking at ARMs, floaters, or inverse floaters of any kind. More degrees of freedom for modeling the yield-curve are needed. Therefore, in order to keep analysis consistent among different types of MBS tranches and derivatives, it appears critical to use the least common denominator of term structure models that will accommodate all possible tranche types and analysis, and not succumb to using different models for different types of bonds or situations.

Advances in term structure modeling have placed the following features into the hands of mortgage analysts:

- Multiple knots on the yield-curve.
- Correct pricing of OTC derivatives using the model.
- Pricing in a volatility "skew" (i.e., options not struck at-the-money may be priced at a different volatility than standard at-the-money options).
- Sophisticated simulation of future mortgage interest rates based on the swaps curve and volatility.

The point is that a term structure model that does not do these things opens up arbitrage opportunities against an investor using it. In an extreme case, flaws in the term structure model will misstate value and risk numbers associated with a CMO.

Forward Curve Bias

Despite all the care being put into term structure models, and their freedom from arbitrage, it is important also for investors to recognize the forward curve bias in these models, which creates a paradox.

- In order to remain arbitrage free, the term structure model must use the forward yield-curve as its base case.
- In practice, the forward yield-curve is usually wrong.

How can we reconcile these two facts?

The short answer is that we should use the forward yield-curve, because if we do not believe something that it is predicting, we can trade against it and make money if we are correct. At times, the second point becomes plainly obvious. For example, when the yield-curve is extremely steep, forward rates predict massive flattening of the yield-curve over a short period of time. If the Fed appears to be on hold during this time, are we likely to get the full amount of the yield-curve flattening? Probably not. However, it may be easier to trade on this view directly in the derivatives or futures market rather than trying to implement it in the mortgage market.

Prepayment Model

The prepayment model is a very important component of mortgage analysis and OAS. Over time, prepayments have become more efficient. While most prepayment models address the standard issues of age, relative coupon, etc., there are now various subtleties for which a model needs to account:

- Does the model account for "credit impaired" mortgages issued at above market rates?
- How does prepayment "burnout" work in the model? Can burnout be erased over time?
- Does the model account for "underwater" mortgages correctly (where the loan is for more than the home is worth)?

A prepayment model that is out of date or incorrect, even if only on a small segment of the market (e.g., high-premium mortgages) can have a large impact on an OAS because OAS models tend to generate some paths with very high and low interest rates—testing the boundaries of prepayment models and their ability to generate reasonable prepayment forecasts at out-of-sample interest rates.

Why A + B Can Be Greater Than C...

One of the last topics we will cover in this section is why A + B > C, even if A and B are made up of the component cash flows of C. Here are some factors.

- *A and B are unique and more cannot be created.* For example, once a Trust IO/PO deal is closed, additional collateral cannot be added later to increase the size of the deal. Thereafter, a squeeze in A or B will increase their price in relation to C, which is simply TBA collateral. A + B can never be less than (C – transaction cost) for long, as this would create a recombination arbitrage.[3]
- *A or B is getting squeezed.* One of the risks in the IO/PO market is that bonds can be re-securitized and hence lost to the possibility of recombination. For example, if virtually all of the POs in a Trust deal are re-securitized, the remaining POs will be in very high demand to hedge the remaining IO tranches. In addition, trust IO/PO sizes can be small enough that one dealer or investor can potentially squeeze the market in one of these bonds, making A + B > C.
- *The underlying collateral is valuable.* Sometimes A + B may be compared with the wrong C. For example, comparing a Trust IO and PO to TBA collateral may be appropriate most of the time. However, after the deal is seasoned for a while, the underlying collateral itself may be worth a pay-up to TBAs (seasoned collateral typically commands a premium price to TBAs).

Examining Deal Call Risk

A feature in many CMO deals, but not discussed often and sometimes not modeled, is the embedded call. Calls were originally conceived as a way to limit ongoing fixed expenses for deal trustees on CMOs that have shrunk to a very small size, but the implications for investors can be significant. For example, the last cash-flow holder will typically be exposed to the call. A call that sounds small for an entire deal (say, 1%), may actually make up a large portion of the last tranche remaining in a CMO deal. For a tranche that was only 5% of the deal's original principal, a 1% cleanup call is exercised when 20% of the last tranche is remaining. The impact for investors of other tranches is *de minimus,* but obviously can be large for the last cash-flow holder.

The good news is this call is exercised most of the time, because the fixed costs of the deal tend to be large enough that the trustee wants to exercise the call whenever possible. This assumption makes analysis easy. However, if the price of the collateral is significantly below par, calling the deal costs the trustee money. Analysis of the probability of call of deals in this situation is difficult. Therefore, the bond holder may want to run the bond with and without the call to assess the possible impact.

3. Typically, an IO and a PO from the same trust can be recombined to form the underlying collateral for a 1/32nd fee and resold as collateral. While this typically never happens in practice, it creates an arbitrage floor for the IO and PO prices, which is important from a liquidity and pricing standpoint. This is much harder to do for floaters and inverse floaters, as both sides of the combination in that case may be harder to find and less liquid, not trading on broker screens as Trust IOs and POs do.

Investor Types and Behavior

In this section, we examine different types of investors, such as commercial banks. We cover the following information for each:

- Types of CMOs typically purchased by these institutions
- Methods potentially used by these institutions for bond selection

Historically, banks have been the largest holders of MBS.

Banks

Banks are large consumers of the CMO product. For many banks, the longer duration and possible duration extension of pass-throughs does not match their liabilities adequately. Often, it is easier for many banks to achieve a shorter duration security or less extension risk by buying appropriately structured CMO bonds than pass-throughs. Banks are typically buy and hold investors in CMOs, although some bonds may be placed in the trading account.

In general, banks focus on shorter duration CMOs. A 10-year bond typically does not fit the liability structure of a bank. A two-year sequential CMO is a typical purchase for a bank. In general, banks will accept some prepayment and convexity risk in order to get a better spread. Therefore, banks tend to prefer sequentials over PAC bonds. Banks do very little hedging of their negative convexity using the options market, although they may delta hedge their mortgage position as its duration changes.

CMO selection at banks generally comes down to a few things: yield bogey, duration, and OAS. In general, a bank will have a target net interest margin over their cost of funds in order to purchase a security. This target may be translated into a yield or spread bogey over a market rate. Also, a bank may not want to take too much duration risk, so the duration of the security must fit the asset-liability framework of the bank, or it must be prepared to hedge the duration of the CMO. Some banks use OAS to determine relative value among tranches, but in general asset-liability and liquidity concerns tend to dominate their CMO purchase decisions.

Note also that banks are the largest consumer of mortgage "whole loans," or mortgages that are not securitized. These whole loans are mostly ineligible for agency securitization, or are ARMs or hybrid ARMs.

Insurance Companies

Insurance companies buy CMOs across the spectrum of "regular" tranches—PACs, sequentials, and PACquentials. Property and casualty companies tend to buy shorter maturity tranches, such as two year sequentials. Life insurance companies are looking for more structure to match against their liabilities and are more likely to purchase longer duration bonds, such as 10-year PACs. While MBS are a break from the credit risk that insurance companies typically take on the corporate bonds in their investment portfolio, they are well aware of the

convexity risk that they are taking in MBS. In 1995, S&P devised a "convexity test" that penalized insurance companies for having negative convexity in their portfolios. This served primarily to reduce mortgage holdings at some particularly large "outlier" firms that held lots of MBS, but has also generally reduced MBS holdings over time to smaller amounts at insurance companies.

In general, insurance companies may have restrictions on selling CMOs because of gain or loss constraints. Property and casualty companies may sell bonds against claims (e.g., after a hurricane).

Money Managers

Money managers vary in sophistication. They generally are not subject to gain/loss constraints because they mark-to-market constantly, unless they are managing a separate account for a financial institution. Some money managers are active in the CMO derivatives market, but many are not. Most money managers are benchmarked against an index that contains pass-throughs. Therefore, any CMO is effectively an "out of index" bet for them. They will typically be comparing that CMO either to collateral or perhaps to Treasuries/agencies for certain types of CMOs. OAS analysis tends to be an important tool for them.

Liquidity tends to be a bigger issuer for money managers than for insurance companies. The money manager may need to be able to shift assets around quickly, and thus is prepared to give up something in order to have better liquidity. Most money managers own many more pass-throughs than CMOs because of this fact. In addition, pass-throughs have the opportunity to finance special (via the dollar roll market). Income from special financing can be a windfall for money managers, as this income is typically not included in mortgage index returns the money managers are benchmarked against.

Money managers frequently take long-term views about strategy in mortgages. One type of view is to have a portfolio that has better (or worse) convexity than their benchmark index. A money manager can typically get better convexity by buying PAC bonds, or give up convexity to gain yield by buying companion bonds or certain types of sequentials or broken PACs.

Pension Funds

Pension funds in some ways operate similarly to money managers. However, ERISA (pension fund law) or investor considerations sometimes keep them from investing in mortgage derivatives. Similar to life insurance companies, they can be interested in longer duration tranches at times.

Hedge Funds

Hedge funds can operate in a manner similar to money managers, but at times they enter into more complex trades involving OTC derivatives. For example, they might buy a CMO and try to hedge its cash flows over time using swaps and options, netting a positive spread that they hope to earn over time.

Certain hedge funds specialize in mortgage derivatives: inverse floaters, IOs, POs, inverse IOs, etc. They use sophisticated models to value these tranches, purchase them, and hedge them. One of the main issues for these funds will be pricing of their inventory (as individual bonds may not trade for months) and liquidity.

Retail Investors/Regional Dealers

Many CMOs, including CMO derivatives such as inverse floaters, end up in the hands of regional dealers. In turn, these regional dealers may sell those bonds to retail clients. In general, yield tends to be the focus of these buyers, and thus companion bonds are often sold via this channel.

Note that any broker who sells CMOs to retail investors must include a series of special disclaimers that is mandated by securities regulation.

Lessons from the Past

Investors in MBS, and especially in derivative MBS, have gone out of business in the past. In a crisis, while the mortgage market may continue to trade via pass-throughs, the CMO market can lose liquidity, and the derivatives market can practically stop trading for some period of time. Investors should be prepared for all risks, including the risk of illiquidity and radical changes in pricing due to such illiquidity. Dealers must make sure they "know their customer" and that the customer is buying bonds appropriate for their goals.

KEY POINTS

- Agency CMOs are structured by broker-dealers into multiple tranches using agency pass-throughs as collateral. The deals are wrapped and issued by Fannie Mae, Freddie Mac, or Ginnie Mae. Ginnie Mae has the full faith and credit backing of the U.S. government, while the other two have an implied guarantee.
- Agency CMOs can be a safe, attractive investment for banks, mutual funds, insurance companies, and other institutional investors. Standard types of CMO tranches include PACs (created to mimic corporate bonds), sequentials (that time tranche principal cash flows), and companions (that return a high yield in return for highly variable principal cash flows).
- Unlike most other bonds, all MBS (including CMOs) have unpredictable return of principal, creating the opportunity of higher yield and the risk of callability. The homeowner in the United States typically has the option to refinance at any time, effectively exercising a call to the investor. Using OAS and prepayment models helps investors understand the nature of the MBS they own or are buying.

- Analysis of CMOs depends to some degree on the type of investor: yield tables and OAS analysis are the most popular. Banks typically look at average life profiles, yield tables, and may consider OAS. Money managers tend to be more focused on OAS and less on yield.
- CMO derivatives can provide hedging benefits or unusual return profiles. For example, Interest-only strips have a negative duration—they generally increase in price as interest rates rise. Inverse floaters have bond coupons that rise as interest rates fall, sometimes creating bonds with very long OADs.

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CHAPTER
TWENTY-SEVEN

THE EFFECT OF AGENCY CMO PAC BOND FEATURES ON PERFORMANCE

LINDA LOWELL
Principal
OffStreet Research LLC

Planned amortization class (PAC) bonds represent one of the largest sectors of the collateralized mortgage obligation (CMO) market. Among the factors expanding the market for these bonds were widespread defections from the corporate market by investors who were attracted by the high yields and triple-A credit quality and discouraged in their natural habitat by limited supply and tight spreads, as well as by event risk.

Typical PAC buyers tend to be asset/liability matchers such as life insurance companies and commercial banks, but the PAC market appeals as well to investors with active bond management strategies. These investors may have, for instance, opinions about the direction of mortgage-Treasury spreads or mortgage-corporate spreads, they may wish to execute barbell or other strategies designed to take advantage of expectations regarding the shape or direction of the yield-curve, or they may be seeking value advantages, for example between the PAC and other CMO sectors, or within the PAC sector, among PACs with different features.

The main attraction of PAC bonds lies in the fact that they provide a defined schedule of principal payments (or, similarly, target balances), which is guaranteed as long as prepayment rates remain within a specified range. (Hence the name, planned amortization.) Holders are insulated to a significant degree from the uncertainty regarding the cash flows of most MBS, which arises from the right of mortgage borrowers to prepay their loans at any time. The fact that the prepayment process is interest rate-sensitive—the tendency of homeowners to move or refinance is inversely related to the direction of interest rates—has a material impact on the average life, duration, and performance of mortgage securities. MBS shorten in rising markets and extend in declining markets. To compensate investors for taking this risk, pass-throughs and other MBS are priced at higher yields than other, noncallable bonds of similar credit quality (such as agency debt). PAC bonds partake of the incremental yield available in the MBS market while at the same time providing more certain cash flows. In addition to providing

guaranteed payments within a range of prepayment behavior, PAC bonds can be further refined to concentrate payments over a shorter period of time or "window." PACs with narrow windows are perceived to be better substitutes for corporate and Treasury bonds with bullet principal payments, and therefore typically trade at tighter spreads than PACs with wider windows.

This chapter is intended to serve both classes of investors—the buy-and-hold PAC buyer, who wants to partake of the attractive yields in the mortgage market but whose liabilities or actuarial requirements necessitate more stable cash flows than either pass-throughs or standard CMOs can provide, and the active portfolio manager. The chapter examines the different features of PAC bonds and their effect on market value and investment performance. Where it is possible to isolate a specific characteristic, an attempt is made to model and examine its impact on the average life and yield behavior of the bond, as well as on its theoretical or option-adjusted value.

THE TERM STRUCTURE OF CMO YIELDS

The yields that investors require for occupying different average life sectors of the PAC market are determined by the same factors that influence other fixed income investors: portfolio objectives and constraints, the current and anticipated shape of the yield-curve, expectations regarding the underlying monetary and economic determinants of interest rates, and so forth. In addition, PAC buyers require additional yield as they extend the maturity of their investments to compensate them for the increased risk that the prepayment collars may be broken, as well as the greater average life volatility of the later tranches in a transaction if the prepayment collars are broken. An indication of the average life volatility of PAC tranches of different nominal average lives is provided by Exhibit 27–1. The graph depicts the average lives of a series of PACs from a single CMO issue[1] at two prepayment speeds extreme enough to break both the upper and lower collars of all the PAC bonds. The range between the average lives at the extremes gradually widens for longer expected average lives to its widest point among the intermediate-term PACs.

As a result of investors' demand for greater compensation for holding longer-term PACs, the generic CMO yield curves are more steeply sloped than the Treasury yield-curve. Generic yields for current-coupon PACs backed by current-coupon conventional collateral and for on-the-run Treasuries are depicted in Exhibit 27–2. Although a satisfying discussion of the issue is beyond the scope of this chapter, it should be noted that CMO spreads are also influenced by the same factors that

1. This example assumes the normal case, a structure in which PACs have priority to excess principal payments in the order of their scheduled maturities after the support bonds have been retired. Note that all examples in this chapter were created at the time when the author had direct access to research models as well as the trading desk's structuring tool, an exceptional circumstance. The general result of those 'experiments' have held over successive interest rate environments and vintages of CMOs.

EXHIBIT 27–1

Extension and Shortening of PAC Bond Average Lives as Prepayments Vary between 0% and 600% PSA

▼ Average life at issue. PAC bonds backed by FNMA 9s with prepayment collars of 85–300% PSA.

EXHIBIT 27–2

Illustrative Treasury and PAC Yield Curves

affect pass-through spreads—volatility of market yields, prepayment expectations, supply of new product, and so forth. Normally CMO spreads track pass-through spreads, with the relationship enforced by the existence of CMO arbitrage opportunities. When pass-throughs cheapen relative to CMOs, new transactions are marketed, increasing the supply of CMOs and ultimately allowing CMOs to cheapen relative to pass-throughs, thereby reducing the arbitrage opportunity.

Other features of the structure such as the collateral coupon, the PAC's coupon, the collars, and the window result in additional adjustments to the required yields. In addition, the cash-flow performance of the bond outside the collars is affected by other characteristics, such as whether its schedule is supported by accrual from a longer-term Z-bond positioned later in the structure, and its priority for receiving excess cash-flow. These characteristics determine how volatile the average life and returns of a PAC are outside the collars, and so also affect its marketability.

COLLARS AND COLLATERAL

The strength of the collars—whether they will be broken by actual prepayment experience—should be investors' primary concern. The strength is only nominally indicated in the differential between the top and bottom collar speeds. This range must be related to the specific collateral to gauge the strength of the protection provided. The type of collateral—the agency, the differential between current mortgage rates and the mortgage rates on the underlying loans, seasoning of the loans, and the degree to which the pools have prepaid in the past—determines how quickly or slowly the collateral will prepay in different interest rate scenarios. The collars simply define a range of prepayment speeds over which the PAC payments will not vary. When prepayments fall outside the collars, payments to the PAC holders may be either delayed or accelerated (the collars could be broken temporarily without affecting the payment schedule). A given set of PAC collars will provide stronger or weaker protection, depending on the collateral. For example, a top collar of 300% PSA provides greater call protection should interest rates decline if the collateral is a current coupon than if it is a premium coupon. Similarly, a bottom collar of 100% PSA provides better protection from extension if the collateral is a conventional pass-through than if it is a GNMA.

All else being equal, PAC bonds backed by premium-coupon collateral do exhibit greater average life variability than PACs backed by current-coupon collateral. This is illustrated by the comparison in Exhibit 27–3, which displays the average lives at different prepayment speeds of two series of PACs, one backed by FNMA 9s (9.77% weighted average coupon [WAC], 349-month weighted average remaining term [WART]) and scheduled at 85% to 300% PSA, the other backed by FNMA 10 1/2s (11.13% WAC and 347-month WART) and scheduled at 95% to 350% PSA.[2] (Similar comparisons could be made in

2. These examples were created in January 1990, when 9% coupon pass-throughs were priced below but closest to par, and permitted the creation of tranches with coupons at current market yields across the PAC CMO yield-curve.

EXHIBIT 27–3

Impact of Collateral Coupon on the Average Life Variability of PAC Bonds

Payment Speed (% PSA)	Average Life (years)													
	FNMA 9% Collateral (85%–300% PSA Collars)							FNMA 10.5% Collateral (95%–350% PSA Collars)						
	2-yr.	3-yr.	4-yr.	5-yr.	7-yr.	10-yr.	20-yr.	2-yr.	3-yr.	4-yr.	5-yr.	7-yr.	10-yr.	20-yr.
0	3.20	7.70	11.44	13.74	16.97	20.50	22.75	3.63	8.81	12.78	15.06	18.11	21.01	22.61
50	2.23	3.61	5.25	6.67	9.37	13.49	19.24	2.27	3.79	5.60	7.16	10.06	13.82	19.07
85	2.14	3.05	4.16	5.16	7.13	11.22	19.23	2.16	3.15	4.37	5.45	7.57	11.33	19.07
95	2.14	3.05	4.16	5.16	7.13	11.22	19.23	2.14	3.05	4.16	5.16	7.13	11.22	19.07
300	2.14	3.05	4.16	5.16	7.13	11.22	19.23	2.14	3.05	4.16	5.16	7.13	11.22	19.07
350	2.14	3.05	4.16	4.99	6.29	9.69	17.06	2.14	2.05	4.16	5.16	7.13	11.22	19.07
400	2.14	3.05	3.93	4.40	5.51	8.48	15.09	2.14	3.05	4.16	4.88	6.28	9.81	19.03
450	2.14	2.98	3.52	3.93	4.90	7.52	13.43	2.14	3.04	3.83	4.33	5.56	8.67	15.17
600	2.10	2.38	2.67	2.97	3.67	5.54	9.86	2.14	2.51	2.86	3.22	4.10	6.32	11.11

the case of discount- and current-coupon collateral, but are omitted from this discussion for the sake of brevity.)

Investors recognize the stability lent by discount collateral and will accept a tighter spread for structures backed by discounts when they anticipate prepayments will accelerate. Similarly, bearish investors require wider spreads for PACs backed by premium collateral than if backed by current-coupon collateral. In markets characterized by bearish sentiment, the relative values can be reversed and investors will pay up for premium coupons and premium-coupon collateral while demanding a concession for discount collateral.

INTERACTION OF COLLARS AND COLLATERAL

Before further examining the contribution of the collar to the PAC's value, it is useful to review the mechanics of defining a collar and creating a payment schedule. Visualizing the cash flows is also helpful in seeking to understand the behavior of the structure in different scenarios. The PAC schedule is defined by projecting the principal payments from the given collateral at a high and a low constant prepayment speed. Those payment amounts that can be satisfied by both sets of projected principal payments (that is, the smaller of the two amounts generated for each date) make up the schedule. This is depicted graphically in Exhibit 27–4. The example depicted was structured from $500 million FNMA 9s with a 9.77%

EXHIBIT 27–4

Principal Cash Flows at 300% and 85% PSA—FNMA 9% Collateral

WAC and a 349-month WART[3] on the underlying mortgages, assuming collars of 85% to 300% PSA and a 2-year lockout (the period before the first scheduled principal payment).

The faster speed results in a cash-flow pattern with the bulk of the principal thrown off during the first 5 to 7 years of the issue's life. The slower speed produces a more level set of smaller cash flows extending to the final maturity of the collateral. The intersection of these two sets of payments forms the schedule. In the example, the bottom collar determines the payment amounts during the first 100 or so months of the schedule, and the top collar the amounts in the remaining months.

The graph of *any speed between* those of the top and bottom collars also would contain the area of the schedule below it. The graph of any speed *faster* than the top collar would bunch more principal in the first years and truncate the tail of the schedule in front of the point where the top and bottom collars intersect. Similarly, the graph of any speeds *slower* than the bottom collar would reduce the size of paydowns in the front years. At very slow speeds, most of the principal payments are pushed into the back years.

Once the PAC schedule is defined at the given collars, the PAC schedule may be further divided into classes with different average lives. An individual bond carved from a given schedule may have more prepayment protection than the scheduling collars would indicate. The example in Exhibit 27–5 is split into seven tranches. Some of the earlier bonds in the structure have higher *effective top* collars. An effective collar is the highest (or lowest) constant prepayment speed that would

EXHIBIT 27–5

Effective Top PAC Prepayment Collars—FNMA 9% Collateral

3. The scheduled amortization for the collateral is determined by the WAC and WART.

satisfy the entire tranche's payments. For instance, many speeds faster than 300% PSA will contain the first tranche in this example. The fastest speed containing all of the first tranche is that bond's effective upper collar. Effective top collars are shown in Exhibit 27–5 for the third and fourth tranches. These effective collars are approximately 370% and 330% PSA, respectively. It should be apparent as well that earlier tranches have still-higher effective collars.

Likewise, the lower collars used to structure the PACs in Exhibits 27–4 and 27–5 do not fully indicate the degree of extension protection that the longer average life bonds, tranches 6 and 7, actually possess. Speeds below 85% PSA throw off principal too slowly to satisfy the scheduled payments in the early PAC tranches, but they provide more cash than needed to meet payments after about month 100, where the upper collar binds the schedule. For example, the effective bottom collar on tranche 7 is 55% PSA. Since tranche 6 begins to pay at the point where the top and bottom collars intersect, its effective collar is the same as the structuring collar.

When PACs first became popular, a wide variety of collar ranges and levels were used to generate the schedules, and even as late as the first quarter of 1989, it was not uncommon still to see some variety in collars on new CMO issues backed by similar collateral. However, the smorgasbord of prepayment collars largely has given way to increasing standardization of the speeds at which PAC schedules are created.

The standard speeds used to create PAC schedules may represent the market's aggregate opinion of what constitutes a "good" collar; however, investors should (1) identify the effective collars for a bond and (2) translate the PSA collars into interest rate collars by using an econometric prepayment model to determine how much interest rates must shift to break the collars. Once the collar speeds are explicitly linked to interest rate shifts, investors can determine if the collar does deliver "good" protection over the scenarios appropriate to the investor's outlook and portfolio.

New-issue PACs may be marketed either at the collars used to create the schedule or at their effective collars, although the trend has been to advertise effective collars. Unless the effective collar is known, the extent of the PACs protection against shifts in interest rates cannot be determined. Investors, therefore, should insist on this information, as well as analysis of the bond's performance outside the effective collars.[4] By the same token, investors cannot assume that a new-issue short-term average life PAC with a very high effective collar is better than a comparable average life PAC from a series with only the structuring collars indicated.[5]

4. The top collar may provide little protection in a bull market, when prepayment speeds are sustained at speeds significantly higher than 100% PSA. In that environment, the bond's value will derive from its stability outside the top collar.

5. If effective collars are indicated, it is usually easy enough to deduce the schedule speeds if information on all the tranches is available. Early PACs in the series will have the same bottom collar—the structuring collar—and varying effective top collars. One or more intermediate PACs will have the structuring collars. Later PACs will show the structuring collar as their top collar and varying effective collars for the bottom. Doing so permits first-cut comparisons with PACs offered with their structuring collars stated.

With greater standardization of structuring speeds, the PAC market has developed a two-tiered structure, with standard PACs in the first tier and PACs with weaker collars in the second, trading significantly cheaper than "good" PACs. In mid 1989, issuers began to issue both types of PACs from the same transaction by layering a second set of PACs with narrower collars over the first. These two-layered PACs are, in essence, support bonds with schedules. They are discussed at length in Chapter 29.

In the 1991–1994 rally, the practice of carving "super-PACs" out of the first priority PAC schedule became widespread. The PACs which had second priority to the super-PACs still had standard new-issue PAC collars, but they were subject to much greater average life variability outside the collar speeds. As a result, they tended to trade behind standard PACs. As that "prepayment emergency" continued, collars became less important to astute investors who instead scrutinized bond performance across a spectrum of prepayment scenarios.

PAC COLLAR DRIFT

Many investors do not understand that the PAC collars are not fixed for the life of the tranche, but instead change over time with the actual prepayment experience of the collateral. This is evident from the number of investors who seek to evaluate trades in the secondary PAC market by looking at the collars advertised at issue (which could be either structuring or effective collars). Instead, off-the-run PACs should be evaluated by looking at the current effective collars. In most cases, they can be determined by the security dealers or third-party data services that have modeled the structure and know the current bond and collateral balances.

The effective collars simply express the highest and lowest constant prepayment speeds at which the given collateral can continue to meet the scheduled prepayments. Unless the collateral prepays at precisely the collar speed (and then it can match only one, the upper or the lower collar speed), it will have a different balance than was projected when the schedule was defined. Likewise, the amount of support bonds (and proportion of support bonds to PACs) will be different. Prepayment rates below the top collar cause the collar to shift upward over time (as there is a greater amount outstanding than anticipated), whereas the effective collar is lowered if prepayments are higher. Likewise, prepayments above the bottom collar cause it to rise. Short- and intermediate-term PACs are affected differently by speeds below the collar than are long-term PACs at the end or tail of the schedule. Very slow speeds cause the collar to drift up in the earlier tranches, while speeds below the bottom collar can improve the extension protection of long PACs. Prepayment rates somewhere between the top and bottom collars—historically, the common occurrence—cause the effective prepayment protection to widen as the top collar changes more quickly than the bottom collar (unless prepayments are very near the top collar).

WHEN THE PAC BREAKS

Breaking a PACs schedule and causing it to be partially called or extended are not necessarily negative events for the bond's economic performance. The bond's coupon relative to market yields (or the bond's price relative to parity[6]) determines the effect prepayments outside the collar have on the realized yield or total return. A PAC with a discount coupon may benefit if the upper collar is broken, returning principal at par earlier than anticipated at pricing. Similarly, the extension caused by breaking the lower collar adversely affects the performance of a discount-coupon PAC. In the case of a premium-coupon PAC, it benefits performance when the bottom collar is broken, since the principal remains outstanding longer than anticipated, earning additional coupon interest. And of course, the higher the coupon, the worse the effect of breaking the top collar.

The shape of the yield-curve is also a consideration. Extension can be costly in a steep yield-curve; discounting a bond's cash flows at a sharply higher yield can offset any value additional coupon income might have. Likewise, the capital gain from rolling down a steep curve can offset the loss of coupon income.

As collars deteriorate and approach a point where they may be broken, the market pays increasing attention to the average life profile. A PAC may no longer have measurable effective collars but may still have a stable average life over a reasonable range of prepayment rates.

WINDOWS

A PAC "window" is the interval over which scheduled principal payments are made to the bondholder. As long as prepayment speeds remain at a constant speed within the upper and lower protection bands, or PAC collars, the dates of the first and last principal payments (and equivalently, the length of the repayment period) are certain. PAC buyers in general prefer tighter windows. To some extent, this preference reflects the practicalities of managing their portfolios. The match between a single liability and a single asset is easier to conceptualize when payments are concentrated over a short period. They also are easier to convert to floating-rate assets with swaps. A shorter window also means fewer and larger (relative to investment amount) repayments. Tighter windows producing a more bulletlike pay down are, conceptually, better substitutes for corporates. The chief benefit of a tight window, however, is the superior roll down the yield-curve it provides as it ages. Ideally the average life declines by a year for every year the bond is outstanding (assuming a stable yield and prepayment scenario).

6. The delay in passing payments through to investors from the mortgage borrowers lowers the yield slightly for any given price because the cash flows are pushed out into the future. Different prepayment speeds do not change the yield if a bond is purchased at the parity price (slightly below 100), which adjusts par for the payment delay.

Generally, a tighter window is a greater consideration the longer the average life of the bond. Shorter-term PACs inherently have shorter windows, while the desire for tight windows in the 20-year sector is difficult to satisfy, owing to the "tail-ish" nature of the cash flows in the later years of the transaction. That is, the principal payments scheduled for the later years are relatively small in any month. This is easily confirmed by glancing at Exhibit 27–4. Carving the "tail" into shorter windows would result in more classes with odd, less marketable average lives.

A "good" window in the 3- and 4-year sectors is 12 to 15 months long. The 5- and 7-year buyers prefer a window of 18 to 24 months; 10-year buyers prefer paydowns over a 24- to 30-month period.

Some investors claim to prefer tight windows because they expect superior average life stability. For example, they may believe a tighter window has less average life variability when prepayments are outside the PAC collars. This hunch is disproved by experimenting with different window lengths in otherwise identical PACs (same collateral, same average lives). Exhibit 27–6 shows two such experiments manipulating the windows of the 5- and 10-year PACs in a structure containing a complete series of PACs with average lives from 2 to 20 years, backed by $500 million FNMA 9s (9.77% WAC, 349-month WART) and protected between 85% and 300% PSA. Even at fairly extreme prepayment speeds (0% and 600% PSA, for instance), there is little difference in the average lives of otherwise comparable PACs with different windows. *All else equal, as a result of their slightly wider spreads, PACs with average or wide windows should outperform*

EXHIBIT 27–6

Impact of Window Size on the Average Life Variability of PAC Bonds

Payment Speed (% PSA)	Average Life (years)					
	5-Year PAC			10-Year PAC		
	0.5 yr. Window	2.2 yr. Window	4.4 yr. Window	3.2 yr. Window	5.0 yr. Window	7.3 yr. Window
0	13.78	13.69	13.38	20.68	20.61	20.50
50	6.68	6.67	6.65	13.70	13.62	13.49
75	5.49	5.48	5.48	11.42	11.47	11.50
100	5.16	5.16	5.16	11.22	11.22	11.22
300	5.16	5.16	5.16	11.22	11.22	11.22
350	5.01	4.96	4.87	9.68	9.69	9.69
400	4.40	4.41	4.41	8.47	8.48	8.48
450	3.93	3.94	3.96	7.51	7.51	7.52
600	2.97	2.98	3.00	5.53	5.53	5.54

Note: All structures are backed by $500 million FNMA 9s, 9.77 WAC, 349 WAM and have 85% to 300% PSA collars.

those with tight windows. This result suggests that investors who do not require a bulletlike repayment of their investment, but rather can accommodate greater payment dispersion, should not discriminate between window sizes, particularly in a flatter yield-curve environment. Investors who can adapt to a longer paydown period by such means as modifying their cash management procedures, adopting more sophisticated techniques for modeling and managing their asset/liability positions, initiating or other procedural changes, would also be able to take advantage of the relative cheapness of wide windows.

There is an exception. Tighter windows may improve performance when the PAC is a current pay bond. In this case, a shorter window reduces the likelihood that prepayments can accelerate or decelerate to levels outside the bands before it is fully retired according to schedule.

LOCKOUT

PAC bonds can be "locked out" in two ways. First, the entire PAC schedule can be locked out by shifting a portion of the PAC schedule at the very front to the support bond classes; resultant PAC bonds are locked out for the period over which those principal payments are made instead to support bonds. Typically this lockout could extend from the first 12 to 24 months of the issue's life. The objective of the lockout is to stabilize the early support bond class. This is achieved by paying to the support bonds the principal cash flows that in effect have the highest effective collars (that is, they will be realized across a very wide range of prepays). These cash flows, which have a high degree of certainty, are used during the lockout to pay the support bonds. Some market participants, however, speak of the lockout as a PAC bond characteristic or feature; they may be viewing the lockout as a device for narrowing the PAC window. Others may perceive the lockout as somehow detrimental to the PACs in the structure, perhaps assuming that the PACs are somehow hurt to the extent the support bonds are helped.

Whether any of these assumptions are valid should be apparent from the example in Exhibit 27–7. The table contrasts the volatilities of 3-, 7-, and 10-year average life bonds from a structure without any lockout with those from one with a 2-year lockout. Both structures are backed by the same collateral, FNMA 9s, with a 9.77% WAC and 349-month WART, and use the maximum PAC schedule consistent with collars of 85% to 300% PSA, and, as appropriate, a lockout. The sizes of the bonds compared have been adjusted to match their average lives within two decimal places. (The 20-year bonds are not included in the comparison because their average lives were too different after matching the earlier bonds.)

The lockout, according to the exhibit, benefits the PAC bonds by reducing both call and extension risk. Earlier bonds benefit more than later bonds, with the 10-year classes displaying only marginal reductions in average life volatility. Two effects are at work here. First, the lockout reduces the size of the schedule by removing all payments in the first two years. This results automatically in a smaller amount of PAC bonds relative to the support bonds; conversely, more

EXHIBIT 27–7

Impact of Lockout Feature on the Average Life Variability of PAC Bonds

Payment Speed (% PSA)	Average Life (years)					
	No Lockout			2-Year Lockout		
	3-yr.	7-yr.	10-yr.	3-yr.	7-yr.	10-yr.
0	11.14	18.98	21.96	7.46	16.57	20.72
50	4.41	10.22	14.36	3.60	9.23	13.75
85	3.05	7.10	11.22	3.05	7.10	11.22
300	3.05	7.10	11.22	3.05	7.10	11.22
355	3.01	6.26	9.70	3.05	6.34	9.68
400	2.84	5.49	8.49	3.02	5.58	8.47
450	2.66	4.89	7.53	2.89	4.96	7.51
600	2.17	3.66	5.55	2.37	3.71	5.53

Note: Both structures are backed by $500 million FNMA 9s, 9.77 WAC, 349 WAM and have 85% to 300% PSA collars.

support bonds protect the remaining PAC schedule. Since they contain those cash flows from the collateral with the lowest degree of call risk, the support bonds are much less vulnerable to call risk, and even at very high prepayment speeds a larger proportion of support bonds remain outstanding to shelter the PAC bonds than would otherwise have been the case. At the same time, these principal amounts are no longer bound to a schedule, meaning that later scheduled payments have a better likelihood of being paid on schedule in event of speeds below the bottom collar.

The second form of lockout is a natural form of call protection common to all types of CMO structures. It refers to the bonds (or principal amount of bonds) that will pay down, in the worst case, before the specific bond begins to pay principal. In a simple sequential structure, all but the shortest average life bond enjoy some lockout while earlier bonds in the structure pay down. PACs enjoy explicit call protection from the support bonds as well as inherent call protection from any earlier bonds in the schedule. In other words, the longer the average life, the better the bond's inherent call protection. The impact of lockout is particularly apparent when we examine the effect of average life on option costs later in this article.

IS THERE A Z IN THE DEAL?

A Z, or accrual, bond ("Z" standing for zero coupon) is a type of CMO bond structure that pays no interest until it begins to pay principal. Until that time, the interest payments are accrued at the coupon rate and added to the principal

amount outstanding. A Z-bond is most typically included in a CMO structure as the last bond class to be retired. Of course, the underlying collateral continues to pay coupon interest; the portion that would have gone to the Z-bond holders, had it been structured as a coupon-paying bond, is used instead to retire the earlier classes. In effect, then, the presence of a Z-bond permits CMO structurers to increase the size of the earlier classes, since the "accrual" amounts are additional to the projected principal payments from the collateral. More pertinently, the "accrual" helps to stabilize the earlier bonds, since a portion of the cash-flow used to retire them is not directly determined by the level of prepayments.

The interaction of Z-bonds with earlier classes is discussed in detail in Chapter 28. Readers who are unfamiliar with the Z-bond structure, or are interested in more complex manifestations of the Z structure, should refer to that chapter. The objective of this discussion is to examine the value, if any, that a long-term Z-bond contributes to PACs. A related issue also is explored, namely the possibility that accrual from the Z-bond is used to stabilize earlier support bonds and not the PAC bonds, or equivalently, to pay down stated-maturity-type bonds. Such a mechanism might not be explicitly disclosed when the bonds from the structure are traded, and may only be indicated in the prospectus or by careful review of the entire issue.

Two CMO structures were modeled to examine more closely the impact of a Z-bond on their performance and relative value, again backed by the same FNMA 9% collateral, and containing the maximum principal amount of PACs given collars of 85% to 300% PSA and the relevant accrual mechanism. The schedule has been divided into a series of bonds with nominal average lives of 2-, 3-, 4-, 5-, 7-, 10-, and 20-years, the average lives of all but the 20-year matching to within two decimal places (as in the lockout example, because the schedules differ significantly in amount, the 20-year bonds are not comparable).

Both structures contain 20-year Z-bonds. The first passes accrual to PAC and earlier support bonds alike, the second to earlier support bonds only. The average lives of the two PAC series at various prepayment rates are displayed in Exhibit 27–8.

Investors should note the difference in average life performance between the PACs supported by a Z-bond and the PACs whose support bonds alone are supported by the Z-bond. The Z-bond *stabilizes the PAC bonds when prepayments break the lower collar.* This makes sense—accrual cash-flow is generated as long as the Z-bond is outstanding. On the other hand, *PAC bonds shorten more sharply* in the structure with the Z-bond when the upper collar is broken, because a smaller proportion of support bonds is outstanding at any time to cushion PACs from high rates of prepayments. In fact, the faster the prepayments, the smaller the principal balance of the Z-bond when it begins to absorb excess cash, and the quicker it can be extinguished. This example should warn investors not to assume, however, that because a Z-bond is present in the structure, that the PACs will have less extension risk. There is no rule in the marketplace requiring issuers to pay accrual to PAC bonds. In some market environments, diverting accrual to the support bonds can

EXHIBIT 27–8

Impact of Z-Bond Accrual on the Average Life Variability of PAC Bonds

Prepayment Speed (% PSA)	Average Life (years)											
	Accrual to PACs and Supports						*Accrual to Supports Only*					
	2-yr.	3-yr.	4-yr.	5-yr.	7-yr.	10-yr.	2-yr.	3-yr.	4-yr.	5-yr.	7-yr.	10-yr.
0	2.74	6.03	9.05	11.04	14.01	17.11	3.20	7.70	11.44	13.74	16.97	20.50
50	2.21	3.53	5.07	6.40	8.85	12.24	2.23	3.61	5.25	6.67	9.37	13.49
85	2.13	3.05	4.16	5.16	7.13	11.23	2.13	3.05	4.16	5.16	7.13	11.22
300	2.13	3.05	4.16	5.16	7.13	11.23	2.13	3.05	4.16	5.16	7.13	11.22
350	2.13	3.00	4.13	4.76	6.19	9.68	2.13	3.05	4.16	4.99	6.29	9.69
400	2.13	2.82	3.68	4.19	5.93	8.47	2.13	3.05	3.93	4.40	5.51	8.48
450	2.13	2.21	3.30	3.74	4.83	7.51	2.13	2.95	3.52	3.93	4.90	7.52
600	1.97	1.82	2.52	2.84	3.62	5.53	2.10	2.38	2.67	2.97	3.67	5.54

Note: Both structures are backed by $500 million FNMA 9s, 9.77 WAC, 349 WAM and have 85% to 300% PSA collars.

make them more marketable, and a CMO arbitrage more viable. If this is the case, then issuers will structure their CMOs accordingly. The moral of the story: ask for the priorities in detail and read the prospectus.

Readers also may have noticed that the average life profile of the PACs that receive no accrual in this example is identical to that of the PACs backed by the same collateral in a structure with no Z-bond. (See Exhibit 27–3.) In other words, for PAC buyers, diverting accrual to the support bonds is the same as not including a Z-bond in the structure at all. This makes sense: The same aggregate amount of support bonds is available to support the PAC bonds, with the only difference being that the weight of support bond principal payments is shifted forward in time since the payments to the non-Z support bonds consist in part of interest accrued by the Z-bond.

EFFECT OF JUMP-Z AND VADM STRUCTURES ON PAC BONDS

In 1990, structurers began to create a special bond class from the accrual thrown off by a Z-bond. Variously called thrift liquidity bonds, VADMs (very accurately determined maturity), or SMAT (stated maturity), these bonds first appealed to savings and loan institutions, who are required by regulation to maintain a portion of their assets in very high quality, short-term investments, and who, accordingly, are willing to pay a premium for instruments that qualify *and* offer yields more attractive than those of, for example, government issues. These bonds appeal to investors such as commercial banks, who are sensitive to the extension risk associated with rising yield environments, so that VADMs with final maturities greater than two years have been issued in growing amounts. The size of a VADM class is determined by the amount of accrual (or accrual and principal) thrown off at a zero-prepayment rate up to the desired final maturity; obviously, faster prepayments will shorten the maturity, but no event can lengthen it. The presence of a VADM has the same effect on the PAC performance as diverting the accrual to the support bond classes has in the preceding example.

In a handful of issues, structurers designed the support bond Z-bonds to convert to a "payer" if certain trigger conditions occur, changing their payment priority among support bonds from last to current. There are a variety of ways to make a Z "jump"; the chief ones are described in Chapter 28. Once the Z-bond converts to the current pay bond and begins to pay coupon interest, its support is no longer available to the PAC classes. The effect on PAC performance is generally the same as in the basic example above. However, the degree to which the PACs lose extension protection is moderated by the amount of time it takes to trigger the conversion, and by whether the jump is a temporary response to some condition (such as a specified prepayment threshold) or permanent (a "sticky" Z). This structuring strategy was more common in the late 1980s and hasn't been seen in recent market environments.

PRIORITY TO RECEIVE EXCESS CASH FLOWS

The PAC schedule is protected by the existence of support bond classes. The mechanism is simple: In any period the support bonds absorb all principal in excess of the scheduled payments, and any current-paying PACs have first claim on all principal received. This protection ceases when all the support bond classes have been fully retired, an event that occurs if the collateral consistently pays at speeds above the top collar. Once the support bonds are retired, any principal is distributed to the outstanding PACs, according to priorities defined for the particular CMO issue. Frequently, these priorities pay excess principal to the outstanding PACs in order of final maturity, but this is not always the case. A wholesale examination of CMO prospectuses will unearth numerous examples of structures that paid excess in the reverse of maturity order or otherwise insulated some classes at the expense of others. The impact of such schemes has, as would be expected, a significant effect on the average life volatility of the various PACs.

A simple example contrasting two priority schemes is shown in Exhibit 27–9. This exhibit compares the average lives of two sets of PACs at various prepayment speeds—one receiving excess principal in the maturity order, the other in the reverse maturity order. As the exhibit indicates, reversing the order in which PACs are subjected to prepayments above the top collar drastically alters the average life performance of the PACs, if prepayments are outside the collars. As would be expected, shorter PACs benefit at the expense of the longer. When the excess is paid in reverse, the short- and intermediate-term PACs are more significantly stable; when prepayments increase, longer PACs, with 10- and 20-year average lives, shorten up much more significantly.

THE OPTION COSTS OF PAC FEATURES

Most participants in the PAC market evaluate individual bonds by examining their average life and yield over various constant prepayment scenarios outside the collars, a technique similar to the one used in this chapter to analyze the various PAC features. The procedure has recognized disadvantages, some of which can be reduced to the complaint that they use a constant prepayment assumption. Using such tools, investors can devise investment criteria for PACs such as "I will buy 10-year PACs with 4-year windows at 120 off if they don't shorten to less than 8 years average life given an instantaneous 200-basis point (bp) drop in yields." Implicitly, they are using these tools to measure and value the prepayment options embedded in their PAC bonds. However savvy and tough-minded the criteria sound, they are at bottom purely subjective guesses about how much the random exercise of those options will impair or help investment results.

It is possible to measure the impact of prepayment risk on the yields earned by PACs by employing option pricing models. These models generate spreads, durations (price sensitivity), and convexities (the sensitivity of duration to yield changes) that are explicitly adjusted to account for expected

EXHIBIT 27–9

Impact of Excess Payment Order on the Average Life Variability of PAC Bonds

Speed (% PSA)	Average Life (years)													
	Excess in Order of Maturity							Excess in Reverse Maturity Order						
	2-yr.	3-yr.	4-yr.	5-yr.	7-yr.	10-yr.	20-yr.	2-yr.	3-yr.	4-yr.	5-yr.	7-yr.	10-yr.	20-yr.
0	3.20	7.70	11.44	13.74	16.97	20.50	22.75	3.20	7.70	11.44	13.74	16.97	20.50	22.75
50	2.73	3.61	5.75	6.67	9.37	13.49	19.24	2.73	3.61	5.75	6.67	9.37	13.49	19.24
85	2.14	3.05	4.16	5.16	7.13	11.22	19.23	2.14	3.05	4.16	5.16	7.13	11.22	19.23
300	2.14	3.05	4.16	5.16	7.13	11.22	19.23	2.14	3.05	4.16	5.16	7.13	11.22	19.23
350	2.14	3.05	4.16	4.99	6.29	9.69	17.06	2.14	2.05	4.16	5.16	7.14	11.95	5.42
400	2.14	3.05	3.93	4.40	5.51	8.48	15.09	2.14	3.05	4.16	5.16	7.17	9.65	4.07
450	2.14	2.95	3.52	3.93	4.90	7.52	13.43	2.14	3.04	4.16	5.16	7.26	7.56	3.35
600	2.10	2.38	2.67	2.97	3.67	5.54	9.86	2.14	2.51	4.16	5.16	7.24	3.09	2.27

Note: Both structures are backed by $500 million FNMA 9s, 9.77 WAC, 349 WAM and have 85% to 300% PSA collars.

prepayments on a large sample of possible interest rate paths over the life of the PAC. In particular, these models derive an average cost of the prepayment options in the PAC, and determine the expected reduction in total spread caused by interest rate volatility.[7] The model, in simple terms, summarizes hundreds more scenarios than investors can digest looking at price-yield tables. The scenarios, moreover, are more realistic in that they permit interest rates to move randomly at each point along the path.

Option-adjusted spreads (OASs) vary with market conditions. For this reason, a discussion of current OASs is inappropriate here. However, the option costs derived from the analysis are not as sensitive to current market yield levels (although they will vary somewhat with changes in the level of implied volatility), and can be discussed here without becoming hopelessly stale with the next rally or correction in fixed income markets.

As expected, PACs demonstrate low option costs. *Option costs in the current-coupon-backed structures discussed in this chapter generally ranged from 0 to 20 bps for bonds with 3- to 20-year average lives.* By comparison, the collateral (FNMA 9s) had 35 bps of option cost. (Bear in mind that absolute measures of option costs, yields, and so forth are calibrated to a specific option model. PAC and other CMO option-adjusted spreads and costs should always be benchmarked to those demonstrated by the collateral in the same model.) The PAC bonds backed by premium collateral (FNMA 10 1/2s) had demonstrably higher option costs, ranging from 3 to over 40 bps. The collateral had an option cost of 68 bps.

The general pattern revealed by the option-pricing model is illustrated in Exhibit 27–10. The option costs are calculated for the series, described in earlier sections, of 2-, 3-, 4-, 5-, 7-, and 20-year average life-PACs backed by FNMA 9s. (See Exhibit 27–3 for the average life profile of these bonds.) The patterns displayed by option costs for premium-backed PACs are shown in Exhibit 27–11. The option costs for these series are analyzed in three scenarios: assuming that the interest rate environment (of January 23, 1990) remains constant and assuming instantaneous parallel shifts in interest rates of up and down 100 bps. Assuming a constant option-adjusted spread, the shifts in the up and down cases are typically large enough to give the tranches, which currently are priced close to par, a discount or premium price. In this way it is possible to draw some conclusions about the sensitivity of the structure to interest rate shocks. Ranging from 3 to over

7. The model employed in this discussion, like many other OAS models, used Monte Carlo simulation and an econometric prepayment model. A minimum of 200 paths was generated in the analysis. The total spread computed is a total spread to the entire Treasury yield-curve (precisely, the forward rates implied by current Treasury yields), as opposed to a single benchmark. It roughly approximates the spread to a particular Treasury quoted in the market, but differs more or less depending on the slope of the yield-curve. The total spread is the spread over Treasuries the security would earn given its current market price if there were zero volatility. The option-adjusted spread (OAS) is the average spread earned across a large sample of interest rate scenarios given the market price. The option cost is measured as the difference between total and option-adjusted spread, and captures the reduction in total spread caused by interest rate volatility.

EXHIBIT 27–10

Sensitivity of Option Costs in PACs* to Interest Rate Shifts (Current-Coupon Conventional Collateral)

*PACs backed by FNMA 9s; instantaneous interest rate shifts assumed.

30 bps, the option costs demonstrated by the current-coupon-backed PACs in the bullish scenario are consistent, as well, with the general magnitude of option costs observed in premium-coupon-backed PACs.

As expected, the option costs rise with the average life of the PAC. This result is expected if only because the probability an option will be exercised is

EXHIBIT 27–11

Sensitivity of Option Costs in PACs* to Interest Rate Shifts (Premium-Coupon Conventional Collateral)

*PACs backed by FNMA 10 1/2s; instantaneous interest rate shifts assumed.

greater the later its expiration date. Comparing the current and bearish cases, the increase in extension risk as interest rates rise results in a slightly higher option cost for 2- and 3-year PACs. Of greater interest is the fact that, going from the 10-year PAC to the 20-year, option costs either decline or increase at a slower rate in every interest rate case. This result holds for the option costs in a similar set of PACs depicted in Exhibit 27–11, backed in this instance by premium coupon collateral (the average life profile is shown in Exhibit 27–3). *The fact that option costs tend to peak with 10-year PACs rather than 20-year PACs* should take some market participants by surprise, and suggest to others that the typical incremental spread required by 20-year PAC buyers over 10-year PACs represents extra value. The result is intuitively appealing as well. It reflects the long lockout imparted by comparisons and shorter PACs in the schedule and the limited room for extension. In addition, the prepayment model used to project prepayments over various interest rate paths correctly reflects the tendency of mortgage pools to "burn out" following sustained periods of fast prepayment rates. As a result, prepayments tend to slow down in the later years of the pool's life.

When the effect of a lockout was examined using average life profiles (Exhibit 27–7), the benefits to the PACs were more pronounced the earlier the bond came in the series. By explicitly valuing the option costs for the same example, a similar effect is observed, as shown in Exhibit 27–12. However, the 7- and 10-year tranches receive no benefit from the lockout on an option-cost basis, whereas their average lives are observed to lengthen less sharply in extremely slow prepayment rate environments. The exhibit also indicates a benefit to the 20-year PAC, except

EXHIBIT 27–12

Sensitivity of Option Costs in PACs* to Interest Rate Shifts in Structures with and without a Lockout

*PACs backed by current-coupon conventional collateral; instantaneous interest rate shifts assumed.

when interest rates drop and the collateral becomes a premium security and subject to faster prepayments. The 20-year PACs were not compared in Exhibit 27–6 since, given a different amount in the schedules, it was not possible to match the average lives of all four bonds (the 20-year in the lockout structure had an average life close to 16 years). This difference also may account for the lower option cost imputed to the 20-year in the lockout structure.

The impact of various window lengths on 5- and 10-year PACs also was examined, with no increase or diminution of option costs observed, except for the 5-year bonds in the bullish case. Even then, only slight differences, at best 3 bps, were manifested. This reiterates the conclusion, stated earlier, that the length of the window does not significantly affect the average life stability of the bond outside the collars.

Some security analysts and investors resist this result. They believe, for instance, that a tight window lowers the likelihood of breaking the collars during the paydown period. Therefore, they reason, the prepayment options that they effectively hold should be less costly. The time value of the options, however, includes the period prior to the first payment, because the protection implicit in the collars can be damaged or enhanced by prepayment experience in earlier months or years of the structure's life. More than one full interest rate and housing industry *cycle* can occur before a single principal payment is made to a 5- or 7-year PAC, with periods of slower prepayments tending to improve a PAC's call protection and faster prepayments tending to erode it. If prepayments violate the lower collar when earlier PACs are paying, both the call and extension protection of the later PACs can actually improve! When many such possibilities are simulated, the net effect should be small or negligible.[8]

The option costs for two series of PACs in Z-bond structures, one funded by the Z-bond and one not, are displayed in Exhibit 27–13. The fact that the Z-bond helps reduce the extension risk in the PACs but exposes them to additional call risk is illustrated. The PACs paid down with accrual tend to have higher option costs, except in the bearish case, where prepayments are less likely to retire the Z-bond before the PACs have been paid. (The relationship appears to weaken for 20-year bonds, but this most likely reflects the fact that the 20-year bonds have very different average lives as a result of matching the earlier bonds. The 20-year PAC paid by accrual actually has an average life of over 26 years.)

Reversing the priorities when the top collar is broken, so that the last PAC in the schedule is the first to receive excess principal after the support bonds are retired, has a very large effect on the option costs in the 7-, 10-, and 20-year PACs. This effect is apparent in Exhibit 27–14. The higher the priority, the greater the call risk and the higher the option costs. The impact is, as expected, accentuated as declining yields elevate the risk of prepayment. By contrast, shifting the call risk to the later tranches strips most of the already low option costs from the earlier tranches.

8. The first PAC, then, should benefit the most from a tight window. A 2- or 3-year PAC, however, already tends to have a short window and very low option costs, for reasons previously explained.

EXHIBIT 27–13

Sensitivity of Option Costs in PACs* to Interest Rate Shifts When Z-Bond Funds Supports Only and When Z-Bond Funds Both PACs and Supports*

*PACs backed by current-coupon conventional collateral; instantaneous interest rate shifts assumed.

EXHIBIT 27–14

Sensitivity of Option Costs in PACs to Interest Rate Shifts When Excess Cash Is Paid to PACs in Sequential and Reverse Orders

KEY POINTS

- The scheduled payments of PACs, protected over a wide range of possible prepayment speeds, appeal primarily to insurance companies and other buy-and-hold investors who are matching specific liabilities. The liquidity, yields, and wide diversity of features in the market also attract growing numbers of active bond managers.
- Misconceptions about the value of certain PAC features can create a number of opportunities for investors in both groups. Most notably, many premium coupon-backed PACs may be undervalued when their current effective collars are taken into account; the length of the PAC window does not contribute to economic value; lockouts benefit short-term average life PACs as well as support bonds; and Z-bonds can protect earlier PAC bonds from extension risk.
- Investors who fail to stress-test PAC investments may overlook the fact that effective collars are significantly different from those stated at issue. Any kink or deviation from sequential order in the prioritization of excess cash-flow to the PACs after support bond classes are retired must be detected, as it could drastically affect the performance of the longer-term PACs. Although the impact on value is less dramatic, investors should also determine whether a long-term Z-bond pays support bonds or PACs in the structure.
- PACs are normally evaluated by examining the yields and average lives of PAC investments over a variety of prepayment scenarios. Such analyses must be carried a step further and linked to possible interest rate scenarios. The soundest way to do this is to employ a prepayment model that explicitly recognizes the determinants of prepayment behavior. Such an analysis can be supplemented and its insights extended by employing option-based pricing methods.

CHAPTER
TWENTY-EIGHT

AGENCY CMO Z-BONDS

LINDA LOWELL
Principal
OffStreet Research LLC

Traditional accrual collateralized mortgage obligation (CMO) bonds in agency deals are long-term bonds structured so that they pay no coupon interest until they begin to pay principal. Instead, the principal balance of an accrual bond is increased by the stated coupon amount on each payment date. Once the earlier classes in the CMO structure have been retired, the accrual bond stops accruing and pays principal and interest as a standard CMO bond. Accrual bonds are commonly called **Z-bonds** because they are zero-coupon bonds during their accrual phase. Bonds created in this way provide investors with long durations, attractive yields, and protection from reinvestment risk throughout the accrual period. The cash-flow pattern produced is suited to matching long-term liabilities, and, as a result, the bonds are sought after by pension fund managers, life insurance companies, and other investors seeking to lengthen the duration of their portfolios and reduce reinvestment risk.

Z-bonds have been a staple product of the CMO market since its earliest days. The bulk of the Z-bonds currently outstanding are from traditional, sequential-pay CMOs, but the generic structure has adapted well to the PAC-based CMOs favored by the market since the late 1980s, and the inclusion of an accrual bond as the last class continues to be a common practice. At the same time, the Z-bond was the focus of innovation in the CMO market, as issuers created a significant amount of intermediate average life Z-bonds, a growing number of bonds of various average lives that accrue and pay according to a PAC schedule, and bonds that use various conditions or events to turn the accrual mechanism on or off. These innovations expanded the traditional market for Z buyers by improving the stability of Z-bonds' cash flows, issuing Z-bonds in a wider range of average lives, or by creating bonds that perform well in rallies and preserve their high yields better in declines.

The chapter discusses this important sector of the agency CMO market. We begin with an examination of the mechanics of the traditional Z-bond as well as Z-bonds issued with PACs, and focus on the behavior of these structures in

An earlier version of this chapter was coauthored with Bruce Mahood.

different prepayment scenarios. We also consider the effect Z-bonds have on the other bonds in a CMO, and the relationship between the basic characteristics of the Z-bond and its market properties and economic performance. A discussion then follows of the characteristics of more complex Z-bond structures, such as serial Z-bonds, PAC Zs, and Jump Zs.

THE BASIC ACCRUAL STRUCTURE

Most Z-bonds have been issued from traditional, sequential pay CMO structures. Typically, they were the last in a four-class bond issue, and had nominal average lives of 20 years. The principal and interest cash flows for a traditional, sequential-pay CMO containing a Z are diagrammed in Exhibit 28–1. As the graph indicates, the first class pays principal and interest until it is retired, at which time the second class begins to paydown. The coupon-paying bonds, Classes A, B, and C, receive payments of interest at their stated coupon rates on their original principal balances. The Z-bond Class Z, however, receives no payments of interest until the preceding classes are fully retired. Instead, its principal balance increases at a compound rate, in effect guaranteeing the bondholder a reinvestment rate equal to the coupon rate during the accrual period, and insulating the investment from reinvestment risk as long as the earlier classes remain outstanding. The principal balance can triple or quadruple in amount over the accrual period projected at issue. This is graphically depicted

EXHIBIT 28–1

Total Principal and Interest Payments of a Traditional Sequential-Pay CMO with a Z-Bond*

*Prepayments at 165% PSA.

EXHIBIT 28–2

Principal Balance of a Z-Bond Over Time—$25 Million Beginning Balance*

*Prepayments at 165% PSA.

in Exhibit 28–2, which indicates the growth of the principal balance of the Z-bond in Exhibit 28–1 over its expected life at an assumed constant prepayment speed of 165% PSA. The principal balance of the tranche at issue is $25 million, and grows to a maximum level of $79.5 million by the 150th month. From that point, coinciding with the last payment to the preceding tranche, the balance begins to decline as scheduled amortization and prepayments from the collateral are paid to the bondholders.

If actual prepayments occur at a faster rate than 165% PSA, the principal balance of class Z at the end of the accrual period will be smaller than the $79.5 million shown in the diagram. Since the earlier tranches pay down sooner, the Z-bond accrues over a shorter period of time, and the total amount of accrued interest is lower. Conversely, slower prepayments allow the Z-bond to accrue for a longer period, resulting in a larger principal balance at the time when the Z-bond begins to generate cash for the bondholders. Principal balances at the end of the accrual period are shown for various constant prepayment speeds in Exhibit 28–3. At the pricing speed of 165% PSA, the balance in this example reaches an amount more than three times the size of the original face amount at issue. At a faster speed of 350% PSA, the original face amount doubles, and at a slower speed, 100% PSA, it quadruples. Likewise, faster prepayments accelerate the receipt of the first payment of principal and interest. In the example, the first payment jumps from halfway into the 12th year at 165% PSA to the beginning of the 9th year at 350% PSA. If prepayments slow to a constant rate of 100% PSA, the first payment to the Z-bond is not made until the beginning of the 16th year after issue.

EXHIBIT 28–3

Effect of Prepayment Speed on the Length for the Accrual Period and the Principal Balance at the End of the Accrual Period of a $25-Million 20-Year Average Life Z-Bond Class*

Payment Speed (% PSA)	Principal Balance Outstanding ($MM)	Months from Issue
75	115.4	194
100	102.1	180
125	91.8	166
165	79.5	150
200	71.4	135
250	63.4	119
300	57.2	106
350	52.9	96
425	46.6	80
600	41.1	64

*Total issue $300 million sequential-pay CMO backed by FNMA 9½s.

The effect of faster or slower prepayments on the average life and yield of this same example is shown in Exhibit 28–4, under the heading Z-Bond in a Traditional Sequential-Pay CMO. The average life of the Z-bond at the pricing assumption of 165% PSA is about 18.5 years; traditional Zs typically have expected average lives at pricing of 18 to 22 years (and expected accrual periods of 8 to 10 years). If prepayments occur at a constant rate of 100% PSA, the bond lengthens modestly, to an average life of about 22 years. Like other last tranches, the Z has more room to shorten. In this example, the Z shortens to an average life of about 12 years at 350% PSA, and down to about 7.5 years at 600% PSA.[1]

The yield received on a Z-bond is less sensitive to differences in prepayment speeds the closer to par it is priced. At deeper discounts, Z-bonds, like other discount mortgage-backed securities, will benefit as their average lives shorten,

1. Average life calculations are intended to measure the weighted average time until receipt of principal payments. Some measures of expected life may include the accrued interest as a cash-flow. These increases in the principal balance can enter the calculation as negative weights applied to the elapsed time to early payment dates, and the actual principal payments as positive weights applied to the elapsed time to later payment dates. By placing negative weights on small numbers and positive weights on large numbers, the results can be larger than the remaining term of the underlying collateral (for example, a number of years greater than 30). To avoid this unrealistic result, the convention in the CMO market is to exclude from the calculation all increases in the factor or balance, with the understanding that this method can substantially understate the true interest rate sensitivity of a security.

EXHIBIT 28–4

Yield and Average Life at Various Prepayment Speeds of Comparable CMO and 20-Year Average Life Bonds in Structures with and without Z-Bonds (Pricing Assumption: 165% PSA)

	Coupon-Paying Bond in a Traditional Sequential-Pay CMO		*Z-Bond in a Traditional Sequential-Pay CMO*		*Z-Bond in a PAC Structure*	
Payment Speed (% PSA)	**Yield* (%)**	**Average Life (Years)**	**Yield[a] (%)**	**Average Life (Years)**	**Yield[b] (%)**	**Average Life (Years)**
75	9.97	25.01	9.82	22.91	10.17	22.91
100	9.98	23.25	9.83	21.71	10.20	21.71
125	9.94	21.40	9.83	20.47	10.24	20.47
165	10.00	18.55	9.85	18.55	10.30	18.55
200	10.02	16.41	9.86	17.02	10.35	17.02
250	10.05	13.88	9.89	15.02	10.44	15.02
300	10.08	11.92	9.91	13.37	10.52	13.54
350	10.11	10.38	9.93	11.96	10.69	12.48
425	10.15	8.66	9.98	9.80	11.18	8.38
600	10.27	6.18	10.06	7.61	13.02	3.05

*Price: 96:28.
[a]Price: 96:29.
[b]Price: 90:10.

since principal is returned at par earlier than assumed at pricing. The deeper the discount, the sharper the boost in yield at faster prepayment speeds. Conversely, the yield declines as a function of a slowdown in prepayments and the original discount. Traditional 20-year average life Zs have been issued at original prices as low as 30, but prices above 85 currently are more common. In general, issuers can lower the coupon, achieving a more attractive price, by using discount collateral or by stripping interest into another class.

HOW THE Z INTERACTS WITH OTHER BONDS IN THE STRUCTURE

The interaction of the Z-bond with earlier bonds in the CMO structure is a key determinant both of its own behavior and that of the other bonds. By including an accrual bond in the CMO structure, issuers accomplish two purposes: (1) a higher proportion of the total issue can consist of tranches with earlier final maturities than if there were no Z-bond in the structure, and (2) the earlier classes have more stable cash flows and average lives across a range of prepayment rates

than in a comparable structure without a Z-bond. Furthermore, since the timing of cash flows from the Z-bond depends on when the earlier tranches are retired, the Z-bond itself also is more stable.

An accrual bond supports a larger proportion of early classes because the coupon interest that would have been paid on the outstanding balance of the Z-bond is added to the principal payments from the collateral and used to retire the earlier classes. At the same time, the principal amount of Z-bonds is increased by the dollar amount of interest diverted. Although at first glance this may look like sleight of hand, the accrual procedure maintains a simple algebraic relationship in which the sum of the principal balances of the outstanding bonds always equals the outstanding principal balance of the collateral. The simple numerical example in Exhibit 28–5 illustrates this relationship. In the example, the collateral pays a 10% coupon and a $100 principal balance in ten equal payments. Both Class A and Class Z have stated coupons of 10%, so that the sum of the interest paid to Class A and either accrued or paid to Class Z is always equal to the interest paid by the collateral. (In an actual CMO, there can be a differential between interest on the collateral and the interest paid to the bondholders, which is then payable to the residual holders.) Notice that Class A is paid down more quickly than it would be if the Z were a coupon-paying bond.

The accrual structure permits issuers to create larger classes with short- and intermediate-term average lives. The effect of an accrual bond on the size of the earlier classes is graphically illustrated in Exhibit 28–6, a diagram of the principal payments only from the CMO in Exhibit 28–1. The discontinuity between the size of principal payments to the Z and those to the earlier tranches reflects the fact that the Z-bond's pro rata share of coupon interest is treated as principal in order to pay down larger earlier tranches (if the last payment to the fourth would be much smaller). This strategy is attractive to issuers when the CMO arbitrage depends primarily on the shape of the yield-curve, and larger profits can be made the larger the amount of bonds that can be priced off the front end of the yield-curve. In periods when the yield-curve is flat or inverted, this strategy helps issuers minimize the proportion of longer average life bonds in the issue. This works because interest payments from the collateral, which would have been paid to holders of the last tranche, are used to support the first tranche. Just how much of an effect an accrual class can have on the allocation of principal to the earlier classes is shown in Exhibit 28–7. The exhibit compares two four-tranche sequential pay CMOs backed by the same collateral, one with a Z and one without. The four tranches in each issue have the same average lives, roughly 3, 7, 10, and 20 years. (The fourth tranches from these examples, all nominally 20-year bonds, are included as well in Exhibit 28–4.) The two structures differ in the way the collateral's principal is distributed among the classes. For example, in the Z-bond structure, a $25 million Z-bond class supports a $136 million 3-year first tranche. The structure without a Z-bond has $120 million 3-year bonds in the first class and $79 million 20-year bonds in the fourth tranche.

EXHIBIT 28–5

How a Z-Bond Accrues and Pays: A Simplified Example

Collateral: $100 10% loan amortizing in 10 annual payments

CMO: Class A $50 paying 10% coupon
Class Z $50 Z with 10% coupon

	Collateral			*Class A*			*Class Z*		
	Payments			*Payments*			*Payments*		
Payment	**Interest ($)**	**Principal ($)**	**Balance ($)**	**Interest ($)**	**Principal ($)**	**Balance ($)**	**Interest ($)**	**Principal* ($)**	**Balance ($)**
0	0.00	0.00	100.00	0.00	0.00	50.00	0.00	0.00	50.00
1	10.00	10.00	90.00	5.00	15.00	35.00	0.00	(5.00)	55.00
2	9.00	10.00	80.00	3.50	15.50	19.50	0.00	(5.50)	60.50
3	8.00	10.00	70.00	1.95	16.05	3.45	0.00	(6.05)	66.55
4	7.00	10.00	60.00	0.34	3.45	0.00	6.66	6.65[a]	60.00[b]
5	6.00	10.00	50.00	0.00			6.00	10.00	50.00
6	5.00	10.00	40.00	0.00			5.00	10.00	40.00
7	4.00	10.00	30.00	0.00			4.00	10.00	30.00
8	3.00	10.00	20.00	0.00			3.00	10.00	20.00
9	2.00	10.00	10.00	0.00			2.00	10.00	10.00
10	1.00	10.00	0.00	0.00			1.00	10.00	0.00

*Amounts in parentheses are not cash flows but upward adjustments of principal balance.
[a]$6.65 = Principal remaining after Class A retired.
[b]$60 = Previous balance – Principal Paid = $66.55 – $6.65.

EXHIBIT 28–6

Total Principal Payments of a Traditional Sequential-Pay CMO with a Z-Bond*

*Prepayments at 165% PSA.

The accrual mechanism imparts greater stability to all the bonds in a typical structure. This is readily apparent in Exhibit 28–8. Each column compares the average life at different prepayment speeds of the different tranches from the sample structures. In each case, the average lives of the tranches are less variable across all scenarios for the structure containing a Z-bond than in the structure without.

CMOs WITH PACs AND A Z-BOND

The Z-bond has a similar effect on earlier bonds in a typical PAC structure. For a given collateral and pricing assumption, accrual from the Z can be used to support a larger amount of PAC and support bonds in the earlier tranches. The principal and interest payments for a structure containing 3- and 7-year PACs, a 7-year support bond, and a 20-year Z are shown in Exhibit 28–9. The yield and average life at various prepayment levels of the Z-bond from this structure are included in Exhibit 28–4, and the size and average life of the various classes are shown in Exhibit 28–7. (In fact, the average life of the Z-bond is 18.6 years, matching, for the sake of discussion, the average lives of the Z and regular coupon-paying tranches in the other examples.) Funding the earlier classes from the Z-bond's accrual generally creates a much larger portion of available principal, for a given pricing speed, from which to carve PACs, allowing issuers to increase the size of the PAC classes.

EXHIBIT 28–7

Comparison of Various CMO Structures Created with and without Z-Bonds*

	Traditional CMO Without Z		*Traditional CMO With Z*		*PAC CMO with Z*	
Class	**Original Balance**	**Average Life**	**Original Balance**	**Average Life**	**Original Balance**	**Average Life**
A	$120,000,000	3.0 Years	$136,000,000	3.0 Years	$ 80,000,000	2.8 Years
B	66,200,000	7.4	84,000,000	7.4	70,000,000	7.0
C	34,500,000	10.9	55,000,000	10.9	125,000,000	7.3
D	79,300,000	18.6				
Z			25,000,000	18.6	25,000,000	18.6
Total	$300,000,000		$300,000,000		$300,000,000	

*Collateral: FNMA 9 1/2s; structured at 165% PSA.

EXHIBIT 28–8

Effect of a Z-bond on the Average Life Variability of the Various Classes in a Traditional Sequential-Pay CMO*

	Average Life in Years							
	3-Year Tranche		*7-Year Tranche*		*10-Year Tranche*		*20-Year Tranche*	
Prepayment Speed	**No Z-Bond**	**With Z-Bond**	**No Z-Bond**	**With Z-Bond**	**No Z-Bond**	**With Z-Bond**	**Coupon Bond**	**Z-Bond**
75% PSA	5.2	4.7	13.2	11.1	18.4	14.9	25.0	22.9
165% PSA	3.0	3.0	7.4	7.4	10.9	10.9	18.6	18.6
425% PSA	1.6	1.7	3.4	3.8	4.8	5.9	8.7	10.3

*Collateral: FNMA 9.5s.

EXHIBIT 28–9

Total Principal and Interest Payments of a CMO with PACs and a Z-Bond*

*Prepayments at 165% PSA.

Since support bonds absorb the prepayment volatility from which the PACs are shielded, the proportion of PACs to support bonds is an important parameter in determining the degree to which the average lives of the support bonds will vary over various prepayment scenarios. The presence of a Z-bond increases the total amount of principal available at the pricing speed to pay both the PACs and the support bonds. This means that, all other factors being equal, more PACs may be issued with less negative effect on the stability of the support bonds. In turn, the length of the accrual period is more stable. Nonetheless, the Z-bonds created to support PAC tranches are necessarily more volatile than Z-bonds in the traditional CMO issues. The truth of this can be seen by comparing the average life at various prepayment speeds of a Z from a PAC structure to those of a Z from a traditional CMO, as was shown in Exhibit 28–4. As is the case with the fourth tranches in the sample traditional deals, this Z also has an average life of 18.6 years at 165% PSA. As the exhibit indicates, the average life of the Z from a PAC structure would extend more significantly as well, since slow prepayment rates will delay the retirement of the support bonds, further extending the accrual period for the Zs. (This effect is obscured by oversimplification of the example.)

If the support bond tranche(s) in front of a Z are targeted amortization class bonds (TACs), the Z may be more volatile than if structured with standard support bonds. When the priorities enforcing the structure require that principal in excess of the TAC (and PAC) payments be paid to the Z, then the Z may begin to receive payments before the support bond TAC is retired. This kind of structure produces a Z that is much more volatile in bull markets than a traditional or support Z-bond. Prepayment speeds fast enough to shorten a traditional 20-year Z to a 10-year can shorten this bond to a 1-year. When they carry a low coupon, these bonds are priced to produce generous returns from accelerating prepayments. Indeed, this is one way to create the bullish Z-bond known as a "Jump Z." The Jump Z is discussed in greater detail later in this chapter.

PERFORMANCE OF Z-BONDS

The variability in the yield of a Z-bond over a range of prepayment rates gives at best an imperfect indication of the Z's expected price, and hence, economic performance in different interest rate scenarios. A major drawback of using yield as a measure of a Z-bond's, or for that matter, any mortgage-backed security's expected performance is that the calculation of yield-to-maturity presumes that the amount and timing of cash flows are known with certainty and are reinvested over the life of the investment at a rate equal to the yield. In actuality, mortgage-backed securities are more exposed to reinvestment risk than other common fixed income investments. Most CMOs pay both principal and interest monthly. More importantly, prepayments of principal normally accelerate when market rates decline, just as the yields available on reinvestment opportunities are declining. The opposite occurs as market yields rise; prepayments decline, slowing the receipt of principal just as more attractive reinvestment opportunities appear. Z-bonds are protected somewhat from this later source of reinvestment risk, since the reinvestment rate is locked in over the accrual period. They are not fully protected, however. The accrual period is of uncertain length, and when it ends the bonds begin to pay exactly like a coupon-paying CMO bond. For these reasons, yield does not capture the difference in the Z-bond's performance relative to a security with lower reinvestment risk, such as a Treasury bond that pays only coupons until maturity, or one with a fixed accrual period, such as a Treasury zero.

Prepayment risk also exposes investors to call and extension risk, and these have additional consequences for market value. For mortgage-backed securities purchased at prices above par, the early return of principal at par is a negative event, since less interest is earned over the investment horizon. Reflecting the market's perception of these risks, the prices of premium coupon CMOs, including Z-bonds, rise more slowly the steeper the decline in interest rates. Investors also are exposed to possible declines in market value when the bond's average life extends and it shifts outward on a positively sloped yield-curve. When a bond

lengthens in an upwardly sloping yield-curve environment, the discount rate applied to the expected cash-flow rises, resulting in a lower market value.

Another characteristic that yield calculations cannot reflect is the call provisions established for CMOs. Newer issues tend to have minimal clean-up call provisions designed to pay off the bonds when the remaining balance falls below a certain low level. The market considers as fairly favorable terms that permit the bonds to be called at par, 10 or 15 years after issue, when the outstanding balance of the tranche has declined by 10% to 20% of its original amount. These also are the most common. Less favorable terms stipulate a higher remaining balance or a shorter period, or both. Investors are advised to carefully examine the call provisions of Z-bonds before trading them.

Z-bonds have considerably longer expected durations than coupon payers with similar average lives because the principal balance grows over time. This can be seen by comparing a Z to a coupon payer with the same principal structure (sequential, support bond, etc.) and similar average life at the same pricing speed. For example, FHLMC 1727 Z, a support Z, and FNMA 93-204 J, a support payer, are both 20-year bonds at 125% PSA (on November 28, 1994) backed by 6.5s. FHLMC 1727 Z has an average life of 20.4 years at 125% PSA, FNMA 93-204 J an average life of 21.5 years. At this speed, the Z-bond has a modified duration of 15.4, while the payer has a modified duration of 9.8. At slower prepayment speeds the divergence is even greater: at 90% PSA the Z-bond has an average life of 23.4, but a duration of 16.7, the payer an average life of 24.0 and duration of 10.3. Only at speeds which significantly shorten the average lives of these support bond structures does the Z-bond's duration converge to that of the comparable payer. At 250% PSA, the Z-bond shortens to an average life of 6.1 years, with a modified duration of 3.6 and the payer to an average life of 6.2 years with a duration of 3.5. An option-adjusted analysis produces a similar result: The Z has an expected duration of 15.9, the payer 10.0. Given this pattern of price sensitivity, investors should expect Z-bonds on a total return basis to underperform CMO payers and Treasuries with comparable average lives and maturities in bearish scenarios. On the other hand, as a result of the accrual mechanism, Z-bonds tend to outperform comparable Treasury zeroes in rising rate scenarios. In bullish scenarios, the long duration of the Z-bond produces high rates of return, although the Z-bond loses its advantage over comparable securities as it shortens dramatically in more sharply declining yield interest rate scenarios.

MORE FUN WITH ACCRUAL BONDS

Under some market conditions, structurers have made more creative use of the basic accrual mechanism. The variations on the accrual theme include PAC Zs and structures containing an intermediate- as well as long-term Z-bond or a series of Z-bonds of various average lives. Other structures turn the accrual

mechanism on and off, depending on the amount of excess principal available after scheduled payments are met. As complex and exotic as these structures may appear at first glance, the same basic principles at work in traditional Z-bonds continue to apply. And in most cases, any additional complexity is accompanied by considerable additional value for investors with particular objectives and investment criteria.

PAC Zs

PAC Zs combine the cash-flow characteristics of a standard Z-bond with the greater certainty of a PAC regarding the amount and timing of actual payments. When prepayments occur within the range defined by the PAC collars, the PAC Z will accrue to a scheduled principal balance over a fixed period and make scheduled payments thereafter. As with more familiar, coupon-paying PACs, any excess cash-flow is absorbed by support bonds as long as they are outstanding. Similarly, the coupon interest earned on the PAC Z's outstanding balance during the accrual period is used to support earlier classes in the structure, and the balance of the PAC Z is increased by an equal amount. For prepayment levels within the PAC collars, the structure eliminates reinvestment risk over a defined accrual period, and then provides predictable payments until maturity. This structure is particularly well suited to matching liabilities. The fact that PAC Zs are issued in a range of average lives (typically 5, 7, 10, or 20 years) increases their applicability. Furthermore, the call and extension protection provided by the planned payment schedule means that the duration of the investment is less likely to increase as interest rates rise (or decrease as interest rates decline) than is the duration of a standard or support Z. That is to say, the PAC Zs are less negatively convex than standard or support Zs. For this reason, active portfolio managers should consider using the PAC Z to lengthen the duration of their portfolios in anticipation of market upswings.

STRUCTURES WITH MORE THAN ONE Z-BOND

It is also possible to issue two or more Zs from a single structure. Considerable variety is possible in structuring deals with multiple classes of Z-bonds, but two common strategies have been to issue a sequential series of Zs with a range of average lives (5, 7, 10, and 20 years, or 7, 10, 15, and 20 years, for example), or a pair of Z-bonds having intermediate- and long-term average lives (5- and 20-year bonds or 10- and 20-year bonds are common examples). In the case of an intermediate- and long-term average life pair, the bonds do not necessarily pay in sequence, but more typically pay down before and after intervening coupon-paying classes. Both strategies have been employed in traditional CMOs as well as in structures containing PAC bonds.

In general, multiple accrual classes in a CMO interact with the rest of the structure in the same way a single traditional Z-bond does, supporting the repayment of earlier classes, which themselves may either pay current-coupon interest or accrue it. In a series of Zs, the longer Zs lend stability to the shorter Zs, just as they would to coupon-paying bonds with earlier final maturities. Accrual from the later Zs can be used to retire earlier Zs when they become current-paying bonds, just as if they were coupon-paying bonds.

The cash flows from a sequential-pay CMO containing a series of 5-, 7-, 10-, and 20-year Zs preceded by a 2-year coupon-paying tranche are shown in Exhibit 28–10. This example was constructed using the same collateral and pricing speed as in the previous examples containing a single Z. The last tranche, 5Z, is the same size as in the previous example as well, and for this reason has the same average life at various prepayment speeds. For the sake of discussion, the first tranche is also the same size as the first tranche in the traditional CMO with a Z-bond, $136 million. As indicated in Exhibit 28–11, the large amount of accrual bonds in the structure has the effect of shortening the average life of this bond from 3 years at 165% PSA in the single Z example, to 2 years in this. (Readers will note that this example is not necessarily realistic. Structurers would be concerned to issue larger amounts of short-term average life bonds that can be sold at lower yields for greater arbitrage profits, manipulating the coupon and

EXHIBIT 28–10

Total Principal and Interest Payments of a Sequential-Pay CMO with a Series of Z-Bonds*

*Prepayments at 165% PSA.

EXHIBIT 28–11

Average Lives at Various Prepayment Speeds of the Bonds in a Sequential-Pay CMO with a Series of Z-Bonds

	Average Life (years)				
	A	**2Z**	**3Z**	**4Z**	**5Z**
75% PSA	2.5	6.6	10.1	14.0	22.9
165% PSA	2.0	5.0	7.6	10.5	18.6
425% PSA	1.4	3.1	4.5	6.0	10.3

offer price, and so forth.) Exhibit 28–11 lists the average lives of the first five classes at various prepayment speeds. In general, intermediate-term Zs demonstrate considerable stability. This is more evident when the 7- and 10-year Zs are compared to the 7- and 10-year coupon-paying bonds from earlier examples in Exhibit 28–8. The 10-year is supported by a 20-year Z, and is noticeably less variable than one in a CMO without a Z. As would be expected, given the larger amount of accrual being passed to successively shorter bonds in the current example, the 5-year Z-bond is considerably more stable than a comparable 5-year standard payer supported by a single Z. The general result is that the shorter Zs in a series of Zs are "cleaner," that is, they have progressively less average life variability than otherwise comparable coupon-paying bonds. Intermediate-term average life Zs interspersed among coupon-paying classes in a structure supported by a 20-year Z (the other common strategy) will benefit similarly. They will be more stable than otherwise, and the degree of stability will depend on the size of the Z-bond supporting them.

The consequences of multiple-Z strategies are that they produce bonds possessing relatively stable cash-flow patterns—not as stable as PACs with decent collars, but more stable than traditional sequential-pay bonds. These stable bonds also possess the partial shield against reinvestment risk that is a chief attraction of traditional Z-bonds, and they make it available in any array of expected lives, broadening the appeal of Z-bonds to investors with intermediate- rather than long-term horizons.

Tricky Zs

Another twist is the "trick" Z, in which the accrual mechanism is turned on or off under certain conditions. One such condition might be a date; for example, the rule of allocating cash flows between classes might be "accrue until such and such a date" instead of the traditional "accrue until A, B, and C tranches are retired." Or, the decision to accrue the Z-bond might depend on the amount of principal

available to make payments to the nonaccrual bonds currently paying. The use of such rules results in bonds with performance characteristics that can be very different from the Z-bonds discussed previously.

CMO issuers have tinkered with the accrual mechanism of Z-bonds to create CMO classes that alternate between paying interest and accruing interest. These special-purpose classes are structured with a set of rules that turn their accrual mechanism on or off according to certain cash-flow conditions. These accrual rules are often designed to help preceding classes meet their cash-flow schedules and/or expected maturity dates. For example, issuers included these variable-accrual bonds in CMO structures to help earlier classes meet the 5-year maturity requirement for inclusion in thrift liquidity portfolios. These benevolent Zs pay as follows: when cash flows from the mortgage collateral are insufficiently large enough to retire the liquidity bonds according to schedule, their accrual mechanisms are turned on and corresponding coupon from the collateral is applied to the earlier classes; when cash flows are sufficient to retire the liquidity bonds on schedule, their accrual mechanisms are turned off and the bonds act like standard coupon payers. Incorporating a conditional accrual rule into a bond class is an effective way to reduce extension risk on earlier classes. Of course, the extension risk is not eliminated but is instead largely transferred to the benevolent Z and other, later bond classes.

Another wrinkle is to permanently transform Z-bonds into coupon-paying bonds when certain cash-flow levels are met. An early example of this Z-bond structure was issued as the last of nine classes in FNMA 89-15. This bond was not marketed with any distinguishing label. The other bonds in the structure were a series of PACs and TACs followed by a support bond dubbed an "S" bond. The Z-bond pays as follows: any excess above the scheduled PAC and TAC payments is distributed to the Z-bond as an interest payment; if the amount is lower than the amount that was accrued, the shortfall is accrued; if the amount is greater, the excess is distributed as principal; beginning in the month following the first payment of a complete interest payment, the so-called Z class distributes interest each month. As a consequence, one month of exceptional prepayment experience could trigger the conversion to coupon bond. Thereafter, the average life would be shorter than it would otherwise have been, owing to the fact that a portion of its cash flows is dispersed over what would have been the accrual period. Any protection against reinvestment risk offered by this "chameleon" bond is ephemeral at best. Once converted, the bond behaves like any other support bond.

Even PAC Zs have been subjected to genetic alteration. The first PAC Z issued, the fifth tranche in Ryland Acceptance Corporation Four, Series 88, for example, accrued only until the date of its first scheduled payment or until non-PAC classes in the deal had been retired. Until that date, the PAC Z was the first PAC in line for excess cash flows should the support bonds be paid down, and after that date, the last in line. This meant it had greater call risk during the accrual period. As a result, its average life was only stable at or below the pricing speed.

The resultant average life volatility was more typical of a reverse TAC, which does not extend, but has considerable call risk.

Jump Zs

Another Z-bond innovation is the jump Z. Generically, the jump Z is a bullish support Z-bond that is designed to convert to a current payer and to be paid down from excess principal when prepayments accelerate. Under bullish scenarios, this bond "jumps" ahead of other bond classes in the order of priority for receiving from principal payments. Once triggered, a jump Z typically receives all excess principal (above scheduled PAC payments) until it is retired. Conceivably, holders of the jump Z could receive these payments early in the expected accrual period. This acceleration of principal can shorten the bond's average life significantly: A Z-bond issued with a 20-year average life might shorten to less than 1 year. Since these bonds typically have low coupons and are issued at significant discounts to par (in the eighties), jump Z holders realize high returns in a rally. In general, a jump Z priced at a deeper discount traded at a tighter spread, because investors assigned more value to the jump feature. Many investors purchased jump Zs to offset the negative convexity of their other mortgage securities and to enhance the performance of their mortgage-backed securities portfolios in bullish scenarios.

Jump Z-bonds have been issued with an extremely diverse set of jump rules. Although apparently lacking uniformity or standardization, these rules have the common objective of increasing the bonds' performance in bullish economic environments. Jumps can be activated by an event associated with a market rally: rising prepayment rates, declining interest rates, or increased cash-flow. However, most jump Zs were structured with prepayment triggers: The bonds shortened when prepayment rates on the underlying mortgage collateral rose above a CMO's pricing speed or some other predefined prepayment level. Generally, prepayments above the pricing speed shortened the average life of the jump Z considerably. In structures containing TAC bonds, jump Zs were often designed to shorten when prepayments exceed the speed that defines the TAC schedule. In addition to prepayment triggers, CMO issuers also structured jump Zs with interest rate triggers that were activated when Treasury yields fall below some threshold level. Interest rate triggers eliminated the need for investors to accurately forecast prepayment rates, and ensured that jump Z holders would benefit even in a market rally that was not accompanied by rising prepayments. In general, the closer the jump trigger is to actual prepayment speeds or current interest rates, the more valuable the jump Z.

Jump Z-bonds can be classified as *cumulative* or *noncumulative,* as well as "sticky" or "nonsticky." A cumulative trigger is activated when since-issuance prepayment rates, or other cumulative measures of prepayment experience, exceed some threshold value. In contrast, a noncumulative trigger only requires prepayments to satisfy the jump condition during a single period. Holders generally

prefer noncumulative triggers, since a single month of abnormally high prepayments could force early retirement of their discount security. The adjectives *stick* and *nonstick* indicate whether a jump Z-bond will revert back to its original priority in the CMO structure if jump conditions are no longer met. Once triggered, a sticky Z will continue to receive principal payments, even if prepayments subsequently decline below the threshold value. On the other hand, a nonsticky Z can revert back to an accrual bond once its jump rules are no longer satisfied. Holders generally assign the greatest value to jump Zs with noncumulative sticky triggers, because a single increase in monthly prepayment rates could force early retirement of the entire bond class. For jump Zs backed by unseasoned mortgage collateral, a tiny increase in prepayments could trigger a jump: A small increase in CPR can translate into a large PSA spike when prepayments are benchmarked off the early part of the PSA ramp.

The other common approach for creating a jump Z-bond—preceding it with a TAC and other support bonds in a PAC structure—was described earlier. The jump Z acts like a traditional support bond and absorbs volatility from both PACs and TACs. Preceded by a TAC, the jump Z receives principal when principal payments from the underlying collateral and Z accrual exceed the amount required to meet the PAC and TAC schedules. The degree to which the bond's average life will shorten depends on its jump rules and the overall deal structure. Jump rules control whether the bond jumps in front of the TAC class when payments break the TAC schedule (sticky Z) or receives only excess payments above the PAC and TAC schedules (nonsticky Z). All else being equal, the average life of a sticky Z is likely to shorten more than a comparable nonsticky Z. Preceded by PACs, TACs, and other support bonds, these jump Zs have a negligible amount of extension risk since they are typically structured as the last support class in the CMO. In addition to their jump rules, the average life variability of jump Zs is also affected by the features of their preceding PAC bonds. For example, PAC lockouts, typically 1 to 2 years in length, can accentuate the shortening of jump-Z average lives. Since no scheduled principal payments are made during a lockout, there is a much larger amount of cash-flow available to pay down a jump Z in the event it is triggered.

This simple form of jump Z (simple to visualize and analyze) does not involve any modification of the standard accrual mechanism: The Z's share of interest is added to principal payments used to pay down earlier bonds according to the schedules and order of priorities established for the deal. Some early jump Zs, however, had modified accrual mechanisms that imposed conditions under which accrual would be turned on or off. These rules can control how coupon interest is paid both before and after the bonds have jumped. Perhaps the most common example of accrual manipulation occurs with jump Zs that pay only a portion of their coupon interest and accrue the shortfall. The exact amount of interest that a jump Z will pay, after being triggered, often depends on the number and size of the support classes that the bond jumped over. For example, when preceded by both Level I and II PACs, the amount of coupon interest paid to a

jump Z-bond will depend on whether it jumps over the secondary PACs. If the jump Z remains subordinate to the Level II PACs, then part of the jump Z's coupon interest can be used to support the second-tier PACs.

KEY POINTS

- Traditional accrual bonds in a CMO structure, commonly referred to as Z-bonds, are structured so that they pay no coupon interest until they begin to pay principal.
- Z-bonds offer investors some of the longest durations and highest yields available in the derivative mortgage-backed securities market, as well as a cash-flow pattern well suited to matching long-term liabilities.
- The interaction of the Z-bond with earlier bonds in the CMO structure is a key determinant both of its own behavior and that of the other bonds in the structure.
- Numerous innovations have been introduced that provide accrual bonds with desirable investment characteristics, including greater stability or accelerated return of principal in rallies, and have widened the availability of intermediate-term Zs.

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CHAPTER
TWENTY-NINE

SUPPORT BONDS WITH SCHEDULES IN AGENCY CMO DEALS

LINDA LOWELL
Principal
OffStreet Research LLC

Collateralized mortgage obligations (CMOs) were first devised to meet two general objectives. The first was to make a better match between a wide range of investors' maturity requirements and the expected cash flows from a pool of mortgages. The second was to redistribute prepayment risk to different classes at levels that many more investors would accept. The initial solution to the problem simply split the returning principal among a series of sequential-pay bonds. Subsequently, this structure has evolved into an array of reduced-risk CMO bond structures, the most heavily issued of which is the planned amortization class (PAC). PACs provide investors with payments scheduled as to payment date and amount, occurring within a defined paydown period (window), and protected over a range of likely prepayment scenarios.

Support bonds, also known as support bonds, are the natural by-product of creating PAC bonds.[1] In order to protect the schedules of PAC bonds in a CMO issue, a sufficient amount of bond classes must be created to absorb excess principal paydowns and to provide a buffer from which scheduled payments can be made when prepayments are slow. Because support bond classes accept additional prepayment volatility, their payments are necessarily more uncertain than either PACs or traditional CMO bonds. As a result, the actual yields or economic returns realized from an investment in support bonds can vary widely from those projected at the time of investment. Investors recognize this risk, and they demand yields that compensate them accordingly.

Issuers and underwriters also have developed a variety of devices that serve either to reduce the risk of a portion of the support bond classes or to create more

1. Other structural devices intended to reduce or transform prepayment risk for some classes in a CMO issue also create support classes. The discussion here should not be presumed to apply to them. Unless clearly indicated, the terms "support" or "support bond" when used in this chapter means PAC support bond.

volatile instruments that reward holders when interest rates (and presumably prepayment rates) move strongly in a particular direction. Lockouts[2] are among the first group, while super-POs and jump Zs are typical of the second. Another very common strategy is to create support bonds with floating and inverse floating-rate coupons. One of the oldest and most extensively employed strategies, however, is to give schedules to a portion of the support bond cash flows and to provide those schedules with more limited prepayment protection than the primary PAC series receive. This family of reduced-risk support bonds is the subject of this chapter.

Support bonds having schedules partake either of the properties of targeted amortization classes (TACs)—so that they are protected against either call or extension risk (a reverse TAC) but not both—or of PAC bonds, so that they have call and extension protection over a range of prepayment scenarios (a Level II PAC). The concept of Level II PACs took hold during the third quarter of 1989. In the early 1990s, it became common to create several levels of PACs with successively narrower bands of prepayment protection, so that a single transaction could contain PAC Is, IIs, and IIIs. In addition, the practice of carving a "super-PAC" schedule out of a primary PAC schedule became popular.

The following discussion explains how support PAC and TAC bonds are structured and how their structures affect their performance in different prepayment scenarios. The effect of adding a TAC, reverse TAC, or Level II PAC on the behavior of the remaining support bonds is also explored.

SUPPORT BOND BASICS

Support bond classes are created from the principal payments remaining after the PAC schedules are defined. In general, support bond classes have second claim on excess principal paid down from the collateral after the PAC schedules, and pay sequentially until all the support bonds are retired. At the pricing prepayment assumption, support bond classes pay simultaneously with the PACs. At very slow constant prepayment rates, they must wait to receive principal until the PACs have been retired. At very high constant speeds, they pay simultaneously with the short-term average life PACs and are quickly retired, after which the PACs themselves must absorb excess paydowns and are retired ahead of schedule.

A simplified example of a standard PAC-support bond structure is depicted in Exhibit 29–1. The large unshaded area paying from the first to about the 300th month contains *all* the scheduled payments that would be available to construct PAC bonds, assuming collars of 85% and 300% PSA.[3]

2. A lockout shifts to a support bond principal payments that otherwise might be used in a PAC schedule. The effect of a lockout is to push forward the beginning of the first PAC window to a specified date and to stabilize the support bond. Lockouts are normally applied to the first PAC for a period of 2 or 3 years, lending stability to the earliest support bond class.

3. Generic current coupon collateral is assumed.

EXHIBIT 29–1

PAC with Standard Support Bonds, 165% PSA

Normally, structurers would divide this PAC region into a number of PACs with varying average lives. The actual number of PACs created would depend on the demand for particular maturities and windows (the time elapsed between first and last principal payments to the PAC bondholders). For ease of exposition, the PAC region in this and subsequent examples is not divided. The support bonds are not influenced by the partitioning of a single PAC region into individual bond classes; they are affected, instead, by the size of the entire PAC region in relation to the total size of the support bond classes. (In general, the larger the PAC class, given a fixed amount of collateral, the more volatile the support bond class is.) The principal payments left over after the PAC region is defined constitute the support bond classes. In Exhibit 29–1, these are depicted by the shaded areas. At a pricing prepayment assumption of 165% PSA, the support bonds pay sequentially over the entire remaining life of the collateral. In this example the support bond paydowns at 165% PSA have been divided into three classes with average lives of 3.1, 11.5, and 20.3 years (nominally a series of 3-, 10- and 20-year bonds).

The impact of actual prepayment experience on the size and timing of principal payments to the support bond classes is graphically depicted in Exhibits 29–2 and 29–3. When prepayments occur at a constant speed of 300% PSA (the upper PAC collar), as shown in Exhibit 29–2, the PAC schedule is not disturbed, but the support bonds shorten dramatically and are all fully retired by the 8th year.

EXHIBIT 29–2

PAC with Standard Support Bonds, 300% PSA

By contrast, when prepayments slow to 85% PSA (the lower PAC collar), the first support bond does not begin to pay until about the 8th year, as Exhibit 29–3 indicates. The resultant average life volatility is very significant. Bonds with average lives at pricing of 3, 10, and 20 years shorten to 1.0, 2.5, and 5.8 years, respectively, at 300% PSA; and at 85% PSA, the bonds have average lives of 15.0, 21.1, and 25.6 years, respectively.

EXHIBIT 29–3

PAC with Standard Support Bonds, 85% PSA

The average life variability of a support bond is generally a function of the size of the PAC region relative to the entire issue, the size of the support bond relative to the remaining support bonds, and its average life at the pricing prepayment assumption. A detailed examination of how these characteristics interact to produce the actual behavior of support bonds in different prepayment scenarios is beyond the scope of this chapter. Still, it is worth outlining the basic relationships between support bond structure and behavior because they apply as well to the more complex, schedule-based structures that are the subject of this chapter.

The order in which a support bond is scheduled to receive excess cash flows also can profoundly affect its average life behavior. It is normally assumed that support bonds will be retired in the order of their average lives at issue and that this order of priority does not change over the term of the transaction (indeed, that assumption is made throughout this discussion). This assumption, however, could be altered, generating results that are entirely specific to the transaction in question. Rather than assume that a certain order of priorities is standard, investors should assure themselves that they understand the priorities and other rules on which the structure is based, as well as the conditions under which they may be switched on or off.

There are basically three different ways to vary the relative size of the support bonds. Lockouts, already mentioned above, are typically employed to improve the stability of payments to the earliest support bond class in the issue. Moreover, with two or three years of schedulable paydowns added to its size, the first support bond can provide a larger buffer against call and extension for subsequent support bonds. A similar technique is to pay the later years or "tail" of the PAC schedule to the support bonds projected to be paying at the same time. Intermediate- or long-term support bonds can benefit from this technique. The third, tightening the collars, can increase the size of the support bonds.

Raising the bottom collar increases the principal available for support bond classes in the early years (generally the first quarter to first third of the remaining term of the collateral), and lowering the top collar increases principal in later years.

It also should be apparent that the smaller the scheduled PAC payments, the more principal will be available to make payments to support bonds at any given prepayment speed. This means that extension risk is reduced; call risk is also reduced. The smaller the PAC region, the larger the projected paydowns to the support bond in any one period and the smaller the excess principal as a proportion of the projected support bond principal payment will be. In other words, excess principal has a proportionally smaller impact on the dollar weights used to compute the support bond's average life.

For similar algebraic reasons, changing the proportion of PACs, while holding the average lives about the same, has a bigger impact on the volatility of support bonds constructed from cash flows at the tail, because smaller dollar weights are applied to later dates. The absolute magnitude of the average life at issue of a support bond also determines how much it can lengthen or shorten. This is also very intuitive: The longer the average life at issue, the less room to lengthen and the more room to shorten. Similarly, short-term bonds have less room to shorten, more to lengthen.

The shortening of a CMO bond's average life in a bull market or, conversely, its lengthening in a bear market generally are negative events from the investor's point of view. Two effects are of particular concern. For one, the additional cash-flow accelerates or decelerates at the wrong time. As a consequence of the interest rate sensitivity of the prepayment process, reinvestment opportunities are most likely to have declining yields when prepayments are increasing, and rising yields when prepayments are drying up. Second, as average life varies, so too does the bond's duration or price sensitivity. In a bull market, the bond's price appreciates more slowly as market yields decline, generating a lower economic return than a bond of like but stable average life. In a bull market, the support bond's value depreciates more quickly as yields rise.[4]

Since support bonds absorb additional volatility from the protected bonds, changes in expected average life resulting from changes in prepayment experience in the collateral are of heightened concern to investors who hold them. As crucial as an accurate model of the prepayment process is for anticipating the performance of other mortgage-related products in various interest rate scenarios, it is even more valuable in the evaluation of support bonds. Without appropriate prepayment projections, such as can be derived from an econometric prepayment model, it is not possible to link changes in interest rate levels to meaningful estimates of the yield or total rate of return of a support.

SUPPORT TAC BONDS

Since their introduction in the third quarter of 1988, support TAC bonds have proved to be a highly marketable innovation. Indeed, since the first TACs were issued, the market has evolved away from TAC-only structures to prefer support TAC bonds. Clean TAC bonds (from structures without PACs) tend to be offered less frequently.

A TAC schedule is created by projecting the principal cash flows for the collateral at a single constant prepayment speed. This speed is typically the prepayment speed at which the bonds are priced. In the case of a clean TAC, the projected principal payments define the schedule. In the case of the support bond, TAC, the TACs are constructed from projected principal remaining after scheduled PAC payments are made. The TACs have first priority after the PACs to principal payments, and their schedules are protected from call risk by the existence of other support bond classes that absorb any principal paydowns that exceed both the scheduled PAC and TAC payments in any period. The larger these "support" classes are in relation to the support TAC bond, the greater the protection provided to the TAC schedule.

4. Structurers can improve the appeal of volatile securities to some investors by manipulating the coupon so that they are priced as deep discounts to benefit from fast prepayment speeds or as high premiums to benefit from slow prepayments.

EXHIBIT 29–4

PAC with Standard Support TAC, 300% PSA

Compared to a clean TAC with similar (in the example they are the same) average life and underlying collateral, the support TAC bond necessarily receives less protection, because a larger proportion of the total collateral has already been allocated to high-priority PAC bonds, and a much smaller proportion of principal remains to be allocated to lower-priority support tranches. For this discussion, a simplified example of a support TAC bond was created from the 3-year support bond in Exhibit 29–1. This was done simply by defining a schedule as the principal payments to the 3-year support bond, assuming a constant prepayment speed of 165% PSA. Since it is identical at 165% PSA to the PAC-standard support bond example, readers should refer to the cash-flow diagram in Exhibit 29–1 to understand this structure. The impact of faster prepayments on this PAC-TAC structure is shown in Exhibit 29–4. At 300% PSA, the higher priority given the TAC schedule forces the 10- and 20-year support bonds to pay down simultaneously with the TAC (instead of sequentially as in Exhibit 29–2). Readers will note that the shape of the support TAC bond at 300% PSA is almost but not entirely identical to its shape at 165%, indicating that the schedule is still well protected at this speed. The size and timing of later payments has been altered slightly at the higher prepayment speed for reasons discussed below.

Support TAC bonds generally have the same properties as clean TACs: They provide a degree of call protection and little extension protection. Many structures actually will first extend, when prepayments slightly exceed the TAC speed, before shortening at higher speeds. The important difference is that support TAC bonds have significantly less call protection since they must absorb

EXHIBIT 29–5

Average Lives at Various Prepayment Speeds of Different 3-Year PAC-Support Bond Structures (Pricing Assumption 165% PSA)

Prepayment Speed (% PSA)	Average Life (years)			
	Clean TAC	Support Bond	Support TAC Bond	Level II PAC
0	16.7	24.7	24.7	23.3
50	8.0	19.9	19.9	16.8
85	6.0	14.9	14.9	9.5
90	5.2	13.7	13.7	3.1
125	4.0	7.2	7.2	3.1
165	**3.1**	**3.1**	**3.1**	**3.1**
225	3.1	1.6	3.1	3.1
275	3.1	1.2	3.1	2.7
300	3.1	1.0	3.2	2.5
475	3.1	0.6	1.6	1.5
600	3.1	0.5	1.2	1.1

excess principal once the remaining unscheduled support bonds are retired. This can be seen by examining Exhibit 29–5, in which the average lives of various 3-year CMO bonds at various prepayment speeds are compared. For comparison, a clean TAC with a 3.1-year average life has been constructed from the same collateral used to create the PAC-standard support bond and PAC-TAC examples. The clean TAC has unnaturally exceptional call protection (it is protected by $360 million of support bonds, which comprise the remainder of the structure). The smaller size of the clean TAC also results in its having a lower average life at very low prepayment speeds than the support TAC bond does (the clean TAC is small enough for even small paydowns at low speeds to reduce its principal balance significantly in the early years).

The more important comparison, since so few clean TACs are issued at present, is with the 3-year support bond from Exhibits 29–1, 29–2, and 29–3. The support TAC bond clearly provides meaningful call protection, requiring speeds in excess of 600% PSA before it shortens as much as the standard support bond does at 300% PSA. The two bonds extend identically. This happens because they both have the same priority after the PACs to receive principal paydowns and no support bonds in front of them (the TAC would have priority over an earlier support bond, which would protect it to a degree from extending, whereas the standard support bond would wait until earlier support bonds were retired, which would cause it to extend).

Notice that at 300% PSA, the support TAC bond's average life is about a month longer than at the pricing speed (rounding exaggerates the difference—at several

EXHIBIT 29–6

Average Lives at Various Prepayment Speeds of 20-Year Support Bond from Different CMO Structures (Pricing Assumption 165% PSA)

	Average Life (years)		
Prepayment Speed (% PSA)	**PAC Structure**	**PAC/TAC Structure**	**Layered PAC Structure**
0	27.7	27.7	27.8
50	26.8	26.8	27.0
90	25.3	25.3	25.6
125	23.3	23.4	23.3
165	**20.3**	**20.3**	**18.2**
190	18.0	18.0	12.5
225	13.6	13.1	5.1
250	10.4	9.2	3.8
275	7.4	5.7	3.1
300	4.8	2.6	2.6
475	2.0	1.0	1.3
600	1.5	0.7	1.0

more places of significance the difference is really about 0.08 year). This phenomenon occurs at relatively high speeds, since principal payments become more bunched in the early months and trail off more sharply in later months. Exhibit 29–4, as mentioned above, gives some indication of what is happening at this speed to the principal cash flows thrown off by the collateral. The paydowns become more "tailish" toward the end of the support bond's schedule, forcing it to wait as excess payments are, going into the tail, not large enough to meet the schedule.

The other great difference between PAC-TAC structures and both clean TAC and PAC-standard support bond structures is how much more volatile the unscheduled support bonds can be. The presence of additional risk-reduced structures forces the remaining support bonds to absorb more prepayment volatility. This is demonstrated in Exhibit 29–6, where various 20-year support bond structures are compared. At prepayment speeds above 225% PSA, the support bond in the PAC-TAC structure begins to shorten much more quickly than the standard support bond.

REVERSE TACs

Payment rules and priorities also can be devised that protect a support bond from extension risk while leaving it more exposed to call risk. These structures fittingly

are termed "reverse TACs." Reverse TACs are more likely to be created when bearish sentiment is strong. These structures typically are created as 20-year support bond classes. Their long lives make them natural candidates for this treatment, as they have not, in any case, more than six or maybe eight years to extend. Additionally, these structures are priced at significant discounts from par in order to benefit from increases in prepayments.

An example of a reverse TAC was created for this discussion by defining a payment schedule for the fourth tranche of the PAC-support bond structure depicted in Exhibits 29–1, 29–2, and 29–3. A cash-flow diagram for prepayments at 85% PSA is included in Exhibit 29–7. (At 165% PSA and faster speeds, the PAC-reverse TAC structure, as will be explained, pays exactly like the PAC-standard support bond, which is depicted at 165% PSA in Exhibit 29–1 and 300% PSA in Exhibit 29–3.) The schedule was run at 165% PSA, the pricing speed in all these examples, and has priority after the scheduled PAC payments are made. The reverse TAC receives excess cash-flow only after the 3- and 10-year support bonds are retired. These arrangements preserve the schedule at prepayment speeds slower than those used to generate the schedule, but not at faster speeds. The reverse TAC does not begin to extend until prepayments fall below a constant rate of about 70% PSA.

The average life volatility of the reverse TAC is compared to that of other 20-year support bond structures in Exhibit 29–8. The reverse TAC in the example has an average life of 20.3 years; in the worst case, that of no prepayments, the bond's average life only extends to 24.5 years. By comparison, the last tranche of

EXHIBIT 29–7

PAC with Reverse TAC Bond, 85% PSA

EXHIBIT 29–8

Average Lives at Various Prepayment Speeds of 20-Year Support Bonds from Different PAC-Support Structures (Pricing Assumption 165% PSA)

Prepayment Speed (% PSA)	*Average Life (years)*		
	Standard PAC	Reverse TAC	Level II PAC
0	27.7	24.5	24.6
50	26.8	20.7	20.3
85	25.6	20.3	18.1
125	23.3	20.3	18.1
165	**20.3**	**20.3**	**18.1**
190	18.0	18.0	18.1
225	13.6	13.6	18.1
250	10.4	10.4	14.7
275	7.4	7.4	8.6
300	4.8	4.8	5.8
350	3.3	3.3	3.7
475	2.0	2.0	2.2
600	1.5	1.5	1.6

the simple structure extends to 27.7 years. The cash-flow diagrams in Exhibits 29–3 and 29–7 make it clear why this is so. In the simple PAC-support bond structure (Exhibit 29–3), at a speed equal to the upper collar, the support bonds pay down sequentially after the PAC bonds are retired. In the structure with the reverse TAC (Exhibit 29–7), the 3-and 10-year support bonds extend to permit the scheduled reverse TAC payments to be met. At 85% PSA, the lower PAC collar, the short- and intermediate-term support bonds pay simultaneously with the reverse TAC. At slower prepayment speeds, the average lives of both support bonds exceed that of the reverse TAC.

The reverse TAC imparts considerably more volatility to the other support bonds when prepayments slow, but it does not cause them to be more volatile in faster prepayment scenarios. This effect can also be seen by comparing the average lives of 3-year support bonds from both structures listed in Exhibit 29–9. This is a natural consequence of the one-sided protection afforded by targeted amortization structures.

Schedules can also be applied to intermediate-term support bonds to protect their average lives from extending in slow prepayment scenarios. At the same time, the structure is "protected" from call risk in moderately fast prepayment scenarios by taking advantage of the natural tendency of TACs to extend slightly as prepayments exceed the pricing speed. The resulting average life

EXHIBIT 29–9

Average Lives at Various Prepayment Speeds of 3-Year Structured Supports from Different PAC-Support Structures (Pricing Assumption 165% PSA)

	Average Life (years)		
Prepayment Speed (% PSA)	**PAC Structure**	**PAC/ Reverse TAC Structure**	**Layered PAC Structure**
0	24.7	26.3	26.1
50	19.9	22.7	22.7
85	14.9	16.5	18.3
90	13.7	15.0	17.4
100	11.5	12.4	14.5
125	7.2	7.2	8.7
165	**3.1**	**3.1**	**3.1**
225	1.6	1.6	1.5
275	1.2	1.2	1.1
300	1.0	1.0	1.0
475	0.6	0.9	0.6
600	0.5	0.6	0.5

profile can be reasonably stable across a significant range of prepayment speeds (for example, extending no more than 2 or 3 years across a range from 50% or 75% PSA to 225% or 250% PSA, assuming a schedule run at 165% PSA). In effect, an intermediate-term support TAC bond can be constructed to provide PAC-like stability. A number of such bonds have indeed been issued, some of them with monikers indicating that the payments are stabilized or controlled.

LAYERED PAC BONDS

The value of support bond classes also can be enhanced by establishing secondary PAC schedules for a portion of the principal remaining after the primary PAC payments are met. A cash-flow diagram for an example of a two-tiered PAC structure, run at a pricing speed of 165% PSA, is shown in Exhibit 29–10. This example uses the same collateral as the previous examples. The same collars—85% to 300% PSA—were used to create the same amount of primary or Level I PACs—$233.0 million of a total original balance of $400 million CMO bonds. Collars for the second tier of PACs were set at 90% to 225% PSA. The second-tier PAC region was further divided into a series of nominally 10- and 20-year bonds and the support bonds into 3- and 20-year bonds. (In order to match the 3.1-year average lives in the previous examples, it was necessary to let the long-term

EXHIBIT 29–10

Layered PAC Structure, 165% PSA

bonds in the layered PAC example have average lives closer to 18 than to 20 years. This does not vitiate the comparison.) The Level II PACs (also called PAC 2s) appear in the figure as a narrow band between the PAC region and the support bonds: At 165% PSA they pay down simultaneously with the primary PACs in the deal. The size of the second tier of PACs is a function of the collars—the tighter the protection band, the larger the amount of PACs that can be created. In this example, protecting the Level II schedule up to 225% PSA limits the amount of 3-year Level II PACs that can be created to $5.6 million. In total, the second layer of PACs only amount to about 11% of the transaction (58.25% of the transaction is standard, Level I PACs).

The Level II PAC schedule remains intact until prepayment speeds break the primary PAC collars. For example, Exhibit 29–11 shows the principal payments at 300% PSA. At this speed, the primary PAC schedule is not violated, but payments to the Level II PACs are significantly accelerated, shortening to average lives of 2.5, 3.9, and 5.8 years, respectively. Similarly, when prepayments slow to a constant speed of 85% PSA, primary PAC payments are made on schedule, but the payments to Level II PACs are delayed. At 85% PSA, as shown in Exhibit 29–12, the support bond PACs have average lives of 9.5, 11.3, and 18.1 years, respectively. As would be expected, the longer Level II PACs are more volatile on the upside, when prepayments accelerate, and the shorter PACs are more volatile on the downside, when prepayments decelerate. The 3- and 20-year support bonds receive no principal until the Level II PACs are paid, extending their average lives to 18.3 years and 25.6 years, respectively.

EXHIBIT 29–11

Layered PAC Structure, 300% PSA

The average life volatility of Level II PACs is compared to that of support TAC bonds and 3-year standard support bonds in Exhibit 29–6. Although not as well protected as primary PACs, Level II PACs do provide modest call protection and decent extension protection. Moreover, these examples demonstrate that they can shorten and extend less vigorously than their TAC and reverse-TAC counterparts

EXHIBIT 29–12

Layered PAC Structure, 85% PSA

when prepayments move outside the appropriate protective boundary. The support bonds of layered PACs are somewhat more volatile over moderate prepayment shifts. As the comparison in Exhibit 29–8 with a 20-year standard support TAC bond and a reverse TAC suggests, the 20-year layered support TAC bond shortens faster between 165% and about 250% PSA than either of its counterparts. Similarly, Exhibit 29–9 indicates that the 3-year layered support TAC bond lengthens more abruptly than its counterparts at prepayment speeds between 165% and 50% PSA.[5]

SUMMARY OF AVERAGE LIFE VOLATILITIES

The average life volatilities of the 3-year support bond structures discussed in this chapter are summarized in Exhibit 29–13, as are those of the 20-year support bonds in Exhibit 29–14. The graphs make plain the differences in call and extension protection that can be provided by furnishing support bond classes with TAC or PAC schedules. The Level II PACs have stable average life patterns between the upper and lower collar speeds. (A Level I PAC would have a similar pattern, only it would be stable over a wider range, say 75% to 300% PSA, and owing to the presence of the support bonds, would shorten or lengthen more moderately outside that range.)

EXHIBIT 29–13

Different 3-Year CMO Support Bond Structures (Average Lives over a Range of Constant Prepayment Speeds)

Note: The average lives of the Support TAC bond and PAC Support Bond are the same between 0% and 165% PSA; the lines have been separated for readability.

5. Bear in mind that all these examples are highly simplified and furnish only a basic understanding of how the structures behave. Actual CMO issues frequently are more complex, containing other structures or variations on those discussed in this chapter. Additional complexity could result in behavior valuably different from that of these examples.

EXHIBIT 29–14

Different 20-Year CMO Support Bond Structures (Average Lives over a Range of Constant Prepayment Speeds)

Note: The average lives of the Support Bond and Reverse TAC are the same at prepayment speeds above 165% PSAs. The lines are separated for readability.

By comparison, the standard support bonds demonstrate steep and continuous changes in average life over the same ranges for which the Level II PACs are protected. The TACs, as would be expected, provide call protection, but no extension protection, while the reverse TACs are stable at slower speeds, but shorten abruptly when prepayments occur at faster constant rates than the prepayment assumption.

KEY POINTS

- Support PAC bonds having schedules partake either of the properties of TACs—so that they are protected against either call or extension risk (a reverse TAC) but not both—or of PAC bonds, so that they have call and extension protection over a range of prepayment scenarios (a Level II PAC).
- Although not as well protected as primary PACs, support PAC bonds with a schedule (also known as Level II PACs) provide modest call protection and decent extension protection.
- Level II PAC schedule remains intact until prepayment speeds break the primary PAC collars.
- Level II PACs shorten and extend less vigorously than their TAC and reverse-TAC counterparts when prepayments move outside the appropriate protective boundary. The support bonds of layered PACs are somewhat more volatile over moderate prepayment shifts.

CHAPTER
THIRTY

STRIPPED MORTGAGE-BACKED SECURITIES

CYRUS MOHEBBI, PH.D.
Managing Director
Morgan Stanley
and
Adjunct Professor
New York University

GARY LI
Senior Vice President
HSBC

TODD WHITE
Managing Director
Columbia Management Investment Advisors, LLC

DAVID KWUN
Managing Director
HSBC

In 1983, Freddie Mac launched the collateralized mortgage obligation (CMO) structure that enabled issuers to tailor-make mortgage securities according to investor coupon, maturity, and prepayment risk specifications. In July 1986, Fannie Mae introduced a new addition to the mortgage security product line—stripped mortgage-backed securities (SMBS). In this chapter we will discuss the particular investment characteristics of SMBS and how they can be used in various investment and hedging strategies by different market participants.

By redistributing all or portions of the interest and/or principal cash flows from a pool of mortgage loans to two or more SMBS classes, Fannie Mae developed a new class of mortgage securities that enabled investors to take strong market positions on expected movements in prepayment and interest rates. As the mortgage pass-through securities market matured, the number of derivative products available increased to give investors a broad range of choices to help them achieve their investment goals. In addition to straight interest-only (IO) securities, and principal-only (PO) securities, investors may now choose from a wide array of synthetic

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coupons from each strip issue. Investors are able to fine-tune their derivatives to match their desired sensitivity to interest rate, prepayment, and market risk.

SMBS are highly sensitive to changes in interest rate and prepayment speeds and tend to display asymmetric returns. SMBS certificates that are allocated all or large proportions of underlying principal cash flows tend to display very attractive *bullish* return profiles. As market rates drop and prepayments on the underlying collateral increase, the return of these SMBS will be greatly enhanced since principal cash flows will be returned earlier than expected. Conversely, SMBS that are entitled to all or a large percentage of the interest cash flows have very appealing *bearish* return characteristics since greater amounts of interest cash flows are generated when prepayments of principal decrease (typically when market rates increase).

The asymmetric returns of SMBS appeal to a broad variety of investors. SMBS can be used effectively to hedge interest rate and prepayment exposure of other types of mortgage securities, such as certain types of CMO bonds and premium-coupon mortgage pass-through securities. Combined with interest rate derivatives, SMBS is also a typical instrument for mortgage servicers to hedge the interest rate and prepayment exposure of the mortgage servicing rights. Thrift institutions and mortgage bankers often use PO securities to hedge their servicing portfolios or use IO securities as a substitute for servicing income. SMBS can also be combined with other fixed income securities such as U.S. Treasuries and mortgage securities to enhance the total return of the portfolio in varying interest rate scenarios. Insurance companies and pension funds frequently use SMBS as a method of tailoring their investment portfolio to meet the duration of liabilities and thus minimize interest rate risk. SMBS are used by various types of investors to accomplish their investment objectives. Insurance companies, pension funds, money managers, hedge funds, and other total rate of return accounts use SMBS to improve the return of their fixed income portfolios.

OVERVIEW OF THE SMBS MARKET

The SMBS market has grown substantially since the introduction of the first SMBS in July 1986. In total, an estimated $522 billion agency SMBS in 603 issues have come to market as of December 2010. Fannie Mae has been the predominant issuer of SMBS with 417 issues totaling $328 billion.

Types of SMBS

Strip securities exist in various forms. The first and earliest type of mortgage strip securities is called *synthetic-coupon pass-through securities.* Synthetic-coupon pass-through securities receive fixed proportions of the principal and interest cash-flow from a pool of underlying mortgage loans. These securities were introduced by Fannie Mae in mid-1986 through its "alphabet" strip program.

Trust IOs and Trust POs, the second and most common type of mortgage strip securities, were introduced by Fannie Mae in January 1987. IOs and POs

receive, respectively, only the interest or only the principal cash-flow from the underlying mortgage collateral. Fannie Mae (FNMA) and Freddie Mac (FHLMC) Trust IO/PO SMBS represent the major issuance and trading activities in the SMBS market. A liquid and dynamic secondary market in conjunction with the agency to-be-announced (TBA) market has been established to allow quick and frequent transactions. Benchmark bonds in the sector (large in size and most liquid issues) enhanced liquidity and investor pricing transparency.

A third type of strip security, the *CMO strips* (also called structured IOs and POs) are also popular among issuers and investors. As implied by their name, structured IOs and POs are tranches within a CMO issue that receive only principal or interest cash flows or have synthetically high coupon rates.

Development of the Agency SMBS Market

The First Mortgage Strip—FNMA SMBS "Alphabet" Strip Securities

Fannie Mae pioneered the first stripped mortgage security in July 1986 through its newly created SMBS Program. For each issue of SMBS Series A through L, Fannie Mae pooled mortgage loans that had been held in its portfolio and issued two SMBS pass-through certificates representing ownership interest in proportions of the interest and principal cash flows from the underlying mortgage loan pools. Alphabet strips were subsequently called synthetic discount- and premium-coupon securities since the coupon rate of the alphabet strip was quoted as the percentage of the total principal balance of the issue. For example, a strip that receives 75% interest and 50% principal of the cash-flow from a FNMA 10% would be a synthetic 15% coupon security since the 7.50% coupon is expressed as a 100% principal (i.e., 7.50% coupon/50% principal = 15% coupon/100% principal). By the same logic, a strip security from a FNMA 10% that receives 50% interest and 1% principal would be a 5,000% coupon security.

The FNMA SMBS Trust Program and IOs and POs

The successive and current FNMA strip program, the SMBS Trust Program begun in 1987, provided a vehicle through which deal managers (e.g., investment banks) can swap FNMA pass-through securities for FNMA SMBS Trust certificates. In the swapping process, eligible FNMA pass-through securities submitted by the deal managers are consolidated by Fannie Mae into one FNMA Megapool Trust. In return, Fannie Mae distributes to the deal manager two similarly denominated SMBS certificates evidencing ownership in the requested proportions of that FNMA Megapool Trust's principal and interest cash flows.

To date, the majority of FNMA SMBS Trusts have contained IO and PO securities. IOs and POs represent the most leveraged means of capturing the asymmetric performance characteristics of the two cash-flow components of mortgage securities. Although IOs and POs can be combined in different ratios to create synthetic-coupon securities, some investors have shown a preference for

one-certificate synthetic securities due to their bookkeeping ease. In late 1993, FNMA added another feature to its SMBS structure. In addition to IO and PO classes, FNMA SMBS Trusts contained a provision for exchanging IOs and POs for another class with a synthetic coupon. The synthetic-coupon classes that are available are determined in the prospectus supplement for each Trust and generally range from 0.5% to double the coupon on the underlying collateral in 50 basis point increments. Exchanges are executed for a small fee and may be reversed back into IO and PO components as well as into any other available combination, provided the proportions of IO and PO are correct. To promote liquidity in the SMBS market, all FNMA SMBS certificates (except FNMA SMBS Series L) have a unique conversion feature that enables like denominations of both classes of a FNMA SMBS issue or Trust to be exchanged on the book-entry system of the Federal Reserve Banks for like denominations of FNMA MBS certificates or Megapool certificates. Because of the potential for profitable arbitrages, the aggregate price of the two classes of any same FNMA issue or Trust tends to be slightly higher (the "recombo premium") than the price of comparable-coupon and remaining-term FNMA pass-through certificates.

All FNMA SMBS pass-throughs (alphabet and Trusts) have the same payment structure, payment delays, and FNMA guarantee as regular FNMA pass-throughs.

FHLMC Stripped Giant Program

Freddie Mac is also a participant in the SMBS market. In October 1989, Freddie Mac announced the Stripped Giant Mortgage Participation Certificate (PC) Program.

Freddie Mac's Stripped Giant Program is similar to Fannie Mae's swap SMBS Trust Program. Deal managers submit FHLMC PCs to Freddie Mac; in turn, Freddie Mac aggregates these PCs into Giant pools and issues Strip Giant PCs representing desired proportions of principal and interest to the deal manager. All Freddie Mac Strip PCs have the same payment structure, payment delays, and payment guarantee as regular FHLMC PCs. Like Fannie Mae SMBS, Freddie Mac Giant Strip IOs and POs have a conversion feature that allows them to be exchanged for similarly denominated FHLMC PCs. Under the Freddie Mac Gold MACS (Modifiable and Combinable Securities) program, IO and PO securities may be exchanged for synthetic-coupon classes that have been predetermined in the prospectus supplement for a fee.

Ginnie Mae Collateral for SMBS

In 1990, Freddie Mac began to issue SMBS collateralized by Ginnie Mae pass-through certificates. Since the beginning of 1990, Fannie Mae has issued 76 trusts that have had underlying GNMA collateral. Freddie Mac began to issue GNMA-backed SMBS in 1993 and has issued seven GNMA strips to date. The increased

availability of GNMA SMBS has further broadened the investor base of SMBS, enhanced the liquidity of the SMBS market, and increased the number of hedging alternatives available to GNMA investors.

PO-Collateralized CMOs

Profitable arbitrage opportunities led to the introduction of CMO securities collateralized by POs. PO-collateralized CMOs allocate the cash-flow from underlying PO securities between several CMO tranches with different maturities and prepayment patterns. The potential for profitable arbitrages with PO securities has enhanced the efficiency of the SMBS market by effectively placing a floor on the price potential of POs and a price ceiling on corresponding IOs in a given market environment.

CMO Strip Securities

Strip securities are included in CMO issues as regular-interest (nonresidual) CMO tranches. CMO strip securities that pay only principal, large proportions of interest cash flows (relative to principal cash flows), or only interest over the underlying mortgage collateral's life are termed PO securities, "higher-interest" securities, IO securities, respectively; they tend to have performance characteristics similar to SMBS. Other types of CMO strip securities receive initial and ongoing collateral principal or interest in cash flows after other classes in the CMO issue are retired or have been paid. These types of strip CMO securities are structured as PO or PAC IOs, TAC IOs, or Super-POs, and perform differently from SMBS.

INVESTMENT CHARACTERISTICS

SMBS enable investors to capture the performance characteristics of the principal or interest components of the cash flows of mortgage pass-through securities. These individual components display contrasting responses to changes in interest rates and prepayment rates. PO SMBS are bullish instruments, outperforming mortgage pass-throughs in declining interest rate environments. IO SMBS are bearish investments that can be used as a hedge against rising interest rates.

Variation of Interest and Principal Components with Prepayments

The cash flows that an MBS investor receives each month consist of principal and interest payments from a large group of homeowners. The proportion of principal and interest in the total payment varies depending on the prepayment level of the mortgage pool. Exhibits 30–1 and 30–2 illustrate these cash flows for $1 million 30-year FNMA current-coupon pass-through securities at various PSA prepayment speeds.

EXHIBIT 30–1

Principal Component of Monthly Cash Flows

Exhibit 30–1 shows the principal component of the monthly cash flows. Since the interest is proportional to the outstanding balance, the exhibit can also be viewed as showing the decline in the mortgage balance at the various prepayment speeds.

At a zero prepayment level, the interest and principal cash flows in Exhibits 30–1 and 30–2 compose a normal amortization schedule. In the earlier months of the security's life, the cash flows primarily contain interest payments. This occurs because interest payments are calculated based on the outstanding principal balance remaining on the mortgage loans at the beginning of each

EXHIBIT 30–2

Total Amount of Interest Cash Flows

month. As the mortgage loans amortize, the cash flows increasingly reflect the payment of principal. Toward the end of the security's life, principal payments make up the bulk of the cash flows.

Prepayments of principal significantly alter the principal and interest cash flows received by the investor in a mortgage pass-through security. Homeowners who prepay all or part of their mortgage loans return more principal to the investor in the earlier years of the mortgage security. All else being equal, an increase in prepayments has two effects:

1. The time remaining until return of principal is reduced as shown in Exhibit 30–1. At 100% PSA, the average life of the principal cash flows is 11.3 years, whereas at faster speeds of 200 and 300% PSA, principal is returned in average time periods of 7.6 years and 5.7 years, respectively.
2. The total amount of interest cash flows is reduced, which is shown in Exhibit 30–2. This occurs because interest payments are calculated based on the higher amount of principal outstanding at the beginning of each month, and higher prepayment levels reduce the amount of principal outstanding.

Effect of Prepayment Changes on Value

A mortgage pass-through security represents the combined value of the interest and principal cash flows. The effects of prepayments on the present value of each of these components tend to offset each other. Increases in prepayments reduce the time remaining until repayment of principal. The sooner the prepayment of principal is repaid, the higher the present value of the principal. Conversely, since increasing levels of prepayments reduce interest cash flows, the value of the interest decreases.

Thus, the interest and principal cash flows individually are much more sensitive to prepayment changes than the combined mortgage pass-through security. This is illustrated in Exhibit 30–3, which shows the present values of the principal

EXHIBIT 30–3

Present Values of Principal and Interest Components of FNMA Current-Coupon Pass-Through Security

and interest components of a FNMA current coupon pass-through security at various prepayment levels.

The greater sensitivity of IOs and POs to prepayment changes is further illustrated in Exhibit 30–4, which shows the realized yields to maturity (or internal rates of return) for a typical IO and PO and for the underlining collateral for given purchase prices. The IO and PO reflect sharply contrasting responses to prepayment changes; the IO's yield falls sharply as prepayments increase, whereas the PO's yield falls sharply as prepayments decrease. The yield of the underlining collateral is, on the other hand, relatively stable since it is assumed to be priced close to par.

Price Performance of SMBS

The preceding discussion indicates that prepayment speeds are by far the most important determinant of the value of an SMBS. Since the price response of an SMBS to interest rate changes is determined, to a large extent, by how the collateral's prepayment speed is affected by interest rate changes, we begin with a discussion of mortgage prepayment behavior.

The Prepayment S Curve

The prepayment speed of an MBS is a function of the security's characteristics (such as coupon and age), interest rates, and other economic and demographic variables. Although detailed prepayment projections generally require an econometric model, the investor can obtain some insight into the likely behavior of an SMBS by examining the spread between the collateral's gross coupon and current mortgage rates.

This spread is generally the most important variable in determining prepayment speeds. With respect to this spread, prepayment speeds have an S shape; speeds are fairly flat for discount coupons (when the spread is negative and

EXHIBIT 30–4

Realized Yields to Maturity for Typical IO and PO

EXHIBIT 30–5

Prepayment S Curve

prepayments are caused mainly by housing turnover), they start increasing when the spread becomes positive, they surge rapidly until the spread is several hundred basis points, and then they level off when the security is a high premium. At this point, there is already substantial economic incentive for mortgage holders to refinance, and further increases in the spread lead to only marginal increases in refinancing activity. This S curve is illustrated in Exhibit 30–5, which shows projected long-term prepayments for current coupon collateral for specified changes in mortgage rates.

In the remainder of this section, we make repeated reference to Exhibit 30–5, since the performance of an SMBS can be explained to a large extent by the position of its collateral on the prepayment S curve.[1]

1. However, the investor should note that not all aspects of prepayment behavior are explained by the spread between the coupon and the mortgage rate. The projected prepayments shown in Exhibit 30–5 are long-term averages. Month-to-month prepayment rates vary (for example, due to seasonality) even if mortgage rates do not change. If a substantial and sustained decline in mortgage rates occurs, then mortgage holders exposed to mortgage refinancing incentives for the first time initially exhibit a sharp increase in prepayments. This gradually decreases as the homeowners most anxious and able to refinance do so. This non-interest-rate–related decline in the prepayment speeds of premium coupons usually is referred to as "burnout." The projected speeds shown in the declining-rate scenarios are the average of the high early speeds and lower later speeds. For seasoned coupons that have experienced a heavy refinancing period, burnout implies that prepayments may be less responsive to decline in interest rates. This applies to the majority of premium coupons currently outstanding. The age effect on prepayments is well known. Prepayment speeds are low for new mortgages and increase gradually until the mortgages are two to three years old, after which the age is less important.

Projected Price Behavior

Exhibit 30–6 gives projected price paths for a current coupon IO and PO for parallel interest rate shifts.[2]

The projected price behavior of the SMBS as interest rates change can be explained largely by the prepayment S curve in Exhibit 30–5.

- As rates drop from current levels, the collateral begins to experience sharp increases in prepayment. Compounded by lower discounted rates, this causes substantial price appreciation for the PO. For the IO, however, the higher prepayments outweigh the lower discount rates and the net result is a price decline.
- If the rates drop by several hundred basis points, the collateral becomes a high-premium coupon and prepayments plateau. The rates of price appreciation of the PO and price deprecation of the IO both decrease. Eventually the IO's price starts to increase, as the effect of lower discount rates start to outweigh the effect of marginal increases in prepayments.
- If rates rise, the slower prepayments and higher discount rates combine to cause a steep drop in the price of the PO. The IO is aided initially by the slower prepayments, giving the IO negative duration, but eventually prepayments plateau on the slower side of the prepayment S curve and the IO's price begins to decrease.

Effective Duration and Convexity

Exhibit 30–7 indicates that for current or low-premium collateral, POs tend to have large, positive effective durations, whereas IOs have large, negative effective

EXHIBIT 30–6

Projected Price Paths for a Current Coupon IO and PO for Parallel Interest Rate Shifts

2. The prices are calculated to give a Libor option-adjusted spread (LOAS) of –15 basis points in all cases. A discussion of OAS analysis is given in the next section. Note that if it is also priced at an LOAS of –15 basis points, the collateral price is just the sum of the IO and PO prices.

EXHIBIT 30–7

IO and PO Effective Durations for Current or Low Coupon Collateral

durations. The effective durations in Exhibit 30–7 reflect the price paths in Exhibit 30–6:

- For the PO, as rates decline the effective duration initially increases, reflecting its rapid price appreciation as prepayments surge. Note that this is in complete contrast to traditional measures such as Macaulay or modified duration, which, reflecting the shortening of the PO, would actually decrease. As rates continue to drop, the PO's effective duration levels off and then decreases, reflecting both a leveling off of prepayments and the fact that, to calculate the effective duration, we are dividing by an increasing price. If rates increase, the PO's duration decreases but remains positive.
- For the IO, the effective duration is initially negative and decreases rapidly as rates drop, before eventually increasing and becoming positive after prepayments plateau. If rates increase, the duration increases and eventually becomes positive.

Convexity measures the rate of change of duration and is useful in indicating whether the trend in price change is likely to accelerate or decelerate. It is calculated by comparing the price change if interest rates decrease with the price change if rates increase. Exhibit 30–8 shows the convexities obtained using the projected prices in Exhibit 30–6.

Comparing Exhibits 30–6 and 30–7 shows that the convexity indicates how the duration is changing. When the duration is increasing (as in the case of the PO when rates begin to decline from the initial value), the convexity is positive, and when the duration is decreasing, the convexity is negative. For example, the IO's convexity is initially negative but begins to increase after rates fall by more than 100 basis points; although the duration is still negative at 200 basis points, the positive convexity indicates that the duration is increasing. The peak in the convexity of the IO at a change of 200 basis points indicates that the rate of increase in its duration is greatest at this point, as shown in Exhibit 30–7.

EXHIBIT 30–8

IO and PO Convexities

In summary, the prepayment S curve implies that for SMBS collateralized by

- Current or discount pass-throughs: The PO has substantial upside potential and little downside risk, whereas the converse is true for IOs.
- Low premiums: There is a somewhat comparable upside potential and downside risk.
- High premiums (including the majority of SMBS issued to date): The PO has little upside potential and significant downside risk, whereas the reverse is true for IOs.

Pricing of SMBS and Option-Adjusted Spreads

The strong dependence of SMBS cash flows on future prepayment rates, combined with the typically asymmetric response of prepayments to interest rate changes, make traditional measures of return such as yield to maturity of limited usefulness in analyzing or pricing SMBS. The most common method of pricing SMBS is with option-adjusted spreads (OAS). OAS analysis uses probabilistic methods to evaluate the security over the full-term range of interest rate paths that may occur over its term. The impact of prepayment variations on the security's cash flows is factored into the analysis. The OAS is the option-free spread over the benchmark curve (Treasury or swap curve) provided by the security. It gives a long-term average value of the security, assuming a market-neutral viewpoint on interest rates.

Exhibit 30–9 shows the use of OAS analysis for a current coupon FNMA Trust and a premium FNMA Trust and the underlining pass-through security's collateral. In each case, the price is chosen to give a Libor OAS (LOAS) of 30 basis points. Also shown are the yields-to-maturity and WAL (weighted average life).

EXHIBIT 30–9

OAS Analysis for Current Coupon and Premium FNMA Trusts

	Price	YTM	WAL	LOAS	Z-Spread	Option Cost
Current Coupon PO	74–03	5.365	6.365	30	–13	–43
Current Coupon IO	27–14	0.578	6.365	30	332	302
Collateral PT	101–23	4.134	6.365	30	72	42
	Price	**YTM**	**WAL**	**LOAS**	**Z-Spread**	**Option Cost**
Premium PO	78–10	5.592	4.989	30	–8	–38
Premium IO	25–31	0.695	4.989	30	310	280
Collateral PT	104–16	3.815	4.989	30	69	39

The OAS at a 0% volatility (the Z-Spread) when mortgage rates stay at current levels, is typically close to the standard benchmark curve spread in a flat yield-curve environment. The difference between the Z-Spread and LOAS, which we label the *option cost,* is a measure of the impact of prepayment variations on a security for the given level of interest rate volatility. The option cost, to a large extent, does not depend on the pricing level or the absolute level of prepayment projections (although it does depend on the slope, or response, of prepayment projections to interest rate changes). Hence, the option cost is a measure of the intrinsic effect of likely interest rate changes on an SMBS.

Before discussing the option cost in Exhibit 30–9, note that, in general, interest rate and prepayment variations have two effects on an MBS:

1. For any callable security, being called in a low interest rate environment typically has an adverse effect, since a dollar of principal of the security in general would be worth more than the price at which it is being returned. (An exception is a mortgage prepayment resulting from housing turnover, when the call could be uneconomic from the call holder's point of view.) To put it another way, the principal that is being returned typically has to be reinvested at yields lower than that provided by the existing security.
2. For MBS priced at a discount or a premium, changes in prepayments result in the discount or premium being received sooner or later than anticipated. This may mitigate or reinforce the call effect discussed in (1).

In general, the first effect is much more important than the second; however, for certain deep-discount securities, such as POs, the second effect may at times

outweigh the first. The net result of the two effects depends on the position of the collateral on the prepayment curve shown in Exhibit 30–5.

- The current coupon FNMA Trust, shown in Exhibit 30–9, illustrates the characteristics typical of SMBS collateralized by current or discount coupons. For discount or current-coupon collateral, prepayments are unlikely to fall significantly but could increase dramatically if there is a substantial decrease in interest rates. This asymmetry means that the PO is, on average, likely to gain significantly from variations in prepayment speeds. The option cost for the PO is usually negative; that is, the PO *gains* from interest rate volatility indicating that the benefits of faster return of principal outweigh the generic negative effects of being called in low interest rate environments. On the other hand, the underlying collateral tends to have a positive (but usually small in the case of discount collateral) option cost; the negative effect of being called when rates are low outweigh the benefits of faster return of principal. Finally, the IO typically has a large positive option cost; the asymmetric nature of likely prepayment changes, discussed in the preceding, means that the IO gains little if interest rates increase (since prepayments will not decrease significantly), whereas a substantial decline in rates is likely to lead to a surge in prepayments and a drop in interest cash flows.
- The premium FNMA Trust is representative of outstanding SMBS with premium collateral. For *premium* collateral, there is, generally speaking, potential for both increases and decreases in prepayments, and the net effect of prepayment variations will depend on the particular coupon and prevailing mortgage rates. Seasoned premiums, for example, will not have potential for substantial increases in speeds and hence, the premium Trust PO normally has a less negative option cost. The collateral has a positive option cost for the same reasons.

The importance of likely variations in prepayments makes the standard yield to maturity of very little relevance in pricing SMBS and therefore, they tend to be priced (as in Exhibit 30–9) on an OAS basis.

KEY POINTS

- Stripped mortgage-backed securities are created by redistributing all or portions of the interest and/or principal cash flows from a pool of mortgage loans to two or more SMBS classes.
- SMBS enable investors to capture the performance characteristics of the principal or interest components of the cash flows of mortgage pass-through securities. These individual components display contrasting responses to changes in interest rates and prepayment rates. PO SMBS are bullish instruments, outperforming mortgage pass-throughs in

declining interest rate environments. IO SMBS are bearish investments that can be used as a hedge against rising interest rates.

- The particular characteristics of SMBS allow users and investors to execute their selected investment or hedging strategies.
- There are various types of SMBS securities, those non-Trust IO/PO securities (such as CMO strip securities) may exhibit slightly distinct behaviors dependent on the specific deal structure.
- Traditional measures of return such as yield to maturity are of limited usefulness in analyzing or pricing SMBS because of the strong dependence of SMBS cash flows on future prepayment rates together with the typically asymmetric response of prepayments to interest rate changes OAS analysis, a probabilistic method to evaluate SMBS over the full-term range of interest rate paths that may occur over its term, is commonly used.

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CHAPTER
THIRTY-ONE

NONAGENCY RESIDENTIAL MORTGAGE-BACKED SECURITIES

DAPENG HU, PH.D., CFA
Managing Director
BlackRock Solutions

ROBERT GOLDSTEIN
Managing Director
BlackRock Solutions

Nonagency RMBS refers to residential mortgage-backed securities that are not guaranteed by government-sponsored enterprises (GSEs) or government agencies. It includes securities backed by prime jumbo, alternative-A (Alt-A), pay-option adjustable-rate mortgages (Option ARMs), subprime, second lien, and manufactured housing (MH) mortgage loans. While the category encompasses a wide range of instruments, from high-quality vanilla loans to loans at the most creative but risky end of the spectrum, these mortgages are mostly nonconforming, either larger than the agency conforming limit or not conforming to the agency underwriting standard. Each nonagency RMBS deal contains hundreds to thousands of mortgage loans. Different from agency RMBS, nonagency RMBS have both prepayment and credit risks. The cash flows of a deal are structured into various pools or tranches so that various tranches bear different risks to suit different investors. Each tranche is an RMBS bond.

Before the financial crisis, prime jumbo, Alt-A, and option ARMs were often referred to as nonagency collateralized mortgage obligations (CMO) and subprime, second lien, and manufactured housing were often referred to as

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residential asset-backed securities (ABS).[1] Nonagency CMOs used to be traded separately from subprime ABS because prepayment and interest rate risks were perceived as the dominant risks for nonagency CMOs, as opposed to credit risk for subprime, second lien, and MH. After the crises, these products are now considered as one general nonagency RMBS category as investors have realized the embedded credit risks and their significances across all of these products. This chapter refers to all these securities as nonagency RMBS.

During the housing boom, the demand for nonagency mortgages increased sharply. This was met by rapid increases in origination, innovation in creating mortgage products, and a flood of so called affordability mortgages. On the other hand, since nonagency RMBS provided slightly higher yields than agency RMBS with seemingly little additional risk, the demand for these securities was significant as investors chased yields. Furthermore, the development of ABS credit default swaps and collateralized debt obligations (CDOs) led to a surge of nonagency RMBS issuance beginning in 2005. Nonagency RMBS issuance reached its peak in 2006 with more than $1 trillion in new issuance and spreads at their tightest level. The subprime crisis and housing market meltdown substantially slowed down new issuance in 2007, and issuance ground to a halt in 2008 and 2009.

Despite the gradual price recovery since the middle of 2009, the nonagency RMBS market has remained in runoff mode. One small deal with new originations was issued in 2010, but failed to generate much traction given the new risk retention requirement, regulatory and policy uncertainties, a weak economic recovery, and general mistrust of mortgage instruments without government guarantees. Given the increasing origination volume in the prime jumbo market, we expect the securitization of prime RMBS to be reintroduced as a critical source of mortgage funding. The need for mortgages among borrowers with less-than-perfect credit may also lead to new Alt-A mortgage origination and the eventual re-emergence of the Alt-A securitization market. However, few in the industry believe that subprime or option ARM products will come back in the foreseeable future.

This chapter first provides an overview of the nonagency RMBS market, with a review of the rise, fall, and likely reincarnation of securitization. It then examines two core aspects of nonagency RMBS—collateral and capital structure. The housing market, the most important macro factor for nonagency RMBS, is also discussed. Of course any discussion of the nonagency RMBS market would be incomplete without touching on the importance of political, legal and regulatory issues as demonstrated most directly by loan modifications and the role played by the government in the housing market. Finally, it concludes with an introduction of relative value and risk analysis.

1. Subprime ABS were sometimes referred to as home equity because the residential ABS market was originally dominated by second lien home equity loans.

MARKET OVERVIEW

Here we provide an overview of the major RMBS product types, the industry structure, as well as the evolution of the market.

RMBS Product Types

Nonagency RMBS are primarily categorized by the dominant mortgage type in each deal. While it is easy to distinguish second lien, MH, and option ARM mortgages from other mortgage types, there is no clear definition for prime, Alt-A, and subprime mortgages. In general prime jumbo mortgages have higher FICO scores and loan sizes exceed the agency conforming limit at origination. The distinguishing characteristic for subprime mortgages is a low FICO score, typically below 660 with an average of 620. Characteristics of Alt-A loans fall in between those of prime jumbo and subprime. Alt-A loans may have either conforming or nonconforming loan sizes and good FICO scores. The distinguishing characteristic is that most Alt-A borrowers chose or were only able to produce limited or no documentation (i.e., income and asset verification evidence) at the time of origination.

Deal type is often identifiable from a deal's prospectus. A prospectus is an offering document that describes collateral characteristics and deal structure, and discloses the associated transaction parties (e.g., underwriters, trustees, servicers) and investment risks. Because issuers typically use different entity or "shelf" names for different product types, the shelf is often used to classify the deal type. For example, Countrywide used "Countrywide Home Loan Mortgage Pass-Through Trust" (CWHL) for its prime deals, "Countrywide Alternative Loan Trust" (CWALT) for its Alt-A and option ARM deals, and "Countrywide Asset-Backed Certificates" (CWL) for its subprime deals. Option ARM deals are sometimes classified as Alt-A because they were typically issued through the Alt-A shelves.

Very often a deal will contain a mix of collateral types. For example, a prime deal may contain a small amount of low-doc loans, a regular Alt-A deal may contain a small amount of option ARM loans, or a subprime deal may have a certain amount of second lien or MH loans. In the prime jumbo and Alt-A sectors, a deal or a bond typically contains either 100% fixed-rate mortgages or 100% hybrid (fixed for several years then floating) mortgages. In the subprime sector, however, a deal or a bond typically has a mixture of fixed and hybrid mortgages.

Industry Structure

The process of nonagency securitization involves several institutions ranging from originators to warehouse lenders to issuers to rating agencies to servicers, trustees, etc. Originators underwrite and originate mortgage loans to borrowers. Major originators include banks, mortgage companies, correspondents, and brokers. Warehouse lenders provide short-term financing to originators allowing a critical mass of loans to be accumulated for a deal. Issuers package the loans and structure them into various tranches, work with rating agencies to obtain credit

ratings, and sell the tranches in the capital markets as RMBS. Major issuers include banks, mortgage companies, real estate investment trusts (REITs), investment banks, and the like. Rating agencies analyze the collateral loss and deal structure and assign credit ratings to each tranche. They also conduct surveillance of existing bonds to determine if they are eligible for rating upgrades or downgrades. The major rating agencies are Moody's, S&P, and Fitch. Trustees administer the deals including releasing remittance reports that detail the performance of the collateral and the bonds and distributing the cash flows to investors.

Mortgage servicers play a critical role in the nonagency RMBS life cycle. They collect payments from borrowers and pass them on to trustees. Depending on the type of deal and the terms of the prospectus, the servicer will generally be responsible for advancing principal and interest payments for delinquent borrowers, provided the servicer believes that the advanced amounts are recoverable. Servicers are also responsible for collection, foreclosure, real estate-owned (REO), and liquidation efforts. Recently, servicers have also become responsible for conducting loan modifications.

During the nonagency securitization boom, several industry participants built vertically integrated securitization businesses named conduits. These businesses acquired loans, either funding them directly through brokers or through a flow program with various correspondents for ultimate securitization exit. They also typically retained the servicing rights to the purchased loans, either performing the servicing themselves or subcontracting to third-party servicers. The "traditional" conduits include names such as Wells Fargo, Countrywide, and ResCap (formerly GMAC-RFC), although, as noted earlier, conduits may also be active in retail originations. From 2004 to 2006, Wall Street dealer shelves such as BSABS/BALTA (Bear Stearns), HEAT (CSFB), and SASC (Lehman) were very active in this segment.

Evolution of Nonagency RMBS Market

Nonagency securitization started in the 1980s. During the early stages of the RMBS market's development, there was an essentially binary division in the secondary mortgage market between agency pools/deals and nonagency deals. Loans that were not agency-eligible were either retained as whole loans or put into a "nonagency deal." The gradations in credit quality and underwriting that later characterized the nonagency sector were, at that point, mostly absent. As a consequence, nonagency deals issued in the 1980s and early 1990s frequently contained a wide variety of collateral types.

In the early 1990s nonagency RMBS began to employ more systematic underwriting standards that were similar to those of the GSEs, which resulted in more homogenous credit quality among prime jumbo deals. Credit (FICO) scores began to be used in mortgage lending providing a consistent industry-wide measurement of credit risk levels. This helped instigate the shift from generic "nonagency deals" to "prime jumbo," "Alt-A," and "subprime" deals. Prime jumbo was the dominant sector while Alt-A was the smallest.

As the housing market started booming in the early 2000s, U.S. mortgage lending began to move away from its traditional roots in 30-year fixed-rate product. Various alternative affordability products emerged and expanded rapidly. Hybrid adjustable-rate mortgages (ARMs) captured a larger slice of the origination market, as did hybrid nonamortizing (i.e., interest-only) and negatively amortizing products. Before 2003, nonagency RMBS accounted for about 20% of the total U.S. RMBS new issuance market. Beginning in 2004, the nonagency market captured an increasing portion of market share from the agency sector, still dominated by prime jumbo. By 2005, securitized nonagency RMBS origination surpassed the agency origination and reached $1.2 trillion, with subprime as the largest nonagency sector followed by Alt-A.

Nonagency securitization was further fueled by the adoption of the pay-as-you-go (PAUG) structure in ABS credit default swaps (CDS) and the rapid expansion of the ABS CDO market. Traditional corporate CDS combines a credit event (typically a bankruptcy) and a physical settlement. However, Subprime ABS deals usually lack a hard or clear-cut credit event. Both principal write down (loss on principal) and interest payment shortfall (loss on interest) are incremental and reversible. In addition, credit protection used to exist through the cushion of mezzanine tranches, which was typically 5% to 10% of a deal's total capital structure or about several million dollars in size. The small size of ABS credit tranches made it very difficult for a protection buyer, other than someone who owned the tranche already, to find a reference obligation to deliver in order to make the physical settlement. These difficulties worked against the wide use of the corporate CDS template in the ABS market. In 2005 the industry adopted the pay-as-you-go structure for ABS CDS deals.[2] Under this structure, if an ABS security encounters a principal loss or an interest shortfall, the protection seller pays the protection buyer the amount of the loss or shortfall. If the security later catches up on the payment, the protection buyer returns the payment to the protection seller. This template essentially made ABS CDS work just like a cash bond, which greatly increased the liquidity of ABS CDS.

The pay-as-you-go template facilitated two key developments that ultimately became critical triggers of the financial crisis: an ability to short the market and the creation of synthetic ABS CDOs. Shortly after the adoption of pay-as-you-go ABS CDS, ABX, an index for or a basket of subprime ABS CDS, was launched. Many market participants who had not historically been active in the U.S. mortgage markets turned to the ABX indices as a way to express their views on mortgage credit. ABX prices became the market barometer of nonagency RMBS and the dominant instrument for shorting the nonagency market. The creation of synthetic ABS allowed the ABS CDO machine to roar. Synthetic ABS, as opposed to cash bonds, refers to using ABS CDS contracts to create cash flows that are similar to owning the reference bond. Before 2005 the demand for CDO

2. Pay-as-you-go was essentially adopted from the payment template of monoline insurance companies that guaranteed the timely payment of scheduled interest and principal amortization.

bonds was greater than the supply of cash assets. Synthetic ABS liberated CDO managers from the relative scarcity of cash bonds by allowing them to create tens of billions of synthetic or hybrid (mix of cash and synthetic bonds) instruments without actual mortgage origination, the most resource-intensive part of the securitization process. This greatly magnified the impact of nonagency mortgage defaults on the overall financial system.

The surge in nonagency mortgage demand directly led to the relaxation of mortgage underwriting criteria. Total combined loan-to-value ratios were increasing as borrowers were not always required to put down substantial equity in order to buy a house. Debt-to-income ratio, credit score, and documentation requirements were all loosened. Appraisal values were often inflated in order to qualify for a loan, underwriting due diligence was often compromised, and the share of affordability products (interest-only, negative amortization, etc.) increased sharply.

The consequence of loose underwriting soon became apparent as early pay defaults (EPDs, refer to delinquency within the first few payment periods) ramped up sharply in newly issued 2006 subprime deals. At the same time, the housing market started to weaken and home sales slowed. This accelerated the 2006 vintage delinquency rates as many borrowers did not have any equity buffer. As delinquency levels continued to rise rapidly beyond EPD in late 2006, it became clear that 2006 vintage was seriously challenged from credit perspective and market prices for associated bonds started to fall.

By early 2007 as the housing market showed no signs of a soft landing and both subprime and Alt-A delinquency rates accelerated monthly, the capital markets started to penalize all RMBS prices and many leveraged investors had to deleverage in order to meet margin calls. This triggered a vicious cycle:

decreased valuations → deleveraging → further valuation decreases → more deleveraging

As a consequence, the demand for new issuance vanished and many originators either went out of business or ceased production. By the end of 2007, almost all nonagency originations had stopped. Nonagency securitization ground to a halt and RMBS spreads widened dramatically. Through the vicious cycle and thanks to the large exposures to ABS CDS and CDO, the credit problem in the nonagency RMBS market quickly transferred to turmoil in the entire credit market.

It is also worth noting the interplay of the capital markets turmoil and deterioration in fundamentals. The liquidity freeze in the capital markets led to a stop in nonagency mortgage origination, which in turn shut off refinancing channels for nonagency mortgage borrowers. Often prepayment and default "compete" because a borrower will look for opportunities to refinance into lower monthly payments or to sell the house before ultimately defaulting. The lack of prepayment opportunities led to a further increase in defaults. At the same time, the credit crunch and liquidity squeeze further froze the housing market and put more downward pressure on home sales and price movements. The deterioration in the housing market further fueled worsening of mortgage credit fundamentals.

A downward spiral unfolded as banks started to mark-to-market their balance sheet assets. The mounting nonagency mortgage related credit losses not only led to huge write downs to bank balance sheets, it also dramatically increased the capital reserve requirements for these large institutions, which further worsened market liquidity. Because many banks and large financial institutions were the major issuers and holders of RMBS, ABS CDS, and CDO assets, the mortgage credit meltdown eventually led to the downfall of large institutions including Bear Stearns, Washington Mutual, Lehman Brothers, AIG, Fannie Mae, and Freddie Mac.

Since late 2008, the nonagency sector has been in runoff mode with very little new issuance. Asset valuation hit a rock bottom in March 2009 and has since been in recovery. CDO liquidation and bank sales provided supply of existing bonds to the market. As of the end of 2010, there are $1.46 trillion nonagency RMBS outstanding, with about $432 billion of Alt-A, $395 billion of subprime, $318 billion of Prime, $158 billion of Option ARM, and $156 billion of second lien. 2006 and 2005 are the two largest vintages, followed by 2007 as a distant third.

During the crisis, the vast majority of AAA bonds experienced rating downgrades, including 99% of Option ARM, 97% of Alt-A, 94% of subprime, and 85% of prime bonds. Many were downgraded from AAA to below investment grade. Only a small amount of outstanding nonagency RMBS remain above investment grade at the end of 2010. As shown in Exhibit 31–1, most 2005, 2006, and 2007 vintage bonds are below investment grade. While most seasoned bonds (2004 and earlier) remain investment grade, the number of bonds and remaining balances in these vintages are small.

Since early 2010, re-securitization has emerged as a meaningful mechanism to help absorb and repackage the universe of nonagency RMBS. Re-securitizations, also known as re-REMICs, place nonagency RMBS bonds into a trust that then issues a senior and a junior bond to investors. Recent re-REMICs were primarily created using bonds that were AAA at issuance. They have utilized a simple structure in which the senior bonds receive all of the principal cash flows until they are paid off while all of the losses are first absorbed by the junior bonds. The presence

EXHIBIT 31–1

Percentage of Investment Grade Bonds within Each Vintage, Notional Balance Weighted, as of December 2010

Vintage	Prime	Alt-A	Option ARM	Subprime
2003	98	93.9	79.4	88.6
2004	92.4	81.8	61.4	81.8
2005	58.4	22.9	24.2	48.4
2006	18.3	4.4	7	13.3
2007	7.8	4	5.9	13

Sources: Moody's, S&P, Fitch, and BlackRock Solutions.

of junior bonds provides the senior bonds a greater credit enhancement than available on the underlying bonds individually; hence, the senior bonds can obtain AAA ratings to meet investor needs. One other benefit of these transactions is that they provide capital relief by allowing new AAA bonds to be created and retained while selling a smaller quantity of lower-rated bonds. Another attempt to revive the nonagency market is the introduction of PrimeX indices in April 2010. PrimeX allow investors to synthetically gain exposure to a basket of prime jumbo RMBS deals via CDS. Since inception, they have been traded fairly actively and have facilitated the trading of existing prime bonds.[3]

The basic elements of securitization—aggregation and subdivision of mortgage pools—has been an important housing finance channel. In spite of the considerable stress in securitization in 2007–2010, we expect nonagency RMBS will undergo structural and regulatory reforms and return to a more stable level.

COLLATERAL

Collateral analysis is a key component of relative value analysis for nonagency RMBS. Here we provide an overall review of the major characteristics of nonagency mortgages, their performance, and major issues in analyzing the collateral for nonagency RMBS deals.

Collateral Characteristics

Different products, vintages, and deals each have different characteristics. These characteristics, together with the macroeconomic environment, drive different prepayment and credit performance. Exhibit 31–2 provides the average characteristics of prime, Alt-A, option ARM, subprime, and second lien collateral.

Fixed versus Hybrid

Hybrid borrowers are typically more leveraged than fixed-rate borrowers. In addition the rate reset can cause substantial payment shocks under an increasing rate environment. Therefore, hybrid loans tend to have worse credit performance. In terms of prepayments, hybrids are also very different from fixed-rate mortgages. Before the crisis, hybrid mortgages prepaid faster than fixed-rate products. Now, with the higher perceived credit risks, hybrid prepayments are substantially slower than fixed prepayments. While hybrids are 40% of prime collateral, they represent 75% of subprime collateral. Unlike prime or Alt-A hybrids, subprime hybrids are dominated by short-reset products such as 2/28 and 3/27. While most prime or Alt-A hybrids reset every 12 months and the rate can go either up or down and is subject to caps and floors, most subprime hybrids reset every 6 months and the rate can only reset up.

3. See Dapeng Hu and Kishore Yalamanchili, "PrimeX—A Roadmap for Investors," *American Securitization* 4, 3 (August 2010), pp 19–21.

EXHIBIT 31–2

The Average Characteristics by Mortgage Type

loan_program	%HYBRID	% 2006 and 2007 vintages	Orig Combined LTV	% PIGGYBACK	FICO	FICO < 680	FULL_ DOC	DTI	AOLS	% IO	ST of FL,CA,NV, AZ	ST of MI,OH,IN
Prime	39.6	14.3	71	9.9	735	11.7	64	33	411962	27.3	52.5	2.5
Alt-A	50.4	35.7	80	31.3	711	27.1	29.2	37	258933	50	52.6	2.6
POA	100	46.1	77	24.6	708	28.1	15.5	35	388488	#N/A	74.6	1.4
Subprime	75.6	25.1	84	17.8	622	83.1	61.6	41	169911	15.2	42.3	5.8
2nd-Lien	8.5	36.9	96	100	680	51	52.1	40	48575	9.2	46.8	4.1

Data sources: LoanPerformance and BlackRock Solutions.

Vintage

Vintage refers to the origination year. Because lenders' underwriting standards change over time, loans originated in different years tend to have different credit quality. Differences persist across measurable characteristics and, more importantly, in characteristics that are not observable to investors, such as appraisal quality, underwriting exceptions, real occupancy, possibility of fraud, etc. Within this decade, 2002 and 2003 vintages are considered the best while 2006 and 2007 vintages are generally thought of as the worst. Besides being subject to looser underwriting standards, 2006 and 2007 vintages also suffered the greatest home price depreciation since they were originated at the peak of the housing market.

Loan-to-Value Ratio

The loan-to-value ratio (LTV) is the most important factor for mortgage credit performance. There are several LTV measurements. Original LTV is the loan amount to house value ratio at origination. Original combined LTV includes second liens at origination in the loan amount. Current LTV refers to the current loan amount to current house value ratio and current combined LTV measures the current total loan amount including second liens to the current house value. A high original combined LTV not only represents high leverage, but often indicates that the home price was aggressive for the borrower given income. Current combined LTV measures how little equity the borrower currently has in the house. When the LTV is higher than 100%, the borrower has "negative equity." Their mortgages are higher than the value of the underlying home.

If the original LTV is greater than 80%, lenders typically require borrowers to buy mortgage insurance. Borrowers often avoided buying insurance with an 80% LTV on the first loan while simultaneously getting a second loan. This is referred to as a "piggyback." As shown in Exhibit 31–3, there are a substantially large amount of piggybacks in Alt-A, option ARM and subprime loans as of year-end 2010. Mortgage brokers would often work with borrowers to obtain both loans simultaneously from the same lender.

High combined LTVs lead to high delinquency and default rates. When a borrower has negative equity, the default option is in-the-money and the so-called rational default rate increases substantially. High LTVs cause high loss severities when a loan defaults. In addition, high LTV loans also prepay slower because it is difficult for the borrower to obtain a new loan.

Another problem was "silent seconds," or second or third liens that were originated after the first lien. During the housing boom from 2004 to 2007, many borrowers took equity out of their houses by borrowing through a home equity loan (HEL) or home equity line of credit (HELOC) outside of the existing first or second lien. This substantially increases leverage and default risk, but neither the first lien holders nor the servicers would necessarily be aware of these loans (hence the name "silent"). Only recently has data on "silent seconds" been made available through credit bureau reports. Exhibit 31–3 shows how severe the

EXHIBIT 31–3

Current Combined LTV and Presence of Silent Seconds as of December 31, 2010

	Prime	Alt-A	Option ARM	Subprime
Current Combined LTV	87	108	131	115
Current Combined LTV from TU	101	125	155	123
% 1st mortgages with silent 2nds (TUC LTV > LPC LTV)	30%	30%	36%	26%

Note: Silent seconds are defined as current combined LTV from TU higher than current combined LTV reported to investors in LP data.
Sources: TransUnion, LoanPerformance, and BlackRock Solutions.

problem is—36% of option ARMs, 30% of prime and Alt-A loans, and 26% of subprime loans have at least one silent second in addition the first lien and the simultaneous piggyback.

Credit Score

The mortgage industry started using credit scores in the late 1990s. The most commonly used credit score is the FICO score, which is generated by independent credit bureaus for each individual using empirical models created by Fair Isaac Corporation (FICO). Scores range from 350 to 900 with a higher score indicating better credit quality. In mortgage origination, FICO is the most important variable to determine if a borrower is prime, subprime, or Alt-A. The average FICO is 735 for prime borrowers, but 620 for subprime borrowers. The percentage of low FICO borrowers is much higher in subprime deals.

FICO scores help predict credit and prepayment performance, even though the FICO reported in nonagency RMBS data is the FICO at origination. Borrowers with higher FICO scores tend to have better credit performance. Since many alternative products and loose underwriting standards existed during the housing boom, low FICO scores did not hurt a borrower's ability to refinance. However, after the financial crises with subprime and Alt-A originations absent, FICO score became such a critical criteria to refinance that it is currently extremely challenging to obtain a new loan with a FICO score below 660.

Debt-to-Income Ratio and Documentation

The debt-to-income ratio (DTI) is a measure of a borrower's ability to pay the loan. There are commonly two DTI ratios in mortgage underwriting, front-end and back-end. Front-end DTI is the ratio of the housing payment (including mortgage payment and escrow) to gross income, also known as housing ratio. Back-end DTI adds all other financial debt and child support to the numerator.

As shown in Exhibit 31–2, prime originations typically require a low DTI, whereas subprime originations tolerated a higher DTI. As an ability to pay measurement, a high DTI indicates a high payment risk.

Lenders often require various documents as proof of a borrower's income and assets. In general, full documentation involves verification of income (W-2, pay stubs, etc.) and assets (bank statements, brokerage statements, etc.). The definition of limited documentation, also known as "low doc," varies greatly from lender to lender and includes stated income, stated assets, no income, and verified assets. A small number of loans were even originated with no documentation. Low documentation requirements used to be prevalent for special borrowers such as a small business owner who has difficulty obtaining regular income documentation. However, it became often used to qualify borrowers who overstate their income in order to qualify for a loan ("liar loans").

A key feature of Alt-A and option ARM products is the large percentage of loans with limited or no documentation. Without having to fully document one's income, many Alt-A borrowers grossly overstated their income levels in order to qualify for a loan. From 2005 to 2007, the documentation standards were substantially relaxed and even many full documentation loans can have considerably inflated incomes.

As a consequence of the various documentation standards, the historical relationship between credit performance and DTI is not clear.

Geography

Geography is another important aspect in analyzing nonagency mortgages. First, the local economy and local housing market can have a material impact on mortgage credit performance. For example, the rust belt states (Ohio, Michigan, and Indiana) have higher default rates because of the distressed local economy and job market. Secondly, differences in state laws and the judicial system can have very large impact on mortgage performance. When a loan is delinquent, the foreclosure process is governed by state law. Judicial states, for example Florida, require a foreclosure case to be presented in court and ruled by a judge, which results in a much longer liquidation timeline than that of non-judicial states such as California. In addition different states may have different requirements on legal documents in a foreclosure case. The impact of the recent foreclosure documentation issue, in which state courts found that many banks failed to submit proper documentation including record of title and deed transfers in some foreclosure cases, varies from state to state.

Negative Amortization and Recast

For option ARM loans, additional risks come from negative amortization and recast payment shock. Since option ARM borrowers have the right to pay a minimum payment, which is typically well below the interest payment, there can be an increase in principal balance, that is, negative amortization. Negative amortization increases the loan-to-value ratio further stretching a borrower's ability to pay.

When an option ARM reaches the earlier of its negative amortization limit or a predetermined time (typically the end of the fifth year), the loan will recast. When a loan recasts it starts to amortize down the outstanding balance at full index rate within the remaining term of the loan. The entire outstanding balance will be amortized (usually close at the original balance if not higher) over a shorter term, so the recast payment shock can be quite high, often 40% or higher.

Other

In addition to the above risk factors there are several other factors that affect mortgage performance. These factors include loan size, loan purpose (purchase, refinancing, or cash-out), occupancy (owner-occupied, second home, or investment property), amortization versus interest-only, property type (single house, planned urban development, condo, co-op, town house, and so on) and prepayment penalty (commonly in subprime and option ARM products and mainly impacts prepayments).

Risk Layering

Each of the individual factors described above can have a negative impact on mortgage performance. When layered together, risks increase exponentially. During the 2005 to 2006 peak of loose underwriting standards, many subprime and Alt-A lenders provided interest-only (IO) mortgages with no down payment. Other common layered risks include high LTV with low documentation and high LTV with high DTI. These loans are extremely sensitive to small declines in home prices because they quickly result in both negative equity and higher future payments.

Collateral Performance

Key measurements of collateral performance include delinquency, default, voluntary prepayment, and loss severity. Additionally, the roll rate or transition metrics provide important indicators for near term future performance. A roll rate is the rate at which previously current or delinquent loans are "rolling" into another status. A transition matrix is a combination of roll rates for each status.

There are two standards of measuring a borrower's contractual delinquency status: the Mortgage Bankers Association (MBA) standard and the Office of Thrift Supervision (OTS) standard. The difference between the two has to do with the presence or absence of a grace period on the receipt of payment. In the MBA method, which is used in the prime market, there is no grace period. In the OTS method, which is used in the subprime market, there is a one day grace period on the receipt of the payment that effectively lowers the reported delinquency by one full month, as compared with the MBA method. Obviously the MBA standard is more stringent than the OTS standard. The reporting for Alt-A deals is mixed but most deals follow the MBA standard in trigger definitions.

There is no standard definition for default but a commonly used one is liquidation, that is, when a previous delinquent loan is liquidated through short sale, foreclosure sale or REO sale, the remaining balance of the loan is counted as default balance.[4] A short sale is a sale of the underlying property in which the sale proceeds fall short of the remaining balance of the loan. It occurs when a servicer decides that selling the property short is better than going through a costly foreclosure process. Foreclosure is a process in which a mortgagee (or other lien holder) obtains a legal termination of the mortgagor's (borrower) equitable right to redeem the property.[5] There are two types of foreclosure sales. Judicial foreclosure, which is available in every state and required in many judicial states, involves the sale of the mortgaged property under the supervision of a court. Nonjudicial foreclosure is authorized by many states if a power of sales clause is included in the mortgage or if a deed of trust with such a clause was used instead of an actual mortgage. After a mortgage is foreclosed, the property becomes REO.

The four panels in Exhibit 31–4 show the historical performance across major products. Voluntary prepayment speeds have been declining substantially for all products. This is a consequence of increasing delinquency rates, higher current LTVs, and tightened underwriting standards. Subprime and option ARM prepayments are grounded around 0 as there is no new origination in these products. Subprime delinquency rose sharply from 2006 and peaked in 2009. Defaults peaked in 2010 and have been slowing down as loan modification requirements and foreclosure documentation issues substantially extended foreclosure timeframes. Loss severity increased greatly from the lows of 2006 and reached a plateau in 2009. Severities continue to remain at elevated levels.

Credit Burnout

After delinquency reached its peak in 2009, subprime mortgage performance started to show signs of improvement. The stabilization can be partially attributed to credit burnout. There are two mechanisms for credit burnout. In a pool of loans, the loans with the worst credit quality will become delinquent and exit the pool leaving loans with better credit quality remaining in the pool. After flushing out the weakest borrowers from the pool through defaults, the performance of a pool of loans improves because the remaining loans are of better credit quality. Another mechanism is at the loan level. If a high LTV loan is underwater for a long period but the borrower continues to pay, the chance of the borrower becoming delinquent tends to decrease.

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4. In the case of principal forgiveness, the forgiven part of principal is counted as default balance as well. There is no standard yet for forbearance treatment.
5. The legal process and documentation requirements of foreclosure are complicated and vary from state to state. For an overview of the recent foreclosure documentation issue, see "Transfer and Assignment of Residential Mortgage Loans in the Secondary Mortgage Market." *American Securitization Forum White Paper* (November 2010).

Credit burnout can be observed through declines in the first time delinquency rate. As shown in Exhibit 31–5, the new delinquency rate reached its peak at the end of 2008 and started to decline in 2009. The trend is quite clear for subprime, Alt-A, and option ARM collateral. Credit burnout was less pronounced in prime jumbo collateral as the elevated unemployment levels had a bigger impact on prime jumbo delinquency.

Servicing Concerns

Collateral performance varies greatly among servicers. While this is partly due to the collateral type and characteristics, differences in servicer behavior have

EXHIBIT 31–4

Historical Performance across Major Products

a. Voluntary Prepayments

b. Defaults

(Continued)

EXHIBIT 31–4

Historical Performance across Major Products *(Continued)*

c. Delinquencies

d. Loss Severity

Sources: LoanPerformance and BlackRock Solutions.

EXHIBIT 31–5

First Time Delinquency Rates since 2008

Data sources: LoanPerformance and BlackRock Solutions.

attracted a lot of attention in the industry. Servicer variations are observed in many aspects of deal performance, including liquidation timelines, stop-advance rates, utilization of short sales, and loan modifications.

Some servicers are more aggressive and are more efficient in liquidating distressed properties and as a consequence, the liquidation timeline (time from a loan becoming delinquent to default to liquidation) is much shorter for these servicers. Investors prefer shorter timelines as the recovery can happen earlier and loss severity tends to be lower.

Service Advance and Stop Advance

In most nonagency bonds, the servicer is required to advance delinquent principal and interest (P&I) to the trustee to the extent that it is deemed recoverable. Most RMBS transactions permit the servicer to be reimbursed for advances at the top of the trust payment waterfall.

Recent high delinquency rates and increased foreclosure and REO timelines are causing liquidity challenges for many servicers that are advancing into RMBS. Additionally, the cost of servicing a delinquent loan has been increasing and in some cases a servicer may not be able to recover all of its costs from the liquidation proceeds. Consequently, there is an increasing trend for servicers to stop advances.

There are also large servicer variations as can be seen in Exhibit 31–6. Servicers with difficult financing are more likely to stop advances. On the other hand, servicers within large banks tend to have a lower stop-advance rate. Servicers that push for more short sales also have lower stop-advance rates.

Stop-advance creates a large uncertainty to deal cash-flow. It can extend the life of senior bonds substantially. On the other hand, stop-advance can also reduce loss severity. The impact of stop advance on loss severity comes from savings on advanced interest payments. The more months that the servicer stops advancing, the fewer payments that will be deducted from the liquidation proceeds and therefore the severity will be lower.

EXHIBIT 31–6

Stop-Advance Rates by Servicer

Data sources: LoanPerformance and BlackRock Solutions.

CAPITAL STRUCTURE

Nonagency RMBS deals are structured to manage the two principal risks inherent in residential mortgages: prepayment and credit. The structure separates aggregated cash flows from the underlying loans into principal and interest and redistributes the cash flows and associated losses to individual tranches (bonds) according to rules specified in the deal prospectus (this is known as the waterfall).

From prepayment point of view, many nonagency RMBS work similarly to agency CMOs. They manage prepayment exposure and average life variability through time-tranching the cash flows, that is, each senior tranche has a different expected maturity and expected time window for principal repayment. Actual maturities will vary based upon realized prepayments, but are marketed based upon assumed prepayment speeds. One complication is that in nonagency RMBS the recovery from a credit default is treated as prepayment.

Many senior classes of RMBS deals also include specialty tranches providing additional exposure or protection to mitigate prepayment risk. Some of these include planned amortization classes (PAC) and companion (support) bonds, nonaccelerating senior bonds (NAS), interest only (IO), inverse IO (IIO), and principal only (PO). These are often created based upon specific investors preferences. In general, they make up a small percentage of total RMBS issuance, but it is important to carefully examine each tranche for cash-flow timing. Because these classes are analogous to those in an agency CMO, we are not going to cover them in this chapter. For a discussion of these bond types see Chapter 26.

Credit risks in nonagency RMBS deals were addressed through credit enhancements: external, internal through deal structure, or both. Credit enhancement levels are established to reasonably insulate senior bond investors from the risk of losses. In practice, issuers structure deals to maximize the issuance of AAA bonds since this maximizes the total deal proceeds. Deals that are backed by loans of high credit quality require less subordination than deals that are backed by loans of low credit quality.

External credit enhancements, primarily bond insurance, were commonly used at the early stages of nonagency securitization. Since the early 2000s, internal credit enhancements through deal structuring became the dominant method.

There are two major internal credit enhancement structures, senior/subordination (senior/sub) and over-collateralization/excess spread (OC/XS). For deals with lesser credit concerns, for example most prime jumbo deals, credit support relies entirely on redirecting losses to lower tranches. A deal typically has AAA-rated senior classes and subordinate tranches rated from AA to B. The prepaid principal is allocated to the senior tranches first and is then allocated down the deal structure while the losses are absorbed from the bottom up. This is the known as the senior/subordination shifting interest structure. For collateral with more credit loss concerns, such as subprime, additional layers of support were often added to the senior/sub structure through extra collateral principal and/or interest.

This is the OC/XS structure. Alt-A deals and early deals are more likely to have the senior/sub structure while deals originated after 2004 increasingly utilized the OC/XS structure.

Fixed versus Floating Coupon

While deals backed by ARM collateral (hybrid and option ARM) are mostly floating coupon bonds, deals backed by fixed-rate mortgages can have both fixed and floating coupon bonds. While the underlying collateral is fixed, floating-rate bonds can be created by creating an inverse IO tranche in which the coupon is inversely correlated to the underlying index. Almost all residential ABS (subprime, HEL, and MH) and option ARM bonds have floating coupons. Prime and Alt-A deals can have both fixed-rate and floating-rate bonds.

Sequential versus Pro-Rata Payment

Sequential and pro-rata refer to the method of distributing payments across the classes in the deal. For sequential structures, the senior classes are paid principal first until they are paid-in-full, then the next senior tranche is paid, and so on. Pro-rata refers to making payments proportional to each tranche's unpaid principal balance. For senior tranches with the same seniority, principal payments can be sequential or pro-rata, but losses are mostly pro-rata. Sometimes there are further hierarchies in AAA classes, with senior support bonds receiving losses before super senior bonds.

Lockout Period

Subordinate bonds are locked out of receiving prepayments for a period of time after deal settlement. The lockout periods for prime and Alt-A deals are typically 5 to 10 years while lockout periods for subprime deals are almost always 36 months. At the end of the lockout period, if the collateral performance meets or exceeds minimum credit conditions known as trigger tests, prepayments can flow into junior classes.

Triggers

To ensure that the credit support is still intact during the period when deals are most likely to experience losses, many deals contain a series of trigger tests to place limits on the amount and timing of any release of credit support (i.e., repayment of principal to the owners of the OC and/or subordinate bonds). The most common trigger is a delinquency test, which allows credit support to be reduced only if the 60+ day delinquency rate is low in relation to the current senior credit enhancement level, expressed as a percentage of the current outstanding balances. Other trigger tests include the factor test, requiring that the pool be paid down by at least half (i.e., the pool factor must be at or below 50%), the credit support level test which requires that the senior credit support level (in percentage terms) has at least doubled, and the cumulative loss trigger test, which limits principal payments to the OC and/or subordinate bonds if cumulative losses exceed some target level.

Linear or Y-Structure versus H-Structure

A deal can have one or several collateral groups. The linear structure is the most straightforward as it only has one collateral group and the cash flows from the single collateral group are distributed to all bonds. The Y-structure is a slight variation of the linear structure. In this structure, all of the subs and mezzanines receive cash flows from all collateral groups. At the AAA level, however, the collateral is divided into two groups by loan size–conforming balance and jumbo balance. Each AAA bond receives payments from only one of these two groups. The separation was intended to provide convenience for the GSEs to buy the conforming-size bonds. In the H-structure, there are two (or more) sets of mezzanine tranches and collateral groups and each mezzanine tranche is supported by each collateral group respectively. Each set of mezzanine tranches supports its own senior tranches. There is often cross-collateralization between groups in H-structure deals.

Cross-Collateralization

For H-structure deals, a deal typically contains multiple loan groups. After interest payments are made to bonds in one group, available funds from that group can be used to pay interest to bonds from another group. Among other things, this feature can also affect the value of residuals. For example, a deal with two loan groups would generally have two residuals. If the Group 1 OC was fully funded and the triggers passed, funds would be available to be released to the Group 1 residual. However, if the subordinates were cross-collateralized, which is normally the case, and the Group 2 OC was not fully funded, those Group 1 funds would be diverted to the Group 2 OC.

Clean-Up Call Provision

Before turning to the details of each type of structure, there is a final provision that is very common to nonagency RMBS deals, similar to agency CMOs—the clean up call. The clean up call gives the owner of that call, who is generally the residual holder, the option to purchase the remaining bonds at a prespecified price, usually at par plus accrued interest, when the factor is at or below a certain threshold, which is in most cases 10%. The main purpose of the clean-up call provision is to minimize the administration cost, but it also adds additional risk to senior bond or IO holders. A deal is more likely to get called if the collateral is clean with premium coupons and less likely to get called if it is distressed. When exercised, the call shortens the payment window and the average life of the back-end tranches. If the clean up call is not exercised when the factor is below the threshold, there is typically a *step-up in coupon* provision, which requires a moderate increase in coupon for the bonds that still are alive.

Senior/Subordination Shifting Interest Structure

Senior/Sub is the most direct approach to generate credit enhancement for senior tranches. In this structure, the senior classes (AAA-rated) typically have

six supporting classes (AA, A, BBB, BB, B, and unrated), hence the name *six-pack*. The AA, A, and BBB classes are called the mezzanines as they are still investment grade; and the BB, B, and unrated residual classes are often referred to as *subs*. There is a lockout period at the early age of the deal when all of the unscheduled principal payments are allocated to the senior tranches and the subordinate bonds are locked out from receiving prepayments. The losses are absorbed from the bottom up, starting from the unrated piece, which is often called the *first loss* piece. At the end of the lockout period, if triggers are passed, the subordination will start to receive prepayments pro-rata.

Exhibit 31–7 illustrates the capital structure of a prime jumbo fixed-rate RMBS deal. In this deal, 96.1% of the total collateral was designed as senior AAA tranches (excluding the IO which is nominal based). Those tranches were supported by 3.1% of mezzanine tranches and 0.8% subs.

EXHIBIT 31–7

Illustration of the Shift Interest Structure RFMSI–2005 S8

Note: Original rating and credit support are in the parentheses.
Sources: Intex and BlackRock Solutions.

There is one IO tranche that receives interest based on all of the deal collateral balance. IO tranches are present in most six-pack structure deals. Although it is not the case in this deal, sometimes IO tranches are used to manage the differences between collateral interest payments and bond interest liabilities (essentially the excess spread).

When prepayments are received before the lockout period (in this case, five years), they first go to senior tranches. Prepaid principal only flows down to mezzanines and subs after the lockout expires and trigger tests are passed. Within the senior tranches, A1 and A2 are sequential so that A2 will not get any principal until A1 is paid off. A3 is a nonaccelerating fixed pay bond which receives only a fixed interest strip in the first five years and then amortizes down on a fixed schedule (hence the name). PO and A1 are pro-rata for all principal payments.

After the lockout period, if the shift-interest trigger test, measured by delinquency rate, is passed prepayments will also start flowing to the mezzanines and then to the subs. If at any point the trigger test fails, all of the unscheduled principal will be redirected back to the senior bonds.

It is important to note that in shifting interest structures, mezzanines and subs are receiving scheduled principal payments (and scheduled interest) during the lockout period. This is different from typical OC/XS structures. In the case of very slow prepayment speeds, as seen in many fixed-rate Alt-A deals today, this amortization can help shorten the WAL of mezzanine tranches substantially in senior/sub deals compared with that in OC/XS deals.

Losses will be absorbed first by the B3 class and then from the bottom up to other subs and the mezzanines subsequently. If losses penetrate all the way through M1, they will be distributed to all the senior tranches (A1, A2, A3, and PO) pro-rata. Note how thin (i.e., small size) these credit cushion classes are. It is not surprising to see the entire sub or mezzanine classes get wiped out. (In fact in this deal, the M3 and below classes have been wiped out and the M2, and even the M1 classes are on the way out as well.)

The shifting interest structure was designed mainly to deal with prepayment risk for senior bond holders. Obviously if losses come in much higher than the support level, senior bonds will suffer significant principal write down because of the thin enhancement. Higher expected losses led to rating downgrades, which put further downward pressure on prices. This is exactly what happened to many prime AAA bonds during 2009.

Overcollateralization and Excess Spread

When collateral credit loss becomes a large concern, issuers typically use the OC/XS structure to add presumably extra layers of protection. Most subprime deals and a large number of option ARM and Alt-A deals use this structure. Given credit pressures, some 2007 prime jumbo deals also adopted this structure.

OC/XS also uses the senior, mezzanine, and subordinate framework, but it adds extra collateral so that the collateral balance backing the deal is larger than

the balance of its bonds. In addition, the note rates of subprime or Alt-A mortgages are typically high allowing collateral WAC (weight average coupon) to be higher than the WAC of the underlying bonds. As a consequence, there can be extra interest payments (excess spread) each month.

OC Target

There is a predetermined OC target, for example 2% of deal collateral, before the step-down date. At the inception of a deal, OC can be anywhere from 0 to the target (OC fully funded). If OC is not fully funded at inception, excess spread (after covering losses) will be used to build up OC. Because defaults typically don't begin until after several months, very often OC could be built up within a year. When OC is at its target, excess spread will go to the residual holder. For deals with fully funded OC at inception, there is typically a NIM (net interest margin) class to receive excess spread. NIM tranches are often owned by residual holders. After the lockout period ends (step-down date) and trigger tests are passed, OC is allowed to be released or step-down gradually into either the NIM or residual holder, on the condition that senior bonds have predetermined levels of support. If triggers fail, the OC step-down can be stopped or it can step-up.

In terms of the order of absorbing losses, XS spread is the first line of defense, OC is the second, and the traditional subordinate tranches provide the final protection before losses reach senior tranches.

Step-Down

The step-down date refers to the time when junior bonds can start to receive principal and the OC can start to be released. It is typically the later of 36 months and the date at which the senior credit enhancement doubles the original CE or reaches a predetermined level.

In addition to the credit enhancement requirement for step-down, there are also many collateral performance trigger tests to control the direction of cash flows starting at the step-down date. Delinquency and cumulative loss triggers are quite common. These triggers are designed mainly according to rating agencies' rating requirements.

Available funds cap risk and interest hedge: Most OC/XS deals pay floating rates to their bonds. The bond coupon is linked to a market index, for example one-month LIBOR + 20 bps. The coupon is typically capped at an available funds cap (AFC). The cap is often the weighted average rate of interest received from the collateral group backing the bond. Subordinate bonds typically pay a higher coupon than senior bonds, so the AFC would hit subordinates first. The major source of AFC risk comes from the mismatch between index movements and mortgage WAC changes. For example, a large movement in one-month LIBOR before the underlying mortgages reset would substantially increase the AFC risk. A large portion of low coupon fixed-rate mortgages in the collateral mix also increases the AFC risk. Large WAC dispersion among underlying mortgages can also result in AFC risk when higher coupon mortgages exit the pool more quickly

than lower coupon mortgages. AFC risk is often hedged directly in the deal using interest derivatives such as a cap or a swap.

Exhibit 31–8 illustrates a sample subprime deal with OC/XS capital structure. 75.15% of this deal was structured as senior bonds with two collateral groups (the A1 group has a conforming balance for the GSEs' convenience), 19.65% mezzanine, 2.3% subordinate, and 2.9% OC fully funded at origination. PEN is the NIM tranche which also receives prepayment penalties and there is a swap as an interest rate hedge. The deal settled in May 2006 and the step-down date was scheduled for June 2009.

Within the AAA classes, the A1 is paid from group 1 and A2A, A2B, A2C, and A2D are paid from group 2. All junior classes are paid by both collateral groups. Bonds A2A, A2B, A2C, and A2D are sequential in terms of receiving principal. However, the principal payments will switch to pro-rata if sub tranches

EXHIBIT 31–8

Sample Subprime Deal Capital Structure, GSAMP 2006-HE3, as of June 2006

Tranche	Collateral Group	Coupon	Coupon (Libor +)	Tranche Size as % of Deal	Orig CE	Orig Rating
A1	1	5.47	0.15	19.07%	24.85%	AAA
A2A	2	5.37	0.05	32.41%	24.85%	AAA
A2B	2	5.42	0.1	11.03%	24.85%	AAA
A2C	2	5.48	0.16	9.52%	24.85%	AAA
A2D	2	5.57	0.25	3.11%	24.85%	AAA
M1	0	5.6	0.28	3.95%	20.90%	AAA
M2	0	5.62	0.3	3.70%	17.20%	AA+
M3	0	5.66	0.34	2.25%	14.95%	AA+
M4	0	5.67	0.35	2.00%	12.95%	AA
M5	0	5.7	0.38	1.85%	11.10%	AA–
M6	0	5.79	0.47	1.70%	9.40%	A+
M7	0	6.2	0.88	1.60%	7.80%	A
M8	0	6.42	1.1	1.40%	6.40%	A–
M9	0	7.19	1.87	1.20%	5.20%	BBB+
B1	0	7.82	2.5	1.20%	4.00%	NA
B2	0	7.82	2.5	1.10%	2.90%	NA
PEN	0	0				NA
OC	0	0		2.90%		NA
SWAP	0	5.32				NA

Note: Group 0 represents all collaterals in the deal. B1, B2, and PEN were not offered. There are also three noneconomic residual certificates R, RC, and RX, which do not receive distribution from the trust except the initial distribution on the first distribution date.
Sources: Intex and BlackRock Solutions.

are extinguished through credit losses. The equivalent credit enhancement levels are misleading. Because of the sequential pay structure among the four bonds, slow prepayments can extend the life of these bonds substantially. Today the front pay A2A bond is paid off, but the lives of A2B, A2C, and A2D have all been extended. With the current very slow prepayment environment, the last pay A2D can have a weighted average life (WAL) of 20 years. If the M1 gets written down before that, it is very likely that the A2D will suffer the highest principal loss.

Different from a six-pack deal, junior bonds in OC deals do not receive any principal until the step-down date and performance triggers are passed. The mezzanine bonds can only start to receive principal after the deal step-down and once senior classes have been paid off. None of the junior tranches of this deal have received any principal since inception. In fact, the OC, M6, M5, to M4 have all been wiped out by losses. It is very likely that all of the mezzanine bonds will also be written down.

Compared with six-pack deals, the OC/XS structure is much more complicated. There are also more trigger events, which can make a bond's cash flows extremely volatile because small changes in performance can trigger large swings in the cash-flow waterfall and have a major impact on a bond's valuation. This substantially increased the uncertainty of future cash flows and made it very difficult to properly analyze these deals. Even though the triggers were set according to the rating agencies' requirements, all senior bonds were downgraded many notches.

External Credit Enhancements

External credit enhancements are third-party guarantees that provide for loss protection against losses up to a specified amount. Typically external credit enhancements include pool insurance, letters of credit, bond insurance, and reserve funds.

Pool insurance is lender paid mortgage insurance at the pool level covering bankruptcy cram-down related losses, losses due to fraud in origination, or losses due to special hazards not covered by homeowner insurance. Letter of credit (LOC) is a financial guarantee by the issuing bank. LOC was one of the oldest forms of credit enhancement and has been rarely used in recent years. Reserve funds are straight deposits of cash generated from issuance proceeds. The fund typically invests in money market instruments. While reserve funds are common in auto and other consumer ABS deals, they are less frequently used in nonagency RMBS deals.

Bond insurance is a financial guarantee for the timely payments of principal and interest if these payments cannot be obtained from the cash flows of the underlying collateral. Bond insurance, also known as monoline wrappers, was provided mainly by monoline insurance companies. The major primary insurers included Municipal Bond Insurance Corporation (MBIA), Ambac Assurance Corporation, Financial Guaranty Insurance Corporation (FGIC), and Financial Security Assurances (FSA). The main reinsurers are ACE Guaranty Re, AXA Re Finance, Enhance Re, and RAM Re.

Bond insurance covers implied write downs as well. An implied write down occurs when a trustee is prohibited from writing down a bond by the deal documentation and there is a discrepancy between the remaining collateral balance and the bond principal balance. In order to correct this discrepancy and realize the losses more quickly, wrappers typically recognize an implied write down as a credit event, which will decrease the reference obligation notional amount even though the bond principal balance remains unaffected. This works the same way as CDS.

Unlike internal credit enhancements, external enhancements are simple and reduce overall credit risk. However, it introduces counterparty risk. During the financial crisis, the monoline insurers suffered a large amount of losses. Some of them are currently in bankruptcy or under serious financial stress and as a result, many bond protections were rescinded. The values of monoline wrappers have dropped substantially and some are even valued at or near zero.

HOUSING MARKET

The housing market is the single most important macroeconomic driver in the nonagency market. Price appreciation and home sales volume are two critical measures of the housing condition. Exhibit 31–9 shows home price appreciation (HPA) and existing home sales (EHS) in the U.S. since the late 1980s. The housing market had experienced rapid growth since the early 2000s, with 10%+ annualized HPA. HPA was, in most cases, accompanied by sharp increases in home sales. In these years, EHS increased from 6% to almost 9%. As a result of the housing market boom, many lenders and investors neglected mortgage credit risks, which in turn greatly stimulated the nonagency RMBS market.

However, this growth was followed by the greatest housing bust in American postwar history as home sales slowed down in mid-2006 and prices started to decline. The decline in 2006 was relatively mild and many people were expecting a soft landing. By early 2007 it was clear that this was wishful thinking, and a downward spiral began. Similar to the nonagency crash, the housing market bust also consisted of several vicious cycles. Due to declining home prices, many potential buyers held off on purchases and this substantially slowed down home sales. The lower demand pushed prices down even further. Additionally, declining prices triggered increases in delinquency, which further increased the distressed housing supply, which dragged down overall prices even further. At the same time, the liquidity crunch put huge pressure on the housing market as many borrowers could not get a mortgage. Therefore, the weakened housing market further deepened the financial crisis.

The housing market reached its worst point in early 2009 with a –18% year-over-year HPA nationwide. Case-Shiller HPI declined by 32% from the peak of Q2 2006 to Q1 2009, while existing home sales declined from its peak value of 9% in Q1 2005 to 5.2% in Q2 2009 (see Exhibit 31–9).

EXHIBIT 31–9

Annualized House Price Appreciation and Percent of Existing Home Sales in the United States since Late 1980s

Sources: Fiserv Case-Shiller, National Associations of Realtors, and BlackRock Solutions.

The housing market started to rebound in mid-2009, driven largely by pent-up demand, the Federal housing tax credit, a low interest rate environment, and credit becoming re-accessible. Home sales activities increased substantially and prices were on the rise. However, after the tax credit expired, excess demand was quickly exhausted. Momentum disappeared and home sales slowed down substantially yet again.

A significant problem in the housing market is the overhang of millions of distressed properties, including those in REO, in foreclosure, and with loans in serious delinquency. With this large shadow inventory it will take a long time for prices to recover. Loan modifications and foreclosure moratoriums slowed down the pace of distressed property flooding the market, which helped to reduce near-term housing pressure. However, these mechanisms also prolonged the liquidation timeline and resulted in a longer housing overhang and a slower recovery.

Geographic Segmentation

The home price index and existing home sales indices reveal a clear geographic segmentation within the overall housing market. Exhibit 31–10 shows Case-Shiller HPI for U.S. Census Geographic Divisions and U.S. aggregate HPI. Geographic segmentation is observed on each level—for states within each census division, metropolitan statistical areas (MSAs) within each state, and zip codes within each MSA.

Geographic segmentation within the housing market makes it extremely important to understand the geographic distribution of nonagency collateral. Loans with the same original LTV but from different geographic segments will have very different mark-to-market LTVs. Future home price appreciation will

EXHIBIT 31–10

Housing Price Index in Selected Census Track

Sources: Fiserv Case-Shiller and BlackRock Solutions.

also be different. It is worth noting that historically the correlation among geographic segments is relatively small, which gives MBS the benefit of diversification. However, the correlation during the crisis tends to be much larger, leading to substantial fat-tail risk.

Variation among Property Tiers

There is also observed segmentation of the housing market based on home values, that is, price tiers. Fiserv Case-Shiller provides HPI on different price tiers. All sales are divided into three groups: high price, medium price, and low price, so that proportions of each tier in total sales are equal. A home price index is then constructed for homes in each pricing tier. Depending on the state, each tier experienced different home price appreciation and consequent depreciation paths. For example, in California, low price homes appreciated the fastest, growing by 230% from Q1 2000 to the peak of Q2 2006, while high price homes during the same period appreciated only by 115%. Consequently, the current drop from peak values is –58% for low price homes and only –31% for high price homes (Exhibit 31–11). However, in other states, like Colorado, all three tiers experienced the same modest home appreciation and consequent depreciation from peak values.

The difference between the high-end and the low-end of the market has large implication on nonagency RMBS relative values. The prime jumbo sector, for example is mainly backed by high-end properties. Home price depreciation is less pronounced for prime jumbo mortgages, which partially contributed to the relatively low delinquency rate in that sector—the prime jumbo

EXHIBIT 31–11

California Case-Shiller HPI by Price Tiers

Data sources: Fiserv Case-Shiller and BlackRock Solutions.

delinquency rate is even lower than that of agency mortgages. However, the lack of financing in the jumbo mortgage market is much more serious than in the conforming market.

MORTGAGE MODIFICATION

Although loan modifications were always available to servicers as a loss mitigation tool, they had never been widely applied before the crisis. As mortgage delinquencies worsened in 2007, the government started asking mortgage servicers to increase their loan modification efforts to try to keep people in their homes. Several guidelines or programs were created by various government agencies. Many failed due to lack of practical clarity, lack of servicer incentive, and lack of mechanisms to prevent corresponding moral hazards. In 2009 the government introduced the Home Affordable Modification Program (HAMP). HAMP set forth a standard model to determine the net present value of modifications and provided monetary incentives for servicers to participate. HAMP was implemented by most servicers. By the end of 2010, there were about 1.2 million loans modified through the HAMP program.

There are several types of modifications. The most common approach is recapitalization in which the accrued interest on a past due loan is rolled into the principal. Sometimes this is accompanied by a term increase, but more often a recapitalization results in an increased monthly payment. A more effective type of modification involves reducing the interest rate of the mortgage, which can reduce the borrower's monthly payment without an immediate principal loss to investors. Principal forgiveness and forbearance are more extreme

approaches, but the most direct to address the negative equity issue that borrowers are facing. Under principal forgiveness the borrower does not owe the remaining balance on the original loan, which leads to a direct loss to the trust. With principal forbearance the remaining balance is due as a balloon payment at maturity.

Under most pool servicing agreements, servicers can modify a borrower's mortgage if they feel that it will benefit the trust through higher recovery or more timely payments. Some deal documents will specify limitations on modifications but for the most part it is up to the discretion of the servicer. Furthermore, servicers can also use HAMP as a safe harbor. If expected default and loss severity levels are high without modification, then modifying loans can actually lead to more cash flowing to the trust. However for a high risk loan, the re-default risk also tends to be high if modified. So it is largely up to servicers' discretion on which loan to modify and how many loans to modify.

The number and type of modifications in nonagency RMBS has changed substantially over time as government programs were developed and altered. While the total number of modifications was greater in the first half of 2009, most of the modifications offered borrowers a recapitalization only or a very modest interest rate reduction. Over time the total number of modifications has decreased, but the share that use principal reduction has increased from 20% at the beginning of 2009 to 35% by the end of 2010 while the share of recapitalization has declined substantially. There have not been as many modifications in Alt-A collateral, but generally the pattern is similar to what is observed in subprime modifications. The number of modifications in option ARM has been relatively small but the majority type is principal forgiveness or forbearance. Prime jumbo modifications are not as common.

Recidivism

Recidivism, or re-default after a modification, is a challenge to modification policy. Exhibit 31–12 shows the delinquency rate post modification for subprime mortgages modified in 2009. Early in 2009, when recapitalizations were the most common type of modification, delinquency rates were very high, surpassing 60%. After HAMP was implemented, in the second half of 2009, delinquency rates fell due to the greater use of interest rate and principal modifications. Principal modifications are particularly effective in the case of negative equity. Reducing the loan principal so that the balance owed is in line with the value of the property reduces the incentive for a borrower to default.

Valuation Impact

The impact of modification for bond investors depends on the type of bond, where it is in the capital structure and current price levels. Exhibit 31–13 shows the impact of applying a stylized modification scenario to several bonds in the ABX.

EXHIBIT 31–12

Observed Delinquency Rate for Modified Subprime Loans

Sources: LoanPerformance, BlackRock Solutions.

The scenario assumes that 10% of loans receive principal and rate modifications, 25% receive a rate only modification and the remaining 65% are not modified. Principal reduction is set to 20% and the rate reduction is 5%. The results in Exhibit 31–13 demonstrate that this scenario does not materially change the cumulative loss to the bonds, but delays defaults thereby extending the bonds and lowering implied yields.

RELATIVE VALUE AND RISK ANALYSIS

Here we introduce the analytical framework for relative value and risk analysis. Prepayment and credit models and roll rate analysis are commonly used in this framework.

Analytical Framework

As described, collateral, capital structure, the housing market, and loan modifications are all important aspects to analyzing nonagency RMBS bonds. To combine all of these factors, investors need an analytical framework similar to the one described in Exhibit 31–14. The primary components of this framework include collateral data, macro assumptions, performance projection models, and cash-flow engines.

Key Risk Metrics

In addition to the standard valuation and risk measurements such as yield, weighted average life (WAL), discount margin, option-adjusted spread (OAS),

EXHIBIT 31–13

Impact of Modification Projections

				With Modifications			Without Modifications		
CUSIP	Deal Name	ABX Series	Price	WAL	Yield	Cum. Loss	WAL	Yield	Cum. Loss
03072SU78	AMSI 05-R11-A2C	2006-1 Pen-AAA	92.92	0.84	9.70	19.85	1.02	8.04	20.78
03072SU86	AMSI 05-R11-A2D	2006-1 AAA	67.47	3.41	13.05	19.85	4.08	11.00	20.78
36244KAD7	GSAMP 06-HE3-A2C	2006-2 Pen-AAA	55.91	3.08	23.19	37.72	5.12	17.16	37.95
36244KAE5	GSAMP 06-HE3-A2D	2006-2 AAA	38.00	11.05	10.50	37.72	12.95	10.62	37.95
61750FAE0	MSAC_06-HE6-A2C	2007-1 Pen-AAA	37.03	10.22	21.95	47.15	11.69	17.04	47.02
61750FAF7	MSAC_06-HE6-A2D	2007-1 AAA	34.53	12.15	17.33	47.15	13.43	14.44	47.02

Source: BlackRock Solutions.

EXHIBIT 31–14

Nonagency Analytical Framework

Source: BlackRock Solutions.

option-adjusted duration (OAD), option-adjusted convexity (OAC). The following metrics are widely used in the nonagency industry.

1. *Cumulative loss:* realized principal loss plus future expected loss divided by original balance of the deal
2. *Remaining loss:* future expected loss divided by current balance of the deal
3. *Principal write down:* principal loss for the bond
4. *Interest shortfall:* interest distributed is less than the amount of interest accrued
5. *Coverage ratio:* measured by the ratio of remaining loss of a deal collateral to credit enhancement of a bond within the deal
6. *Break-even multiplier:* an intensity multiplier that when applied to a model, the projected remaining loss will equal to the credit enhancement to a bond

Prepayment and Credit Models

Prepayment and credit models help project collateral future performance, including conditional prepayment rate (CPR), conditional default rate (CDR), delinquency, and loss severity for each collateral group within a deal. The models typically use historical data to establish relationships of prepayment and credit performance to

EXHIBIT 31–15

Sample Transition Matrix of Alt-A Deal

	Weight	CC	CD	DQ30	DQ60	DQ90	Fcl	REO	Prepay	Default
CC	54.2%	97.4%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%
CD	12.2%	4.3%	86.4%	9.0%	0.1%	0.1%	0.0%	0.0%	0.2%	0.0%
DQ30	4.5%	0.0%	21.5%	48.0%	30.0%	0.3%	0.0%	0.0%	0.2%	0.0%
DQ60	2.4%	0.0%	5.4%	9.7%	39.0%	44.1%	1.4%	0.0%	0.3%	0.1%
DQ90	11.2%	0.0%	3.4%	0.6%	1.1%	83.6%	10.2%	0.5%	0.0%	0.7%
Fc	12.8%	0.0%	1.0%	0.1%	0.0%	3.9%	90.7%	2.9%	0.0%	1.3%
REO	2.7%	0.0%	0.0%	0.0%	0.0%	0.1%	0.6%	85.5%	0.0%	13.8%

Note: CC is currently clean with no delinquency history in the past 12 months; CD refers to a loan that is current but with some delinquency history in the past 12 months.
Sources: LoanPerformance and BlackRock Solutions.

loan characteristics, current loan status, and macroeconomic environments. For example, a delinquency model can be a function of seasoning, FICO, LTV, DTI, documentation, state, etc. The delinquency to foreclosure roll rate can be a function of current LTV, state judicial law, the housing market condition, etc.

The purpose of prepayment and credit models is to project future cash flows under various rate, home price, or other scenarios. Given the empirical natural of these models and the ever-changing market dynamics, it is critical to keep the model updated. As we learned from the mortgage crisis, history does not simply repeat itself. Therefore, a model should never be about purely fitting history. A good model uses historical data to learn about borrower behavior under various environments and puts less emphasis on historical fit, but focuses more on forward looking capabilities; it is really a mix of science and art.

All models require some assumptions. Some are explicit, for example, the future HPA assumption, whereas others are more implicit, for example, the prepayment model may assume that a prepayment channel is always available. It is very important for investors to understand each assumption within the model.

Roll Rate Analysis

Roll rate analysis is a simple but intuitive way to analyze a bond's performance and can be quite accurate in forecasting near term performance. This approach only requires the deal's transition matrix, which can be obtained using recent historical data. Exhibit 31–15 is a sample transition matrix. Given the transition matrix, one can compute the prepayment and default rates for each delinquency status bucket.

The disadvantage of roll rate analysis is that it ignores the underlying economic drivers. For example, it has to assume the roll rates stay the same going forward, which is inconsistent with the natural selection phenomenon many loan pools exhibit over time. If the macroeconomic environment changes the roll rates are unlikely to stay constant.

KEY POINTS

- Nonagency RMBS are not guaranteed by GSEs or government agencies and include securities backed by prime jumbo, Alt-A, option ARMs, subprime, second lien, and manufactured housing mortgage loans.
- The two principal risks inherent in a pool of residential mortgages that nonagency RMBS deals are structured to manage are prepayment risk and credit risk. The structure separates aggregated cash flows from the underlying loans into principal and interest and redistributes the cash flows and associated losses to individual tranches according to rules specified in the deal waterfall.

- Collateral characteristics and capital structure are the two key aspects of nonagency RMBS relative value and risk analysis. Servicers can play a large role in determining the collateral cash-flow.
- Key measurements of collateral performance include delinquency, default, voluntary prepayment, and loss severity.
- Credit risks in nonagency RMBS deals were addressed through credit enhancements: external, internal through deal structure, or a combination of the two.
- The housing market is the key fundamental determinant of nonagency mortgage performance.
- Loan modifications, foreclosure moratoriums, and servicer stop-advancing have created significant uncertainty to deal cash flows and present challenges for investors valuing and assessing risk for these bonds.
- Prepayment and credit models help project collateral future performance.

CHAPTER
THIRTY-TWO

COMMERCIAL MORTGAGE-BACKED SECURITIES

WAYNE M. FITZGERALD II
Managing Director
BlackRock

MARK D. PALTROWITZ
Managing Director
BlackRock

Commercial mortgage-backed securities (CMBS) are structured products that provide debt financing to the commercial mortgage market. CMBS are a component of commercial real estate finance (commercial banks, insurance companies, and pension funds also make direct loans to owners of commercial real estate).

As with residential mortgage-backed securities (RMBS) products, CMBS represent economic interests in pools of mortgage loans. The structure used to create CMBS transfers the credit risk of the underlying commercial real estate loans to the owners of CMBS. Certificate subordination increasingly mitigates the commercial mortgage loan credit risk for certificate holders. CMBS certificate structures apply losses to the most junior outstanding certificates and, depending on the levels of subordination, offer substantial credit risk protection to the holders of the most senior certificates.

CMBS investors should understand the fundamentals of commercial real estate valuations and commercial real estate lending standards to properly analyze the credit risk embedded in CMBS investments. The loans underlying CMBS transactions are typically much larger than loans found in other securitized products. The largest 15 loans in a CMBS transaction can comprise 30% to 50% of a collateral pool. This loan concentration makes asset-level reviews much more important than other securitized products in which the law of large numbers allows effective statistical sampling. Key differences between CMBS and nonagency RMBS are enumerated in Exhibit 32–1.

CMBS issuers have developed several types of transactions. *Conduit transactions* are securitizations of fixed-rate commercial mortgage loans in which no loan comprises more than 5% of a transaction and the largest 10 loans

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EXHIBIT 32–1

Comparison of Key Attributes of CMBS Transactions and Nonagency RMBS Transactions

Attributes	CMBS	Nonagency RMBS
Collateral Composition	Larger-sized loans with fewer loans in the trust—underlying collateral is more heterogeneous. Higher concentration risk with top 15 loans comprising 30%–50% of the transaction.	Large number of loans in a transaction. Loans are small in size and individual loans represent a small portion of the transaction. Given large number of loans, collateral is fairly well-diversified.
Loan Types	Shorter-term loans, with 5-, 7-, or 10-year balloon maturities. Most loans are fixed-rate.	15- to 30-year fixed-rate and floating-rate loans.
Prepayment	Mortgage loans typically prohibit prepayment until a few months prior to the maturity date.	Many mortgage loans are freely prepayable.
Transaction Structure	Transactions typically pay principal sequentially, credit enhancement is in the form of subordination only, and losses are allocated in reverse-sequential order.	Wide range of principal, interest, and loss cash-flow distribution rules, in addition to triggers and multiple forms of credit enhancements such as over-collateralization, subordination, excess spread, reserve accounts, and external credit guarantees.
Modeling	Modeling typically involves detailed loan- and asset-level review, given loan concentrations. Deterministic rules-based default modeling is commonly used due to lack of rich historical loan performance dataset.	Probabilistic modeling of prepayments, defaults, and severities is fairly common with models built on large historical loan-level performance datasets.

comprise less than 30% of the transaction. *Fusion transactions* are typically fixed-rate securitizations in which the 10 largest loans comprise more than 30% of the transaction. Issuers created single-sponsor transactions for sizeable debt offerings for large owners of commercial real estate. CMBS issuers have created floating-rate transactions typically comprised of large loans on transitional properties (i.e., under construction/renovation, undergoing a repositioning). These loans were usually for one or two years with several one-year extensions. Finally, CMBS issuers will bring "single sponsor" transactions to market when

large institutional borrowers seek mortgage loans in amounts that justify a separate CMBS transaction.

The majority of CMBS transactions are considered Fusion transactions. Given the lumpy nature of the collateral concentrations in Fusion transactions, CMBS investors (regardless of credit support) typically perform due diligence on the largest loans to understand whether the mortgage loan originator used a prudent valuation and sized the loan appropriately.

THE COLLATERAL POOL

Because most CMBS transactions have large loans that comprise significant portions of the overall trust, investors typically perform a review of the underlying mortgage loans and mortgaged properties to understand the idiosyncratic credit risks of the investment.

Summary of Valuation Techniques for Underlying Mortgage Properties

Typically, office, retail, industrial, hospitality, and multifamily properties serve as collateral for the underlying mortgage loans. Office, retail, industrial, and hospitality properties constitute "commercial" properties, whereas multifamily properties typically have more than four units available for lease. Commercial real estate values are typically computed by using the direct capitalization method, a discounted cash-flow analysis, the comparables method, or the replacement cost method. The direct capitalization method utilizes a *capitalization rate* (cap rate), which is the unleveraged yield associated with the current income from a commercial property. The direct capitalization method determines property value by using the following formula:

$$\text{Property Value} = \text{Net Operating Income}/\text{Cap Rate}$$

Cap rates are based on many factors and include an interest rate component. Multifamily properties have typically garnered the lowest average cap rates due to availability of debt financing from the government-sponsored enterprises (GSEs) as well as the ability to reset rents on a frequent basis due to short-lease terms. Hospitality properties generally average the highest cap rates due to the volatility of the net operating income associated with the hospitality and travel/leisure industries. Investors value office, retail, and industrial properties with average cap rates between the multifamily and hospitality benchmarks. The direct capitalization method is useful to CMBS investors because the data inputs are typically available from dealers, such that the analysis is based on a standardized data-set.

The *discounted cash-flow analysis* (DCF analysis) is a more precise method of commercial real estate valuation that discounts the property's net operating income through time using the weighted average cost of capital as a discount rate. Commercial real estate equity investors utilize a DCF analysis when purchasing commercial real estate properties; however, CMBS investors typically do not have the required inputs (i.e., cash-flow forecast) to use this valuation technique.

The comparables method attempts to determine commercial real estate values by determining a property's value based on the actual sales of similar properties in the same area. This approach is effective at finding a market value if similar properties traded in the recent past. When marketing CMBS investments, dealers often verbally disclose comparables for the properties securing the largest mortgage loans within a transaction. Property values are distilled to a value/square foot (SF) or unit. As an example, Midtown Manhattan Class A (high-quality) office buildings can trade at $800 to $1200/SF, whereas suburban office buildings in secondary markets can trade at $100/SF. Although dealers make comparable information available during the offering of a CMBS transaction, updated information is not made available through transaction reporting.

The replacement cost approach values real estate by computing the value of the underlying land and the cost associated with constructing the property's improvements less depreciation. This method is not used extensively in commercial real estate valuation as it does not take into account the property's income stream. The appraiser is also required to determine the value of land using the comparables method—given that land sales in highly developed areas are rare, valuations based on this approach would require significant assumptions.

The classic guideline for commercial real estate valuation has not changed in the modern era: Location is essential to determining real estate values. A CMBS investor should appreciate and consider the bespoke nature of commercial real estate properties and their values to properly model the commercial real estate debt exposures in a CMBS transaction.

Commercial Mortgage Lending Standards

As with most hard assets of reasonable credit quality, owners of commercial real estate can improve their overall yields by utilizing leverage. Mortgage loans are sized based on the ratio of the debt to the value of the property (the *loan-to-value ratio* or LTV). Most owners of commercial real estate will borrower 50% to 80% of the value (or acquisition cost) of the property. Typically most CMBS originators will make loans up to 75% to 80% LTV. In 2006 and 2007, CMBS originators offered loan products that provided borrowers up to >95% LTV. During the 2008 financial crisis, most commercial real estate debt offerings (including CMBS) disappeared along with market liquidity. If debt was available, the terms were generally economically punitive (i.e., high coupons and maximum loan sizes up to 50% LTV based on depressed property values).

Mortgage loans are also sized based on the ratio of the net operating income of the underlying collateral to the debt service of the mortgage loan. This ratio is the *debt service coverage ratio* (DSCR). CMBS originators usually require a minimum DSCR of 1.2×; however, certain property-level characteristics could enable a CMBS originator to make a loan at lower DSCR thresholds (e.g., collateral is a long-term ground lease or tenants with lease terms greater than 15 years).

Loan Structures and Features

CMBS dealers will disclose many loan features in the offering documents of a CMBS transaction. Commercial mortgage loans are generally originated with structural features to isolate the underlying collateral for the benefit of the trust. Most borrowers are single-purpose entities (corporations or limited liability companies) that are created for the sole purpose of owning the commercial real estate that is security for the mortgage loan. For larger loans, the single purpose entity includes organizational features that make it difficult for the borrower to declare bankruptcy. These legal protections are necessary for loans underlying CMBS transactions since most loans are nonrecourse, meaning the lender's only recourse in the event of a loan default is seizing the underlying collateral.

CMBS originators require additional loan features to protect the trust in the event the borrower fails to prudently operate the mortgaged property. CMBS originators typically require borrowers to establish reserve accounts with the loan servicer for various property expenses. For example, CMBS originators may require the borrower to remit the prorated portion of the annual property tax and property insurance payments as part of its monthly payment. CMBS originators could also require borrowers to make monthly payments for replacement reserves, tenant improvement, and leasing commissions. Depending on the mortgaged property and its condition, CMBS originators could also require debt service reserves, ground lease reserves, and other reserves to mitigate specific property conditions.

From 2005 to 2007, many borrowers benefited from "holdbacks," which are additional loan proceeds that were held in reserve by the servicer. Holdbacks could be released to the borrower upon the achievement of certain property benchmarks (leasing goals, net operating income (NOI) goals, occupancy goals, and the like). Many of these metrics were based on aggressive property performance expectations that many mortgaged properties failed to achieve due to the financial crisis. In the event the holdback release criteria were not met, many holdbacks would serve as additional loan collateral. In some cases, unreleased holdbacks could be used to pay down the loan principal balance and would cause a prepayment to the certificate holders.

CMBS originators typically require lockbox structures. Lockboxes are deposit accounts held by the servicer. If the CMBS originator required a hard lockbox, immediately following the closing of the loan, the borrower would be required to notify all tenants to forward their rental payments and reimbursements to the servicer for deposit in the lockbox and the borrower would have access to the funds pursuant to the terms of the loan documents. Originators impose various conditions on the release of funds from lockboxes. In many instances, the servicer will fund escrows and debt service on a monthly basis and release the remaining funds to the borrower. As the CMBS market matured, originators would permit soft lockboxes that allowed the servicer to sweep all amounts in the lockbox to a borrower-controlled account on a daily basis. Upon an event of default, the

stringent cash management provisions would be imposed and the borrower would no longer have access to funds from the lockbox.

CMBS loans typically restrict prepayment during the loan term. CMBS originators would typically "lock out" all loans from prepayment during the first two to four years of the loan term. After this initial lockout period, borrowers could defease the underlying mortgaged property by substituting U.S. government securities as collateral for the loan. The substituted securities would be redeemed to make the interest and principal payments of the underlying loan on schedule. The defeasance feature is acceptable to CMBS investors because it preserves the contracted loan cash flows. In some cases, in lieu of defeasance, CMBS originators would allow borrowers to prepay their mortgage loans with the payment of a prepayment penalty or yield maintenance charge. These prepayment penalties would partially compensate certificate holders for an early prepayment of a mortgage loan since their overall yield could be negatively affected by the prepayment.

CMBS originators will sometimes cross-collateralize several mortgage loans. This feature is utilized when a borrower finances several properties using separate mortgage loans (rather than collateralizing a single mortgage loan with multiple properties). Cross default occurs when the originator requires the borrower to agree that any default under the identified set of mortgage loans will cause a default under all the mortgage loans. Cross-collateralization is the corollary feature that allows the CMBS originator to use the collateral securing all mortgage loans to offset the loss on any single mortgage loan.

Diversification of CMBS Loan Pools

In order to understand credit risk, CMBS investors focus on large mortgage loan exposures and collateral concentration. The Wachovia Bank Commercial Mortgage Trust, Series 2007-C32 (WBCMT 2007-C32) illustrates many of the loan features, pool concentrations, and certificate features described in this chapter. Exhibit 32–2 describes the top 15 loans in the WBCMT 2007-C32 transaction.

CMBS transactions usually contain mortgage loans from all US regions. Exhibit 32–3 illustrates the geographic concentration of WBCMT 2007-C32.

CMBS transactions should also contain adequate property type diversification. Concentration in a particular property type may make a CMBS transaction susceptible to specific downturns in a particular industry or segment of the economy. Exhibit 32–4 illustrates the property type concentrations in WBCMT 2007-C32.

The mortgage loans sold into a CMBS transaction should also provide adequate protection by including amortization. CMBS originators required amortization in the earliest vintages of CMBS but shifted to a preference of interest-only or partial interest only loans in later vintages of CMBS. Exhibit 32–5 illustrates the interest-only concentrations in WBCMT 2007-C32.

EXHIBIT 32–2

Top 10 Loans in WBCMT 2007-C32

	Loan Name	Loan Amount	% of Trust Balance	# of SF-Units	Balance ($)/ SF-Unit	Original Maturity Date	Original LTV	Original Underwritten DSCR (NOI)	Underwritten Cap Rate
1	Beacon D.C. & Seattle Pool	$ 414,000,000	10.8%	9,848,341	274	05/07/2012	78.7%	1.27×	7.04%
2	ING Hospitality Pool	283,850,000	7.4	5,796	97,947	06/11/2012	63.8%	2.14×	8.62%
3	DDR Southeast Pool	221,250,000	5.8	7,297,943	121	06/11/2017	63.5%	1.51×	5.77%
4	Two Herald Square	200,000,000	5.2	354,298	564	04/11/2017	66.7%	1.25×	4.93%
5	Westin Casuarina Resort & Spa–Cayman Islands	140,000,000	3.7	343	408,163	06/11/2017	71.4%	1.25×	7.44%
6	DDR-TRT Pool	110,000,000	2.9	678,553	162	06/11/2017	67.0%	1.50×	5.80%
7	Ashford Hospitality Pool 4	103,906,000	2.7	1,396	74,431	04/11/2017	74.3%	1.36×	8.74%
8	17 Battery Place South	95,000,000	2.5	413,828	230	05/11/2012	70.4%	1.54×	6.55%
9	Rockvale Square	92,400,000	2.4	539,661	171	05/11/2017	80.0%	1.38×	6.71%
10	Centerside II	89,300,000	2.3	287,494	311	10/11/2017	56.1%	1.66×	5.33%
	Total / Wtd. Avg.	$1,749,706,000	45.8%				69.9%	1.50×	6.82%

Notes: DSCR = debt-to-service coverage; LTV = loan-to-value ratio; NOI = net operating income

Source: BlackRock Solutions.

EXHIBIT 32–3

Top Five Geographic Concentration of WBCMT 2007-C32

State	Property Count	Loan Amount	% of Trust Balance	Cut-Off Date LTV	Cut-Off Date DSCR	Maturity Date LTV	Wtd. Avg. Coupon
NY	10	$ 597,750,000	15.6%	70.0%	1.44×	69.9%	5.73%
CA	25	575,873,000	15.1	65.6%	1.62×	65.6%	5.74%
Southern	20	525,626,000	13.7	65.5%	1.61×	65.5%	5.74%
Northern	5	50,247,000	1.3	66.7%	1.65×	66.7%	5.67%
FL	44	356,557,496	9.3	71.1%	1.41×	69.2%	5.71%
GA	28	237,654,004	6.2	68.7%	1.45×	67.8%	5.77%
VA	13	199,442,775	5.2	74.4%	1.35×	73.0%	5.81%
Other	155	1,856,575,794	48.6	73.7%	1.42×	71.3%	5.78%
Total/Wtd. Avg.	275	$3,823,853,069	100.0%	71.4%	1.45×	69.9%	5.76%

Source: BlackRock Solutions.

EXHIBIT 32–4

Property Type Concentration of WBCMT 2007-C32

Property Type	Property Count	Loan Amount	% of Trust Balance	Cut-Off Date LTV	Cut-Off Date DSCR	Maturity Date LTV	Wtd. Avg. Coupon
Office	56	$1,169,790,500	30.6%	72.0%	1.40×	71.5%	5.76%
Retail	99	1,026,196,690	26.8	71.2%	1.45×	69.3%	5.66%
Hospitality	61	715,271,335	18.7	68.0%	1.71×	64.5%	5.91%
Multifamily	30	443,196,794	11.6	77.3%	1.32×	76.3%	5.71%
Mixed Use	11	365,700,000	9.6	69.6%	1.27×	69.1%	5.81%
Industrial	10	67,297,750	1.7	78.7%	1.40×	74.6%	5.88%
Special Purpose	2	17,500,000	0.5	63.5%	1.59×	60.9%	6.42%
Healthcare	1	13,000,000	0.3	69.1%	1.37×	65.7%	6.03%
Land	5	5,900,000	0.2	44.1%	1.20×	39.1%	5.98%
Total/Wtd. Avg.	275	$3,823,853,069	100.00%	71.4%	1.45×	69.9%	5.76%

Source: BlackRock Solutions.

EXHIBIT 32–5

Stratification of Amortization Type of WBCMT 2007-C32

Amortization Type	Loan Count	Loan Amount	% of Trust Balance	Cut-Off Date LTV	Cut-Off Date DSCR	Maturity Date LTV	Wtd. Avg. Coupon
Nonamortizing	86	$3,044,468,500	79.6%	71.47%	1.48×	71.5%	5.71%
Partial Interest-Only Amortizing	33	599,077,500	15.7	70.06%	1.38×	64.0%	5.98%
1–12 months	6	46,950,000	1.2	73.7%	1.30×	65.2%	5.83%
12–24 months	6	212,912,500	5.6	70.7%	1.29×	62.7%	6.27%
25–36 months	3	23,780,000	0.6	64.6%	1.53×	57.9%	5.62%
49–60 months	16	281,707,000	7.4	69.3%	1.46×	64.7%	5.85%
>60 months	2	33,728,000	0.9	71.8%	1.15×	68.9%	5.73%
Amortizing – No Partial Interest-Only Period	23	180,307,069	4.7	75.1%	1.27×	62.4%	5.90%
Total/Wtd. Avg.	142	$3,823,853,069	100%	71.4%	1.45×	69.9%	5.76%

Source: BlackRock Solutions.

EXHIBIT 32–6

Loan Sponsor Concentrations in WBCMT 2007-C32 in Excess of 5%

Loan Sponsor Name	# of Loans/ Mortgaged Properties	Loan Number	Aggregate Loan Amount ($)	% of Trust Balance	Cut-Off Date LTV	Cut-Off Date DSCR	Wtd. Avg. Coupon
Beacon Capital Strategic Partners V, LP	1/20	1	$414,000,000	10.8%	78.7%	1.27×	5.78%
Developers Diversified Realty Corporation (DDR)	2/55	3,6	$331,250,000	8.7%	64.7%	1.51×	5.57%
ING Clarion Partners	1/46	2	$283,850,000	7.4%	63.8%	2.14×	5.66%
The Moinian Group	4/4	8,13,16,44	$237,500,000	6.2%	75.1%	1.40×	5.71%
Sharon Sutton	1/1	4	$200,000,000	5.2%	66.7%	1.25×	5.92%
The Irvine Company LLC	3/3	10,15,18	$195,300,000	5.1%	52.6%	1.79×	5.65%

Source: BlackRock Solutions.

EXHIBIT 32–7

Pari Passu Loans in WBCMT 2007-C32

Loan	Loan Number	Loan Amount	% of Pool	% of Pari Passu Debt in Trust	Amount of Pari Passu Debt Outside of Trust ($)	Paymaster Transaction
Beacon D.C. & Seattle Pool	1	$414,000,000	10.8%	15.3%	$2,286,000,000	MSCT 2007-IQ14
ING Hospitality Pool	2	283,850,000	7.4	50.0%	$283,850,000	WBCMT 2007-C32
DDR Southeast Pool	3	221,250,000	5.8	25.0%	$663,750,000	CGCMT 2007-C6
Total		$919,100,000	24.0%			

Source: BlackRock Solutions.

CMBS transactions may also include multiple loans to the same ownership group (Loan Sponsor) that are not cross collateralized. CMBS dealers typically make this information available during the offering process. CMBS investors should monitor the borrower concentrations in conduit or fusion transactions to ensure adequate diversity of borrower risk. Exhibit 32–6 provides a stratification of Loan Sponsors in the WBCMT 2007-C32 transaction.

To mitigate concentration risk from the largest loans and keep the exposure below certain size thresholds that would require additional disclosures, CMBS issuers may split mortgage loans into multiple pieces. Structures could range from A/B note structures, in which the B note provides subordination to the senior A note. Originators also split loans into "pari passu" structures in which the individual notes receive a pro-rata portion of principal and interest (and losses in the event of a note loss).

If an originator creates a pari passu loan structure, the servicing of the loan would be assigned to the servicer of the first securitization that owns the first securitized note from the pari passu loan. This servicer (the Paymaster) is responsible for collecting the loan payments and administering the loan for all the various notes created by the originator. Exhibit 32–7 describes the pari passu loans in WBCMT 2007-C32.

The Beacon D.C. & Seattle Portfolio loan is one of the most complex mortgage loans sold in a CMBS transaction. The $2.7 billion loan was originally split into 6 pari passu notes. After the first notes were securitized, the CMBS originator split one of the pari passu notes (the A4 Note) into three notes. CMBS originators adjust the size of the pari passu notes based on the size of the overall CMBS transaction that acquires the pari passu note. All of the A pari passu notes comprising the Beacon D.C & Seattle Portfolio loan were securitized in various CMBS fusion transactions. Exhibit 32–8 illustrates the loan structure.

By performing due diligence on the largest 10 loans in a CMBS transaction, CMBS investors can understand the credit risk profiles of approximately 30% to 50% of the collateral.

EXHIBIT 32–8

Loan Structure of the Beacon D.C. & Seattle Portfolio

<table>
<tr><td rowspan="2">A1 Note</td><td rowspan="2">A2 Note</td><td rowspan="2">A3 Note</td><td>A4-A1 Note</td><td>A4-A2 Note</td><td>A5 Note</td><td rowspan="2">A6 Note</td></tr>
<tr><td colspan="2">A4-B Note</td><td>Sold into WBCMT 2007-C32</td></tr>
</table>

CMBS TRUST STRUCTURE

CMBS transactions begin with the origination of commercial mortgage loans by loan originators. Various insurance companies, specialty finance companies, conduits, and banks have served as mortgage loan originators for CMBS transactions. Mortgage loans are sold by the originators to a depositor entity to aid the legal isolation of the mortgage loans. The depositor typically forms a common law trust via a Pooling and Servicing Agreement and transfers the mortgage loans to the trust. The trust issues certificates to investors in an aggregate amount that equals the cut-off balance of the mortgage loans. There is typically no over- or under-collateralization of CMBS trusts.

The rating agencies are engaged early in the transaction structuring process to review the proposed loan pool and provide preliminary certificate subordination levels for a CMBS transaction. Mortgage loan originators provide each rating agency with data and loan files to assist the rating agencies with performing their loan due diligence and site visits for properties securing mortgage loans. Rating agencies perform due diligence on the underlying loans and properties, including site visits, to determine the subordination levels required to achieve specific ratings. The issuer and transaction underwriters prepare various documentation for the transaction including the prospectus, pooling and servicing agreement (PSA), and Annex A, which contains detailed information about the underlying loans in the collateral pool. The transaction underwriters market the CMBS certificates to potential investors. The transaction underwriters acquire the certificates from the trust on the transaction settlement date and transfer the certificates to the investors. Exhibit 32–9 illustrates the relationships between the standard transaction participants.

EXHIBIT 32–9

Diagram of Mortgage Loan Transfer, Certificate Issuance and Transaction Participants

Prior to the 2008 financial crisis, CMBS transactions consisted of tranches at every rating notch resulting in thin classes susceptible to being completely written down in the event a large loan experiences significant loss. Subsequent to the 2008 financial crisis, CMBS issuers have simplified capital structures by creating thicker classes that are better able to withstand the default of a single loan. Exhibit 32–10 illustrates typical CMBS certificate structures before and after the 2008 financial crisis.

EXHIBIT 32–10

Illustration of CMBS Certificate Subordination Levels and Ratings before and after the 2008 Financial Crisis

a. WBCMT 2007-C32

Class Type	Tranche	Rating	Balance (mm)	% of Transaction	Sub Rate
Senior AAA	A-1	AAA	$26	0.7%	30.00%
	A-2	AAA	946	24.7	30.00%
	A-PB	AAA	63	1.6	30.00%
	A-3	AAA	949	24.8	30.00%
	A-4FL	AAA	250	6.5	30.00%
	A-1A	AAA	443	11.6	30.00%
Junior AAA	A-MFL	AAA	382	10.0	20.00%
	AJ	AAA	253	6.6	13.38%
	B	AA+	43	1.1	12.25%
	C	AA	48	1.2	11.00%
	D	AA–	29	0.8	10.25%
	E	A+	29	0.8	9.50%
Mezzanine	F	A	38	1.0	8.50%
	G	A–	43	1.1	7.38%
	H	BBB+	48	1.3	6.13%
	J	BBB	53	1.4	4.75%
	K	BBB–	33	0.9	3.88%
Credit	L	BB+	19	0.5	3.38%
	M	BB	10	0.2	3.13%
	N	BB–	14	0.4	2.75%
	O	B+	10	0.2	2.50%
	P	B	10	0.3	2.25%
	Q	B–	10	0.3	2.00%
	S	NR	76	2.0	0.00%
Interest-Only	IO	AAA	3,824	NAP	NAP
Total			**$3,824**	**100.0%**	

(*Continued*)

EXHIBIT 32–10

Illustration of CMBS Certificate Subordination Levels and Ratings before and after the 2008 Financial Crisis (*Continued*)

b. WFRBS 2011-C2

Class Type	Tranche	Rating	Balance (mm)	% of Transaction	Sub Rate
AAA	A-1	AAA	$78	6.0%	17.13%
	A-2	AAA	383	29.5%	17.13%
	A-3	AAA	122	9.4%	17.13%
	A-4	AAA	493	38.0%	17.13%
Mezzanine	B	AA	39	3.0%	14.13%
	C	A	44	3.4%	10.75%
	D	BBB–	68	5.3%	5.50%
Credit	E	BB	21	1.6%	3.88%
	F	B	15	1.1%	2.75%
	G	NR	36	2.8%	0.00%
Interest-Only	XA	AAA	1,077	NAP	NAP
	XB	AAA	222	NAP	NAP
Total			**$1,299**	**100.0%**	

TRANSACTION PARTICIPANTS

Post-securitization, several parties are involved in the administration and management of a CMBS trust. The trustee is the administrator of the assets and liabilities of the CMBS trust and fulfills a variety of responsibilities. The trustee calculates and distributes principal and interest payments to CMBS certificate holders, prepares and discloses periodic remittance data, and maintains the trust's books and records. In certain cases, the trustee also provides support to the master servicer if the latter is unable to fulfill its responsibilities. The trustee receives a fee from the monthly interest income generated by the collateral for performing its duties. The trustee fee is senior to certificate holder interest payments. The trustee can also earn additional income by reinvesting cash flows received from the servicer that will be transferred to certificate holders at a later date.

The master servicer collects loan payments for distribution to the trustee, in addition to performing basic servicing duties such as management of escrows, reserves, and lockboxes. The master servicer collects and provides periodic loan performance data and property financials to the trustee and rating agencies.

When a loan becomes delinquent or distressed, the master servicer transfers its servicing duties to a special servicer that focuses on workout and loss mitigation activities. The master servicer continues to advance principal and interest on the delinquent loan to the trust as long as the advances are deemed to be recoverable upon loan workout. The master servicer also receives a fee that is generally a few basis points of the outstanding mortgage balance. The master servicer's fee, similar to the trustee's fee, is also senior to certificate holder interest payments. The master servicer can also earn additional income by reinvesting underlying mortgage cash flows for a period of time prior to transferring to the trustee.

The special servicer handles distressed loans, which may be in delinquency, bankruptcy, foreclosure, etc. The determination of a distressed loan is typcially made by the master servicer, who then transfers the loan to the special servicer for timely resolution and implementation of workout procedures. The special servicer's responsibility to the CMBS trust is to maximize recovery value of the distressed loan. The special servicer receives a monthly fee during the loan workout period based on the outstanding loan balance. The special servicer also receives compensation for a loan resolution, depending on whether a loan is liquidated or modified. Similar to the trustee and master servicer fees, the payments due to the special servicer are paid prior to allocating cash-flows to the certificate holders.

CMBS transactions typically designate the most subordinate tranche as the controlling certificate holder. Since the controlling certificate holder is in the first loss position if the CMBS transaction sustains losses from a defaulted loan, the controlling certificate holder (via the controlling class representative) is empowered to make certain decisions. The controlling class representative is typically granted the power to (1) replace the special servicer and (2) approve the disposition plan for loans in special servicing. These control rights migrate to the class immediately senior to the current controlling certificate holder if the controlling certificate holder sustains losses in excess of 75% of its original certificate balance. Prior to 2000 and after 2008, CMBS transactions typically require the control rights to pass to the next most senior certificate holder when principal losses and ARAs (defined below) exceed 75% of the controlling certificate holders original certificate balance. In contrast, CMBS transactions issued from 2000 through 2008 allowed the controlling certificate holder to remain in place even when principal write downs in excess of 75% of the controlling certificate holders original certificate balance were imminent.

TRANSACTION FEATURES

CMBS issuers generally incorporate a standard set of transaction features regardless of vintage. With few exceptions, CMBS transaction features have remained generally static since the 1990s with issuers incorporating small changes to meet investor demands.

Subordination

CMBS certificates are created along time and credit dimensions to create a "capital structure" with varying cash flow and risk profiles that cater to different investors. For example, senior certificates typically have priority to principal payments, and therefore, are the shortest certificates in a transaction. Junior certificates are subordinate to senior tranches with respect to principal cash flows and are also first in line to absorb collateral losses. The subordination rate, which is a measure of credit support for a certificate, is defined as the percentage of the collateral balance that must experience a complete principal write-down before the certificate in question is exposed to principal loss. Subordination rates are highest for the senior most certificates in the transaction and decrease down the capital structure.

Conduit transactions have three distinct categories of principal-pay certificates—AAA classes, mezzanine classes, and junior credit classes—with one or more interest-only (IO) certificates. The AAA classes are generally further divided into three different subordination levels starting with super-dupers (senior-most tranches in the transaction—classes A1 through A4 in Exhibit 32–10) at the top of the capital structure having attained the highest subordination rates (usually 30%), followed by mezzanine AAA (the AM class), and junior AAA (the AJ class) certificates. CMBS issuers created the super-duper and mezzanine AAA structures based on investor feedback. CMBS issuers determined the junior AAA subordination levels based on rating agency feedback.

The super-duper AAA certificates constitute approximately 70% of the transaction principal balance and are the senior most certificates in the transaction. A typical conduit transaction has six duper classes—A1, A2, A3, A4, APB, and A1A—each with a different cash-flow profile. The A1 certificate, which is the first-pay AAA, is the shortest certificate in the transaction with a WAL of approximately two years. The A1 also amortizes gradually over time, unlike the A2 and A3 certificates, which have bullet-like principal cash-flow profiles because they are usually tied to five- or seven-year balloon loans. In order to maintain the bullet cash-flow profile of the medium-term AAAs, the APB tranche absorbs amortizing principal cash flow between the maturities of the A2 and A3 classes. The A4 certificate is typically the largest of the AAA classes and also has the longest WAL. The A4 class is often referred to as the benchmark certificate of the transaction. Similar to A2 and A3 classes, the A4 certificate also has a bullet-like principal cash-flow profile tied to 10-year balloon mortgages. Lastly, the A1A class is created only if multifamily and manufactured housing loans exist in the CMBS transaction and is structured specifically for the GSEs to receive the cash flows from selected mortgage loans that meet the GSE's underwriting and/or affordable housing standards.

The mezzanine AAAs (AM classes) usually carry 20% subordination while junior AAAs (AJ classes) carry 10% to 15% subordination level—actual subordination levels vary by transaction and are based on the feedback from rating agencies. AM and AJ certificates are also tied to balloon loans with bullet-like

principal cash-flow profiles. Mezzanine classes are typically rated between AAA and BBB– and constitute a small portion of the original transaction balance. Mezzanine certificates are generally tied to 10-year balloon payments. CMBS transactions can also include tranches rated below BBB—or unrated first-loss classes known as B-pieces. These tranches are tied to the longest maturity loans in the collateral pool. The B-piece is generally the controlling class and retains certain voting rights that allow them to replace the special servicer.

Pass-Through Rates

Traditional conduit transactions are structured such that the net weighted average coupon of the collateral (the assets) exceeds the weighted average coupon of the certificates (the liabilities). The net weighted average coupon of the collateral equals the weighted average coupon of the collateral less the fees payable to the trustee and master servicer. This structure results in excess interest cash flow which is directed to the IO tranches. IOs by definition do not receive any principal.

Conduit CMBS certificates can have three types of coupon structures: fixed-rate, WAC (weighted average coupon), and WAC-capped. Most CMBS tranches pay a fixed-rate coupon. WAC certificates pay the weighted average net coupon of the collateral, which can vary over time as the composition of the collateral pool changes. WAC-capped certificates pay the minimum of a fixed-rate and the WAC rate and are generally lower in the capital structure.

Priority of Payments

In general, given the relative simplicity of CMBS capital structures, the allocation of cash flows and losses across the capital stack—known as the "waterfall structure"—is fairly straightforward. The APB and A1A tranches add a layer of complexity, which is described in detail below.

Principal payments are allocated sequentially from the top of the capital structure to the bottom. Principal cash flows are generated from loan maturities, scheduled amortizations, prepayments, and default recoveries. The sequential payment structure implies that in general a certificate will receive principal payments only if the tranches senior to it in the capital structure have completely paid off.

The A1A tranche receives its cash flow exclusively from designated multifamily and manufactured housing loans in the collateral pool. The rest of the tranches are allocated cash flows from the remaining collateral pool. The APB tranche first receives principal in accordance with its amortization schedule and any excess is diverted to the A1, A2, A3, and A4 classes in sequential order. The A1 tranche (which is the first-pay certificate) receives principal payments only if the APB tranche has received its allocated principal to date. Following the sequential structure, the A2 class does not receive any principal until the A1 class has been fully paid off, and the A3 class does not receive any principal until the

A2 class has been paid off. Once the A3 class has been paid off, all principal from the non-multifamily pool is distributed to the APB class. Finally, once the A1, A2, A3, and APB classes are fully paid off, principal cash flow is allocated in sequential manner to the other classes.

While principal is allocated in "top-down" fashion, losses are allocated "bottom-up" in reverse-sequential order. Given that the credit enhancement in a CMBS transaction is in the form of subordination, a particular tranche will not experience losses until the certificates underneath it in the capital structure are completely written down. It is important to note that all the super-duper certificates in a transaction share the same level of subordination. As a result, although principal cash flows are allocated sequentially to the super-duper certificates, losses are allocated pro-rata across the super-duper certificates after the more junior tranches experience complete principal write downs. Interest payments are allocated pro-rata to the super-duper certificates and to the IO tranche and then sequentially to the rest of the certificates. Interest cash flows are a function of current debt service payments plus any late interest payments from prior periods, received in the current period.

Exhibit 32–11 illustrates the certificate subordination and priority of payments for the WBCMT 2007-C32 transaction.

Interest-Only Certificates

Most CMBS fusion transactions also have an IO tranche. As mentioned, the weighted average coupon that is paid to all the non-IO tranches is generally less than the total interest from the collateral pool. This excess interest is allocated to the IO tranche, once all the non-IO tranches in the trust have received their allocation of the interest payments. The notional balance of the IO tranche may be based on the aggregate balance of the AAA tranches alone or on the entire transaction, depending on the level of the coupon being stripped off of various tranches.

If the difference between the collateral and certificate coupons is substantial, transactions may contain a planned amortization class (PAC) IO structure, where multiple classes of IOs exist, with one class of IO certificates treated as support bonds to absorb the impact of prepayments so that the PAC IO investor receives stable cash flow and low yield variability.

Payment Advancing and Appraisal Reductions

When a loan becomes delinquent, the master servicer is generally obligated to advance principal and interest to the trust to minimize the variability in monthly cash flows to the certificate holders. However, the amount the servicer advances is based on whether it deems the advanced amounts to be recoverable upon liquidation. In order to determine the advanced amount, the servicer hires an appraiser who appraises the property. A haircut (typically

EXHIBIT 32–11

WBCMT 2007-C32 Certificate Structure

*The Class A-4FL and Class A-MFL are created through a swap contract. The CMBS trust swaps the original fixed-rate coupon of each class into a floating-rate coupon. The CMBS issuer markets these certificates as floating-rate certificates; however, if principal losses reach these classes, the swaps typically terminate and the coupons revert to the fixed-rate coupon.

10%) is applied to the appraisal amount and compared to the outstanding loan balance at the time of delinquency. The servicer then advances payments based on the lower of the outstanding loan balance and the adjusted appraised value. This difference is called an *Appraisal Reduction Amount* (ARA). If the delinquency level in a trust is fairly high or if appraised values are substantially lower than the outstanding loan balances, there could be a situation in which interest shortfalls could result to the trust since the servicer's advances are not enough to cover interest payable to all certificate holders. Once the loan is liquidated, proceeds from the liquidation will go first to the servicer to reimburse servicing advances.

Clean-up Call Provisions

Each CMBS transaction includes a clean-up call provision that enables the outstanding certificate holders to purchase the remaining mortgage loans in a trust. The clean-up call is usually limited to when the remaining balance of mortgage loans represents approximately 1% and 3% of the original balance of the trust. The purchase price is typically the outstanding balance of the mortgage loans plus accrued interest. The clean-up call is utilized to wind-down CMBS transactions when the balance remaining in the transaction is too small to justify the ongoing administration costs.

MARKET DEVELOPMENT

The CMBS market developed in the early 1990s with the need to dispose of commercial real estate loans owned by the Resolution Trust Corporation (RTC) as a consequence of the savings and loan crisis. The RTC packaged loans from failed institutions into CMBS transactions using a Real Estate Mortgage Investment Conduit (REMIC) structure under the tax code. This provision was passed as part of the Tax Reform Act of 1986 and allows tranches of securities that would otherwise be treated as equity interests to be treated as debt instruments. The CMBS market grew quickly in the 1990s, culminating in issuance of $74 billion in 1998. The Russian debt crisis and related contagions created substantial turmoil in the debt markets in August 1998, causing a temporary slowdown in CMBS issuance. Transaction volume surpassed 1998 levels in 2003 and CMBS issuance underwent explosive growth through 2007 with $228 billion of issuance as demand for high-quality spread products remained elevated.

From 2001 through 2007, CMBS credit-spreads experienced a general tightening trend.[1] At the height of the market in early 2007, CMBS spreads relative to Treasuries (T) had tightened to approximately T+0.60% for 10-year super-duper AAA certificates and T+1.20% for BBB-rated certificates. The 2007 subprime

1. Spread information provided by Trepp LLC.

mortgage crisis impacted CMBS pricing and in August of 2007, spreads on 10-year super-duper AAA certificates had widened considerably (T+1.50%). Spreads on BBB-rated certificates in early 2007 were T+1.25% and subsequently widened to T+4.75% by the fall of 2007. With spreads widening and contagion from the subprime crisis spreading, issuers curtailed loan originations, in part due to their inability to hedge credit-spread risk in a spread-widening environment. Issuers delivered nine transactions in 1H-2008 with the CMBS market seizing up in July 2008. No privately sponsored CMBS issuance was brought to market until Q4-2009, when the only TARP-eligible securitization was sold to the market. In 2010, the market slowly experienced increased transaction volume with total annual private issuance of approximately $13 billion. See Exhibit 32–12 for CMBS spread history for certain classes.

MODELING

Market participants consider two primary types of risks when analyzing CMBS—interest rate risk and credit risk. Interest rate risk is important given most certificates are fixed-rate and relatively long duration because the underlying loan maturities are in the 5- to 10-year range. Credit risk is relevant since any losses resulting from loan defaults are borne by the certificate holders.

The 0/0 Scenario

Prior to the 2008 financial crisis and subsequent downturn, commercial mortgage defaults had been low and had not impacted senior certificates. As a result, investors traditionally relied on what is referred to as a *0/0 framework,* which means zero prepayments (as measured by the conditional prepayment rate, CPR) and zero default rates (as measured by the conditional default rate, CDR), to quote CMBS prices and yields. This implies that there are no prepayments, defaults, or losses on the collateral pool. This simplistic modeling framework is often augmented with additional loan default and extension scenarios as liquidations and extensions have become more common. Prepayment risk is generally not significant for commercial mortgages due to typical prepayment restrictions at the loan level.

Probabilistic Modeling

Probabilistic models attempt to draw statistical relationships between commercial loan performance and identified drivers of performance. For example, loan default and severity are generally built as a function of DSCR and LTV. All else equal, perceived credit risk is higher with higher LTV and lower DSCR. Investors attempt to project future loan performance by studying the empirical relationship between historical defaults/severities and the pool's DSCR/LTV.

EXHIBIT 32–12

History of CMBS AAA and BBB Spreads (in Basis Points) to 10-Year U.S. Treasuries

Source: Trepp LLC.

Deterministic Modeling

Since loan-level commercial mortgage performance datasets are not readily available, market participants more commonly rely on a deterministic modeling approach. Deterministic models employ a rules-based framework in which loan outcomes are determined by projected property performance and valuation after subjecting the underlying collateral to a series of tests and triggers. Loan performance and valuation are estimated using projected DSCR and LTV (similar to probabilistic models), which in turn are calculated from NOI and cap rate. The NOI and cap rate inputs into deterministic models can vary by property type and/or geography and are typically generated using macroeconomic models that incorporate real estate fundamentals. Each mortgage loan's projected DSCR and LTV is compared through time to a set of trigger levels to discretely determine one of three possible loan outcomes: term default, timely pay-off, or maturity default/loan extension. The three loan outcomes are described in more detail below:

- *Term Default*: During the term of the mortgage loan, periodic tests are run to determine if the loan's DSCR drops below a pre-defined *DSCR default trigger*. The loan is immediately defaulted and enters a workout period if the DSCR trigger fails. At the end of the workout period, the property's terminal value is determined using NOI and cap rate, less a workout or disposition fee. If the final property value is less than the outstanding loan amount, the deficit is recorded as a loss. If the property's NOI never drops below the DSCR trigger, no default is assumed during the loan's term.
- *Timely Pay-off*: At the loan's maturity date, property value is once again determined by applying a cap rate to projected NOI. The loan is assumed to pay-off on time if the property value is sufficiently above the outstanding loan amount (e.g., LTV < 80%).
- *Maturity Defaults/Loan Extensions*: If the loan does not pay-off as scheduled at maturity, it either enters into a one-time term extension or defaults. Deterministic models generally assume that the loan is extended as long as it is not underwater (LTV < 100%), whereas under-collateralized loans (LTV > 100%) are assumed to default at maturity. In the case of maturity default, the property value is calculated at the end of the workout period to determine the loss amount. If the loan is extended, the pay-off versus default calculation is repeated at the end of the extension period.

The DSCR and LTV thresholds are typically set based on a combination of observed historical performance, real estate market trends, and the participant's experience and judgment. Exhibit 32–13 is a graphical representation of a sample deterministic framework.

EXHIBIT 32–13

Deterministic Model Logic Tree

KEY POINTS

- There are major structural and modeling differences between CMBS and other mortgage products.
- Most CMBS transactions are conduit or fusion transactions with diversified exposure by geography and property type: office, retail, industrial, hotel, and multifamily are the primary real estate asset types.
- CMBS typically have many structural features that protect senior investors from credit losses while allowing flexibility for the senior portion of the capital structure to target narrow maturity windows.
- Impacts of prepayments can be somewhat muted given the prepayment restrictions of most mortgage loans.
- Given the idiosyncratic nature of commercial real estate within CMBS transactions, bottom-up loan and property level analysis is necessary to understand the underlying credit and extension risks.

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CHAPTER
THIRTY-THREE

CREDIT CARD ASSET-BACKED SECURITIES

JOHN MCELRAVEY, CFA
Director, Head of Consumer ABS Research
Wells Fargo Securities, LLC

The securitization of credit card receivables began in 1987, and the credit card asset-backed securities (ABS) market grew rapidly over the years to become one of the largest securitization sectors. New issue volume averaged $60 billion per year from 1995 to 2008, and credit cards became a consumer ABS staple. As a result, credit card ABS outstanding grew from $130 billion in 1995 and peaked at $402 billion in 2003. Outstandings settled to about $350 billion in 2007 just ahead of the financial crisis. Because of its liquidity, transparency, and relatively high-credit-quality sponsors, credit card ABS became something of a safe haven for ABS investors during periods of market volatility. Indeed, many investors making their initial foray into ABS would likely dip their toes into credit cards before wading into the many other asset classes available.

The size of the credit card ABS market corresponded with the growth in the credit card market overall. Consumers came to rely on credit cards as a convenient method of payment for an expanding universe of goods and services, as well as an easy means of accessing credit. At the same time, credit card lenders viewed direct access to funding in the capital markets as a cost-effective alternative to gathering core deposits. Since the recession and financial crisis of 2007–2009, many credit card lenders have come to rely less on securitization than in the past. Nevertheless, the credit card ABS sector should remain a core segment of the securitization market. This chapter summarizes the key structural features of credit card securitization and provides an overview of the credit card ABS market.

SECURITIZATION OF CREDIT CARD RECEIVABLES

Credit card securitizations began in the late 1980s and early 1990s by banks looking to diversify funding sources for their credit card businesses and as a way to remove assets from the balance sheet. At this time, the banking industry faced the imposition of stricter capital standards by regulators. Securitization provided a vehicle to help meet these standards by reducing balance sheet assets and thereby improving regulatory capital ratios. Beyond the beneficial capital treatment,

securitization also allowed specialized credit card banks to enter the market and grow rapidly without having to rely heavily on attracting consumer deposits as a cheap funding source. These specialty banks, which included MBNA, First USA, and Capital One, were able to access the credit markets directly and achieve funding costs that were competitive with those of the established bankcard issuers. Much of the increased innovation and competition in the credit card market during the 1990s can be traced to these banks, which could not have grown as rapidly as they did without the benefits afforded by securitization.

Certain changes in accounting rules in recent years, namely FAS 166/167, have forced most credit card securitizations back on the balance sheets of commercial banks. This move has reduced or eliminated the advantageous capital treatment of securitization relative to other forms of on-balance-sheet funding. As a result, credit card ABS will have to compete with equity, debt, and deposits to fund the credit card businesses of commercial banks. While it may be smaller than it was in the past, it seems likely that the credit card ABS market will remain a core segment of the consumer ABS market, and an important source of funding for many credit card lenders.

Basic Master Trust Structure

The structure used for credit card securitization until 1991 was a stand-alone trust with a dedicated pool of credit card accounts and the receivables generated by those accounts. Each securitization required a new trust and a new pool of collateral, and the securities were backed only by that collateral pool. Since 1991, the master trust has become the predominant structure in the market (Exhibit 33–1). As the name implies, the issuer establishes a single trust that can accept periodic additions of accounts and issue multiple series of securities. All of the securities issued by the master trust are supported by the interest and principal collections from all of the receivables contributed to it. The collateral pool is not segmented to support any individual securities.

The credit card issuer, and seller/servicer of the accounts and receivables, pledges the accounts to the master trust (step 1). The master trust sells securities to investors (step 2) in various series. The investors are entitled to their share of interest and principal collections, and are allocated their share of defaults and losses. At the same time, the seller/servicer maintains an interest in the master trust called the seller interest. This seller interest is not credit enhancement for investors, but is *pari passu* with investors. The seller interest receives its share of interest and principal collections, and is allocated its share of defaults and losses. This is returned to the issuing bank (step 3).

For the issuer, the master trust structure lowers the cost of issuing ABS and provides greater flexibility. From the investor's point of view, assessing the credit quality of a new issue may require less analysis because there is only one pool of collateral to review. As the collateral pool in the trust grows, it generally becomes more diversified. While the characteristics of the collateral pool may

EXHIBIT 33–1

Basic Master Trust Structure

Source: Wells Fargo Securities, LLC.

change somewhat over time owing to changes in interest rates, underwriting criteria, industry competition, and so on, any change in the master trust would likely be more gradual than would the differences in stand-alone pools.

Master Note/Owner/Issuance Trust Structures

Credit card master trust structures evolved over time, and now most issuers utilize structures called master note or owner or issuance trusts. This chapter will refer to them as issuance trusts (IT). The bonds issued by an IT are still backed by a pool of revolving credit card accounts and receivables, and the credit analysis for investors is not affected in a meaningful way. However, there are important structural differences from older credit card master trusts using earlier technology. Perhaps most importantly, the IT structure provides the issuer with additional flexibility to meet investor demand for different maturities or types of bonds.

Because of consolidation in the credit card industry over time, many surviving credit card ABS issuers may have more than one legacy credit card trust with its particular collateral pool. Exhibit 33–2 presents an example of an IT structured by an issuer active in the market with a legacy credit card master trust. Like our simple example above, the credit card bank pledges the accounts and receivables to its credit card master trust. This legacy trust has several series outstanding in the investor interest and each series has its own dedicated credit enhancement (Series 1–3).

EXHIBIT 33–2

Master Issuance Trust Structure

Source: Wells Fargo Securities, LLC.

Then, the credit card bank decides to establish an MOT to take advantage of the state of the art in the securitization market. To accomplish this, the existing master trust issues a *collateral certificate* (Series 4). The collateral certificate represents an undivided interest in the assets of the legacy master trust and is allocated its proportionate share of principal collections, finance charges, defaults and losses, and servicing fees. For credit card banks with more than one legacy master trust, it is conceivable that each one could issue a collateral certificate that could be used to pass through to the IT.

Credit card ABS issuers gravitated to the IT structure primarily for the increased flexibility that it allows when issuing new securities. Under the early master trust programs, issuers were required to issue subordinated bonds at the same time as the senior bonds. The senior and subordinated bonds were linked. However, the current credit card issuance trusts can be likened to a corporate

medium-term note program. Different classes of securities can be issued at different times, in varying sizes, and with distinct maturities. This flexibility allows the issuer to be opportunistic with regard to the timing of new ABS securities, and tailor those securities to the demands of its investor base.

This characteristic of the IT is sometimes referred to as a "delinked" issuance trust because the AAA-rated senior securities can be issued separately from the subordinated bonds that provide credit enhancement for the senior notes. The subordinated bonds are no longer directly linked to a specific series of senior bonds having the same maturity. In the IT structure, all of the outstanding subordinated classes act as credit enhancement for all the senior classes. These may be known as *shared enhancement series,* and can be seen in the lower section of Exhibit 33–2. New senior bonds can only be issued to the extent that there is a sufficient amount of subordinated bonds already outstanding. For example, Class B bonds can only be issued if there is a sufficient amount of Class C bonds already outstanding to support them, and Class A bonds can only be issued to the extent there is an appropriate amount of Class B and Class C bonds. A "sufficient amount" is the amount of credit enhancement required by the rating agencies to maintain the desired credit ratings on the bonds.

The subordinated bonds may have different maturity dates than the Class A bonds. If a subordinated class matures prior to a senior class, then a replacement subordinated bond must be issued prior to the maturity to take its place. If a replacement bond cannot be issued in time to maintain the required credit enhancement, then principal collections would be deposited into an account that would support the senior bonds. Therefore, the senior bonds would always have an appropriate amount of credit enhancement outstanding. The senior bonds benefit from the subordination up to and including the required amount. They would not have the benefit of subordinated bonds issued in excess of the required amount.

The IT structure also became popular with issuers and investors because it allowed for an expansion of the potential investor base for credit card ABS, especially for the subordinated bonds. Securities could be issued as notes rather than as pass-through certificates. In doing so, all classes, including the subordinated classes, can achieve ERISA (Employee Retirement Income Security Act) eligibility. This feature is important because pension funds, a significant source of fixed income investor funds, can only buy securities that meet ERISA guidelines. In this way, the total investor base for credit card ABS was expanded, especially for subordinated bonds, which very often could not achieve ERISA eligibility. Liquidity improved for subordinated bonds, which had lagged the senior classes. In addition, the IT structure allows for easier and more timely execution of reverse inquiry issuance when an investor has a particular coupon or maturity need.

Investor Interest and Seller Interest

Credit card master trusts allocate credit and cash flows between the ABS investors and the master trust sponsor. The sponsor is typically the seller/servicer of

the accounts pledged to the trust. The *investor interest* is simply the aggregate principal amount owed to the ABS investors. The *seller interest* is a residual interest in the trust that the credit card issuer is required to maintain. The seller interest aligns the incentives of the credit card bank with those of the outside investors because the seller has a *pari passu* claim on the cash flows of the trust. As noted earlier, the seller interest receives its share of finance charge collections and principal repayments, as well as it allocation of defaults and net losses.

The minimum required seller interest for most master trusts tends to be in the 4% to 7% range of outstanding receivables balances. In practice, the seller interest is likely to be higher than the minimum required by the rating agencies depending on the sponsor's strategy toward using securitization for its funding needs relative to other forms of financing. In addition to aligning the interests of the issuer and the investors, the seller interest is in place to absorb the fluctuations in the amount of outstanding receivables. For example, seasonal patterns of credit card usage mean that the receivables outstanding can change substantially from month to month. In addition, the seller interest would be allocated dilutions from purchases that have been reversed and any ineligible receivables to back the ABS. The seller interest does *not* provide credit enhancement for the ABS, at least not directly. Credit enhancement for the ABS, discussed more fully later, is provided by subordinated securities in the investor interest, or by other structural features of the master trust.

As an issuer's credit card business grows, new accounts that meet the eligibility criteria may be added to a master trust. An account addition normally requires rating agency approval, unless it would amount to a relatively low percentage of the current receivables balance (usually 10% to 15%). Sponsors may also withdraw accounts from the master trust, again with rating agency approval. Sellers are obligated to add accounts if the seller interest falls below the minimum level. If the seller is unable to add receivables, then an early amortization event is triggered and investors begin to receive principal repayments immediately. The risk of an early amortization gives the seller a powerful incentive to support its credit card securitization, because it is often a substantial portion of the funding for the credit card business. Early amortization and sponsor support will be addressed more fully later in the chapter.

THE CREDIT CARD ABS LIFE CYCLE

Under normal circumstances, the life cycle of credit card ABS can be divided into two main periods after it has been issued: the revolving period and the amortization period. We discuss each in the following.

Revolving Period

During the revolving period, investors receive interest payments only. Principal collections on the receivables are used to purchase new receivables created from

customer card usage, or to purchase a portion of the seller interest if there are not enough new receivables being generated by the designated accounts. The revolving period can be used by an issuer to finance short-term credit card loans over an extended period of time. Furthermore, the revolving period is a structural device used to maintain a stable average life on the credit card ABS, and to create more certainty for investors for the expected maturity of the bonds.

Amortization Period

After the end of the revolving period, the amortization period begins and principal collections are used to repay the ABS investors. The length of the amortization period may vary depending on the monthly payment rate (MPR) of outstanding principal of the accounts in the master trust. The MPR is the un-annualized percentage of the principal receivables balance repaid each month. Trusts with slower MPRs would likely require longer amortization periods than those with faster MPRs. For example, credit card ABS with a five-year expected maturity might have a 48-month revolving period and then enter amortization for the final 12 months of its life. The amortization period of credit card ABS usually may be accomplished through either controlled amortization or controlled accumulation. Most trusts today favor a controlled accumulation of principal to pay off its maturing ABS.

In a *controlled amortization*, principal payments are made to ABS investors in equal payments during the amortization period (Exhibit 33–3). This simplified example assumes that one investor series has been issued out of the master trust. During the four-year revolving period, investors receive only interest payments and principal collections are used to purchase newly created credit card receivables. The total amount of receivables varies over time between $700 million and $800 million during the revolving period, and these fluctuations are absorbed by the seller interest. The seller interest percentage averages 19% through the first 48 months, well above the typical minimum levels. At the beginning of year five, the revolving period ends and the controlled amortization begins. In our example, investors receive principal payments in 12 equal installments, and principal collections not needed to repay ABS investors are used to purchase newly created receivables from the cardholders. Interest payments continue based on the declining principal balance of the ABS.

In a *controlled accumulation*, principal collections needed to repay ABS investors are deposited each month into a trust account and held until the expected maturity date (Exhibit 33–4). This example again assumes a four-year revolving period. At the end of the revolving period, principal collections are collected in 12 equal installments and excess principal collections are used to purchase new receivables. Interest payments to investors during the accumulation period are made based on the original outstanding invested amount. A single "bullet" payment of principal is made at maturity to the ABS investors. This structural device developed as a way to emulate the cash-flow characteristics of a corporate bond.

EXHIBIT 33–3

Controlled Amortization

Source: Wells Fargo Securities, LLC.

EXHIBIT 33–4

Controlled Accumulation

Source: Wells Fargo Securities, LLC.

It is generally referred to as a "soft bullet" because, like most securitizations of consumer assets, the legal final maturity of the ABS bond is beyond the expected maturity date of the bond to account for potential variations in principal collections.

Early Amortization

Under certain circumstances, such as poor credit performance or a financially troubled servicer, an early amortization of the master trust could occur as a mechanism to pay off ABS investors early and minimize their potential credit losses. In most trusts, trigger events are put in place to reduce the length of time that investors would be exposed to a troubled collateral pool. Exhibit 33–5 lists some common early amortization triggers found in credit card master trusts. If an early amortization trigger is hit, then a master trust with bonds still in their revolving periods would stop revolving and immediately begin to pass through principal collections to the ABS investors in order of priority. One structural enhancement available in most trusts to protect investors allows for principal to be passed through on an uncontrolled or rapid amortization basis. This mechanism diverts principal due to the seller interest towards payment of the ABS in order to get investors repaid more quickly.

EXHIBIT 33–5

Common Early Amortization Triggers

Collateral pool credit
Three-month average excess spread falls below zero.
Seller interest less than the minimum required level.
Collateral outstanding balance below the invested amount.
Seller/servicer events
Failure to make required deposits or payments.
Failure to transfer receivables to the trust when required.
Events of default, bankruptcy, or insolvency of the seller/servicer.
Breach of representations and warranties.
Legal issues
Trust is reclassified as an "investment company" under the Investment Company Act of 1940.

Source: Various transaction prospectuses.

CASH-FLOW ALLOCATIONS

The collection of principal and interest on the credit card accounts and passing it through to the ABS trust is relatively straightforward. The allocation of cash-flows to investors and the sponsor can take on more complexity.

Groups

A credit card master trust may use the concept of a *group* to help allocate cash flow to different ABS issued by the trust. One or more groups may be established and each series of securities issued to investors would be assigned to a group. At its highest level, the master trust allocates cash flows pro rata between the investor and seller interests. The investor interest would be divided further at the group level. Although many trusts have only one group, others could have two or more. In trusts with more than one group, series of securities with similar characteristics would likely be grouped together. For example, all the fixed-rate coupon bonds could be in one group and all the floating-rate coupon bonds could be in another group. Any sharing of excess principal or finance charge collections, if called for in the cash-flow waterfall of the master trust, would be determined at the group level.

Principal Collections

Principal collections are allocated on a pro-rata basis to each series of ABS bonds in the same group based on the size of its outstanding principal balance. The allocation of principal to each series is determined by where that series is in its ABS life cycle. Series in their revolving period are allocated no principal collections. Their principal is reallocated and may be shared with other series that are amortizing to the extent it may be needed. The sharing of principal collections is a structural enhancement to ensure timely payment of principal to ABS investors. Principal collections that are not needed to repay investors are reinvested in new receivables.

For a series in its accumulation period, principal collections would be allocated to that series. The pro-rata amount of principal allocated to that series would be determined and fixed by its original principal balance at the beginning of its accumulation period. An additional advantage of the sharing of principal collections between series means that the issuer would have less idle cash sitting in a collection account. The repayment of a maturing ABS series could be accomplished more quickly than the monthly payment rate might imply. For example, an MPR of 10% would imply a 10-month accumulation period. However, if there is only one maturity occurring, then excess principal collections could be used to shorten the accumulation period and reduce the negative carry of cash in a collection account for an issuer.

Finance Charge Collections and Allocations

The primary components of the finance charge collections by a credit card master trust include the monthly interest collected on the outstanding account balance (the APR), any annual or late fees, recoveries on charged-off accounts, interchange, and discounted principal receivables. When expressed as a percentage of the trust's receivables balance, finance charge collections are called the *portfolio yield*. The portfolio yield can be thought of as the top-line, revenue number of the master trust.

Most master trusts in use today (master owner or issuance trusts) allocate finance charge collections on a *socialized* basis. In such a structure, finance charges are allocated to each series within a group based on need. Need is determined by the costs incurred by each series—the bond coupon, servicing fees, and allocated charge-offs based on the size of the series in the group. The expenses for the group are the weighted average of the expenses for each series. Since servicing and charge-offs are allocated on a pro-rata basis, the series with higher coupon costs would receive a larger allocation of finance charge collections. The advantage of this method is that collections are combined to help support higher-cost series. However, the fates of all series are linked—all bonds will receive payments as expected, or the entire trust will enter early amortization together.

A few legacy master trusts with bonds still outstanding use older securitization technology that allocates finance charges based first on the size of the series outstanding rather than sharing according to need at the top of the cash-flow waterfall. These are known as *nonsocialized* master trusts. In these trusts, each series receives a "floating" allocation of finance charges based on the outstanding invested amount of each series. Excess finance charge collections may or may not be shared based on the cash flow rules for the trust. A potential advantage of a nonsocialized trust is that the risk of early amortization can be more isolated at the series level rather than risking the unwinding of the entire trust. The disadvantage is that higher coupon series could be at relatively greater risk of early amortization if there is a shortfall in finance charge collections or charge-off rates increase sharply. The sharing of excess finance charges helps mitigate, but does not eliminate, this risk.

Principal Discounting, Interchange, and Recoveries

One of the key sources of support for credit card master trusts during the financial crisis of 2007–2009 was the discounting of principal receivables by the trust sponsors. This support mechanism had long been available to credit card ABS issuers, but it had rarely been used. Most master trust documents allow for the discounting of principal receivables, which are counted as finance charge collections. Discounting is a way to temporarily boost portfolio yield and excess spread. An issuer would most likely use this approach when a trust is under stress from lower finance charge collections and higher charge-off rates, and thus avoid an early amortization.

During the recession that began in December 2007, charge-off rates rose sharply and peaked in the 10% to 11% range by the middle of 2009. This weak credit performance reduced the excess spread substantially for most credit card master trusts. Since the level of excess spread is a major early amortization trigger many issuers supported their trusts by discounting principal receivables. Many of the major credit card ABS issuers supported their master trusts in this way.

Two other parts of the finance charge collection calculation deserve some additional attention: recoveries on defaulted accounts and interchange. *Recoveries* are generally reported as part of finance charge collections, and so they are accounted for in the calculation of the portfolio yield. As a result, when reviewing charge-off rates, it would be more consistent to analyze the gross default rate rather than the net charge off rate. That way any double counting of recovery collections would be avoided in the calculation of excess spread. This calculation of excess spread is discussed in more detail in the Credit Considerations section below. *Interchange* is a fee paid to the bank that issues the credit card. It compensates the bank for taking on credit risk and allowing a grace period before making a payment. Interchange is created when a bank discounts the amount paid to a merchant for a credit card transaction. It is shared by the merchant's bank, the bank issuing the credit card, and the clearing network (e.g., Visa or MasterCard) of the transaction.

CREDIT AND INVESTMENT CONSIDERATIONS

We analyzed above the key structural features and cash-flow allocations of a credit card master trust. In this section, we review some of the most important considerations for investors purchasing credit card ABS. Most investors in securitized products require an investment grade rating in order to add a security to a portfolio. Furthermore, many ABS investors focus more exclusively on bonds rated AAA by one or more credit rating agencies. Despite the moves by regulators to reduce the fixed income market's reliance on credit ratings, it seems likely that credit ratings will remain an important consideration for ABS investors for the foreseeable future because of a lack of a workable alternative.

In order to establish an investment grade rating on credit card ABS, credit enhancement is necessary to absorb potential losses on the collateral pool. The amount of credit enhancement needed will vary from one master trust to another based on the desired rating level and the credit performance of an issuer's credit card portfolio. In addition, the rating agencies will take into consideration the financial strength of the bank sponsoring the securitization. The credit rating of the bank sponsor has taken on even greater prominence in the rating agency review since the financial crisis of 2008–2009.

Credit Enhancement

Early credit card transactions carried letters of credit (LOCs) from commercial banks to guarantee the payment of the credit card ABS. However, the downgrades

of the corporate ratings of a number of credit enhancers exposed ABS investors to downgrades on their investments. Over time, internal forms of credit enhancement that do not rely explicitly on the corporate credit rating of an outside entity have become the norm in the credit card ABS market.

Excess Spread

Excess spread is perhaps the most important measure of the health of a credit card master trust, and it is the first line of defense against losses to bondholders. It is also a key early amortization trigger if the credit performance of the collateral pool begins to deteriorate. Excess spread is the finance charge cash flow left over each month after the investor coupon, servicing fees, and charge-offs have been allocated to the investor interest and the seller interest. The calculation of excess spread is straightforward, as shown in Exhibit 33–6, with the values expressed as annualized percentages of the outstanding receivables balance.

In most credit card master trusts, an early amortization trigger is based on the three-month moving average of excess spread. If the three-month average falls below zero, then the revolving period stops and all principal collections are used to pay off the outstanding ABS bonds. In a nonsocialized master trust, the excess spread trigger is applied at the series level, so an individual series could experience an early amortization without causing the entire master trust to wind down.

Cash Collateral Account

A *cash collateral account* (CCA) is a cash reserve funded at closing and held by the trust for the benefit of the ABS investors. In most trusts, the CCA is typically available as credit enhancement only to the lowest rated class of securities issued. For example, the Class C bonds in most master trusts (generally rated BBB) are supported by the excess spread and the CCA. The Class A and Class B bonds would have the Class C bonds and the excess spread as credit enhancement, but not the CCA. Investors should carefully note these types of structural features when reviewing credit card ABS. The cash to fund the CCA is usually lent by a

EXHIBIT 33–6

Excess Spread Calculation

Gross portfolio yield	20.0%
Less:	
Charge-offs	8.0%
Net portfolio yield	12.0%
Less:	
Investor coupon	3.5%
Servicing fee	1.0%
Excess spread	**7.5%**

Source: Wells Fargo Securities, LLC.

third party and invested in high-grade short-term securities until needed to be drawn on against shortfalls in cash flow due to rising charge-offs. Any draws on the CCA would be reimbursed at a later date from future excess spread.

Collateral Invested Amount

An alternative to a cash reserve is a *collateral invested amount* (CIA), which is a privately placed subordinated tranche available as credit enhancement to the bondholders. The CIA is placed with a third-party investor which may or may not require its investment to be rated by one or more credit rating agencies. The CIA can generally be considered an improvement over the CCA from the viewpoint of the issuer because this tranche is backed by collateral from the master trust rather than cash. The CIA tranche normally has the benefit of any spread account. Draws on the CIA may also be reimbursed through future excess finance charge collections.

Subordination

As the credit card ABS market has evolved, structures have become more complex to provide greater flexibility to issuers and to meet the demand of investors. In the alphabet soup of credit card ABS, LOCs have given way to CCAs or CIAs, which in turn have been replaced in most cases by rated subordinated securities as the market for subordinated bonds became larger, deeper, and more liquid. The subordinated bonds are placed with outside investors and tend to be rated in the single-A and triple-B categories. The generalized capital structure of a credit card master trust may look like the example in Exhibit 33–7.

EXHIBIT 33–7

Credit Card ABS Capital Structure

Source: Wells Fargo Securities, LLC.

In our example, the rating agencies have determined that the AAA-rated securities are 80% of the capital structure and require 20% subordination in addition to the expected excess spread and the implied support provided by the bank sponsor. Likewise, the Class B and Class C bonds are 12% and 8% of the capital structure, respectively. Issuing subordinated tranches to investors allows the issuer to reach a wider investor audience. As indicated earlier, the issuance trust structure allows an issuer to offer senior bonds separately from the subordinated bonds with varying maturities and coupon types.

Master Trust Credit Analysis

While some of the structures may have changed over time, the credit analysis of credit card master trusts has not changed substantially. For example, most credit analysts stress the historical performance of critical variables related to the cash flows to test the structural integrity of credit card ABS. A long period of credit performance over several credit cycles would be ideal when analyzing credit card ABS. Credit data that spans the 2007–2010 period would pick up a severe economic downturn that caused charge-off rates and delinquencies to increase sharply and put substantial stress on the credit card ABS sector. In addition, static pool vintage data would be helpful to see how performance or underwriting standards may have changed over time.

There are several key quantitative variables needed for analyzing credit card securitizations. They include portfolio yield, charge-off rate, delinquency rate, excess spread, monthly payment rate, monthly purchase rate, and the coupon paid to investors. Each of these variables is important for analyzing the ongoing health of a credit card master trust, and they play a role in analysis of a potential early amortization.

Portfolio Yield

As noted, portfolio yield is a measure of the income generated by the credit card receivables. While portfolio yield is driven largely by the annual percentage rate (APR) paid by the cardholders, annual fees and late fees can also boost yield. Furthermore, usage by accountholders is also important. All else equal, a portfolio with proportionately more revolving accounts relative to convenience users will translate into a higher portfolio yield (Exhibit 33–8).

Charge-Offs and Excess Spread

Excess spread has been discussed at length earlier in the chapter, and is perhaps the most important measure of the health of a credit card master trust. Charge-offs are the credit losses experienced by the portfolio and normally are taken when an account becomes 180 days past due (Exhibit 33–9). Peak losses on static pools of credit card accounts have been observed at about 24 months of seasoning. The juxtaposition of excess spread and charge-offs can be a powerful analytical tool for determining tiering among various credit card issuers.

EXHIBIT 33–8

Wells Fargo Securities Portfolio Yield Index

Source: Intex, Wells Fargo Securities, LLC.

Serious Delinquency Rate

A good leading indicator of future charge-offs is the delinquency rate for accounts 60 days or more past due (60+ dpd). The direction of serious delinquencies can point to important credit trends in credit card master trusts. For example, during the recession of 2007–2009, changes in the direction of 60+ dpd provided an early warning signal for the rapid increase in the charge-off rate of most credit card ABS deals.

EXHIBIT 33–9

Wells Fargo Securities Credit Card Indexes

Source: Intex, Wells Fargo Securities, LLC.

Monthly Payment Rate

The monthly payment rate (MPR) is an important, but often overlooked, variable in the analysis of credit card ABS because high MPRs can be a source of strength and implied credit enhancement when a portfolio comes under stress. For example, a large proportion of convenience users, while depressing portfolio yield, can increase payment rates sharply (Exhibit 33–10). The faster turnover of the receivables means that investors can be repaid more quickly in the event of an early amortization.

Purchase Rate

Related to the payment rate is the purchase rate, which is generation of new receivables by the designated accounts. A higher purchase rate means that more receivables are being created to support the outstanding ABS. A bankruptcy or insolvency of the seller/servicer is the main risk with regard to the purchase rate because cardholders may stop using their cards as the utility declines. This risk can be particularly acute in private label or department store cards; however, this event can happen with bank cards as well. As the amount of receivables declines the credit quality of the portfolio is likely to deteriorate.

Investor Coupon

Floating-rate ABS may require more credit enhancement than fixed-rate bonds because the rating agencies assume in their stress scenarios that market interest rates increase dramatically. Higher funding costs for the ABS reduce the available excess spread to protect ABS investors.

EXHIBIT 33–10

Wells Fargo Securities Payment Rate Index

Source: Intex, Wells Fargo Securities, LLC.

Testing Master Trust Structures

In general, stress testing a credit card master trust structure would involve forcing portfolio yields, payment rates, and purchase rates down sharply at the same time that charge-off rates rise. This combination of factors compresses excess spread and causes an early amortization of the master trust. There have been only a few instances of early amortization, but in general charge-off rates do increase significantly, whereas purchase rates fall and the payment rate drops to a minimal level of about 3%. Interestingly, portfolio yield has held up relatively well in these instances. In addition, early amortization tends to have hit weaker, less diversified issuers of credit card ABS.

There are also some important qualitative elements that should go into any analysis. For example, geographic concentration, the strategic objectives of the firm, seasoning of the accounts, and the type of card (general purpose card or private label card). The underwriting standards for new accounts can also play a role in the analysis. These types of qualitative factors can help to determine the degree of stress to apply to various quantitative factors.

As the credit card lending market has consolidated over the past decade, geographic concentration has probably become less of a concern. Most major credit card issuers of general purpose cards, such as those banks that offer Visa, MasterCard, Discover, or American Express, try to source accounts from the general population. However, market pricing of credit card ABS often takes into account the corporate credit quality of the bank sponsor. Stronger banks can offer deeper pockets and more support to its credit card master trust in times of stress than a weaker bank. This tiering became more significant during the financial crisis of 2008–2009.

Credit card lenders have long used certain marketing programs to gain market share and build brand loyalty among cardholders. These programs can play a role in the credit profile of the accounts backing the master trust.

Teaser Rates

For example, lenders may use offers with a low initial APR and no annual fee to lure customers away from competitors. This use of "teaser rates" may also allow borrowers to transfer existing balances from higher rate cards to the new teaser rate. These teaser rate programs may be available for only a limited time, such as 6 to 12 months. One of the potential problems with this approach is that it can create adverse selection in the account base. Borrowers with a poor credit history may be more likely to respond to the cheaper terms of credit. Most banks tend to use these programs on a targeted base of potential applicants in order to mitigate the likelihood of lending to weaker borrowers.

Affinity and Co-Branded Programs

One of the major uses of the technological investment made by credit card issuers has been in the customer retention effort. A package of interest rates, credit limits, and other services can be offered to entice customers to stay once the teaser period

ends. These packages can come in myriad combinations and can be offered based on the credit profile and usage patterns of the cardholder. This strategy of mass customization is made possible by sophisticated computer systems that search huge databases and track the credit history and profitability of existing customers.

Two products created by card issuers to differentiate themselves in the minds of cardholders are affinity and co-branded programs. Affinity cards are issued by a bank in association with a special interest group such as a college alumni association, professional group, or sports team. The group receives a fee from the bank, and the bank gets to market its card to a demographic that it wants to attract. Co-branded cards are programs that associate a bank's credit card with a commercial firm. Customers can earn certain rewards from the firm for making purchases with the card. Mileage awards with airlines, for example, are some of the most popular co-branded programs. However, gasoline companies and hotel chains also make use of these programs to build customer loyalty.

Private Label Credit Cards

The objectives of private label credit card issuers may be somewhat different from those of the general purpose card programs. Private label credit card programs are sponsored by retailers for use in their own stores as a means of boosting sales, although over the past several years the administration of these programs has moved from the retailers themselves to banks that specialize in private label credit cards. Underwriting may be less stringent than that of a general purpose card program, and losses would normally be expected to be higher for credit card ABS backed by private label accounts. On the other hand, APRs and portfolio yields tend to be much higher to compensate for the greater risk. The market pricing of the ABS issued by private label programs tends to be at a concession to that of benchmark, general purpose card programs. Good relative value can be found among private label credit card ABS issuers by investors willing to investigate them.

KEY POINTS

- The securitization of credit card receivables began in 1987, and the credit card ABS market grew rapidly over the years to become one of the largest securitization sectors. many investors making their initial foray into ABS would likely dip their toes into credit cards before wading into the many other asset classes available.
- Credit card ABSs are structured using a master trust structure. The credit card bank pledges certain accounts, and all of the receivables generated by the accounts, to the trust. The issuer establishes a single trust that can accept periodic additions of accounts and issue multiple series of securities. All of the securities issued by the master trust are supported by the interest and principal collections from all of the receivables contributed to it. The collateral pool is not segmented to support any individual securities.

- The revolving nature of credit card receivables created unique challenges for securitization. As a result, the master trust structure was developed to allow for a revolving period when only interest is paid to investors, and an amortization period when principal is allocated to pay bondholders.
- The master trust is segmented between the investor interest and the seller interest. The investor interest is the ABS sold to third-party investors. The seller interest is the bank's retained interest in the collateral pool. The seller interest aligns the incentives of the issuer with outside investors because they share in the collections and losses of the collateral pool.
- Bonds carrying credit ratings require credit enhancement to achieve investment grade ratings. Most credit card ABS utilize internal credit enhancement in the form of subordination and excess spread.
- The key variables needed to do credit analysis on a credit card master trust are charge-offs, delinquencies, monthly payment rate, purchase rate, portfolio yield, and excess spread. In the event of distress, an early amortization of the trust could occur. Stressing these variables in a cash-flow model can help determine the structural soundness of the master trust.
- The bank sponsor of the credit card master trust is an important element in the review of credit card ABS. During the financial crisis of 2008–2009, most sponsors of credit card securitizations came to the aid of their ABS trusts. The ability of the sponsor to support its trust should be one of the factors to consider when buying credit card ABS.

CHAPTER
THIRTY-FOUR

SECURITIES BACKED BY AUTO LOANS AND LEASES, EQUIPMENT LOANS AND LEASES, AND STUDENT LOANS

JOHN MCELRAVEY, CFA
Director, Head of Consumer ABS Research
Wells Fargo Securities, LLC

The securitization of nonmortgage financial assets has been providing firms with direct access to the capital markets since 1985. It is generally accepted that the asset-backed securities (ABS) market first began with a computer lease transaction sponsored by Sperry Lease Finance Corporation. Shortly thereafter, auto loans were being financed using securitization technology. Many other types of consumer and commercial assets have been added to the mix, and the nonmortgage ABS market grew from these humble beginnings to about $800 billion outstanding by 2007. Since the financial crisis of 2008–2009, the ABS market shrunk from its peak, but it remains an important source of capital for the financial system. This chapter describes the securitization process and summarizes some of the key features of three of the larger asset classes in the ABS market: auto loans and leases, equipment loans and leases, and student loans. Securities backed by credit card receivables are covered in Chapter 33.

SECURITIZATION IN BRIEF

Securitization is a process in which financial assets are sold to a special purpose vehicle (SPV) from the originator of the assets. Assets securitized are primarily loans and leases, but many other types of receivables and financial obligations, such as accounts receivable or utility charges, have found their way into the ABS market. The use of an SPV in securitization is a critical step because the assets should be isolated from any potential bankruptcy of the originator. This bankruptcy remoteness allows the debt of the SPV to carry credit ratings that may be higher that those of the originator of the assets backing the securities sold to investors. The vast majority of ABS sold to investors, in fact, carry a AAA rating from one or more credit rating agencies. In the event of the insolvency or

bankruptcy of the originator, the cash-flows from the assets should be able to stand on their own to service the debt and not be consolidated with the bankruptcy estate.

The SPV issues securities to investors that are backed by the cash-flows generated by the assets. The assets are typically a diversified pool with hundreds or thousands of obligors. However, in some cases, there may be certain concentrations, either geographic, obligor, or industry, that may need to be mitigated in the structure or with additional credit enhancement. Interest collections on the assets are used to pay interest to the bondholders, and principal collections are used to repay principal to bondholders. As noted, investors rely on the underlying pool of collateral for repayment and not on the creditworthiness of the originator, or seller of the assets.

This is not to say that the originator or servicer of the collateral pool does not matter. On the contrary, the lender's ability to originate high-quality collateral and service the loans effectively is critical to the success of a securitization. Indeed, the rating agencies explicitly take account of those abilities when determining the amount of the credit enhancement (i.e., referred to as *sizing*) required to achieve the desired credit rating on the ABS. In most cases, the originator of the loans will also be the servicer.

Exhibit 34–1 displays a generalized schematic of the securitization process. After the assets (loans, leases, receivables, or the like) are sold to the SPV, the transaction can be structured and the securities sold to investors. Most ABS transactions offer a senior class of securities (Class A) that are usually rated AAA by one or more credit rating agencies. Subordinated securities, usually rated in the investment grade categories (AA to BBB), may also be offered to investors or they may be retained by the issuer.

The key to receiving credit ratings on ABS backed by a pool of unrated assets is the credit enhancement required. The amount of credit enhancement required will be related to the level of expected credit losses on the collateral pool. For example, a pool of auto loans to prime quality borrowers might be expected to generate credit losses of just 1% of the original balance of the loans. Alternatively, a pool of auto loans to subprime borrowers might be expected to generate losses of 10%. The ABS deal backed by the subprime loans would require substantially more credit enhancement to achieve the same rating than would the ABS deal backed by prime auto loans.

EXHIBIT 34–1

Securitization Flow Chart

Source: Wells Fargo Securities, LLC.

Credit Enhancement

The major types of credit enhancement for ABS transactions include internal sources and external sources. External sources are mainly bond insurance and corporate guarantees that link the rating of the ABS directly to the corporate credit rating of the guarantor. This method of credit enhancement came under severe stress during the financial crisis of 2008–2009, and has fallen out of favor to a large degree since then. Internal sources of credit enhancement include excess spread, cash reserve account, over-collateralization, and subordination. Some combination of them is found in almost every ABS deal.

Excess spread is the amount of interest collected above and beyond that needed to pay interest to bondholders and pay the ongoing expenses of the transaction. This is the first line of defense against losses in most ABS because it can absorb credit losses in each period. The excess interest usually goes back to the servicer if it is not used in a particular payment period, unless it is trapped in an account for the benefit of the bondholders.

A *cash reserve* account may be fully funded at the closing of the ABS transaction, or it may be added to or funded over time by retaining (i.e., trapping) the excess spread. The reserve account is available to provide the deal with additional liquidity in the event that interest or principal collections are less than expected. Cash reserve accounts may also allow funds to be distributed to the originator if credit performance meets certain objectives in terms of quantitative tests. Individual ABS transactions should be reviewed for the details of any reserve release conditions.

Over-collateralization (OC) is the amount of collateral in the pool that is in excess of the ABS bonds issued. For example, if the total collateral pool is $500 million and the ABS issued is $450 million, then the OC would be $50 million, or 10% of the collateral pool. This form of credit enhancement may be preferred by an originator that does not want to tie up cash in a reserve fund.

Finally, subordination is the issuance of other classes of securities that would be junior in priority for receiving principal repayment. Many ABS transactions have rated subordinated classes that are sold to third-party investors. Most structures have ratings on these securities from AA to BBB, but it is not unusual to see a BB-rated class at the bottom of the capital structure. This allows an issuer to receive a higher advance rate against its pool of receivables, and it can reach investors with differing risk profiles.

Credit Analysis of ABS

The credit analysis of ABS is mainly focused on the performance of the collateral pool. Due diligence of the originator of the loans and its servicing capabilities are still an important component of any credit analysis, but for purposes of this chapter the focus remains on the collateral. Here we simply mention the key data needed to track performance.

Delinquency rates provide a signal of future losses, and in particular serious delinquencies of more than 60 days past due. Defaults, net losses, and loss severity/recovery rates are used by the rating agencies to help determine credit enhancement levels, and can be tracked over time to see if credit performance is in line with expectations. Prepayment rates should be followed because most financial obligations can be repaid early, and almost every ABS deal is priced based on some expected level of loan prepayments. The extent to which prepayments vary from expectations can have significant effects on the valuation of ABS.

Finally, most ABS transactions give the issuer the right, although not the obligation, to exercise a clean-up call of the collateral when the pool balance reaches some predetermined level. The call is usually set around 10% of the original collateral balance, although it is not unusual to see the clean-up call set from 5% to 15%. It is important to note that the call is on the collateral pool, and not on the outstanding ABS bonds directly. The call is in place because the fixed costs of servicing become a larger portion as the pool balance declines and it allows the servicer to manage its securitization costs. The history of an issuer's clean-up call efficiency should be followed because the ability and willingness to exercise the call can have an impact on the valuation of ABS securities.

AUTO LOANS AND LEASES

One of the oldest and most active securitization sectors is the auto ABS sector. Since the 1980s, securitization has proved to be an attractive and efficient source of funding for auto finance companies. The auto ABS market has been predominantly based on auto loans to prime quality borrowers originated by the captive finance companies of large automakers. As investors showed growing acceptance of the ABS market during the 1990s, the economics of it brought new issuers that included smaller specialty finance firms as well as lenders to nonprime borrowers. Furthermore, consumers opted to lease new cars in increasing numbers over time, and this led to more auto lease ABS transactions. Auto ABS issuers can be divided into five broad groups: the Detroit Three, foreign automakers, bank lenders, independent finance companies, and subprime lenders. The auto finance sector has witnessed considerable consolidation over the years, especially among lenders to nonprime borrowers.

Auto ABS Structure

Auto loan ABS are typically issued using an owner trust structure, which is a legal form that allows for a time tranching of the senior class, as well as credit tranching to issue subordinated debt. The sequential senior bonds allow issuers to tailor issuance to meet the different maturity preferences of fixed income investors. For example, an auto owner trust may have a senior class that is divided into four subclasses as shown in Exhibit 34–2. The Class A1 tranche would be structured

EXHIBIT 34–2

Example Auto ABS Structure

Class	Weighted Avg. Life (Years)	Pricing Benchmark	Rating	Principal Payment Window (Months)
A1	0.3	Interp. LIBOR	A1 / P1	1–8
A2	1.0	EDSF	AAA / Aaa	8–16
A3	2.0	EDSF / Swaps	AAA / Aaa	16–34
A4	3.0 +	Swaps	AAA / Aaa	34–48
B	3 to 4	Swaps	Aa / AA	48–51
C	4.0+	Swaps	A2 / A	51–51
D	4.0+	Swaps	Baa / BBB	51–51

Other Internal Credit Enhancement
Cash Reserve Account
Over-collateralization
Excess Spread

Notes: Classes C and D subject to clean-up call.
EDSF used to price fixed-rate bonds with WAL < 2.0 years, swaps >= 2.0 years.
WAL and payment windows are for illustrative purposes only.
Source: Wells Fargo Securities, LLC.

with a short average life and would typically meet the requirements for Rule 2a-7 eligibility so that money market investors could buy it.

In addition, there would be classes with one- and two-year average lives, as well as a last cash-flow (LCF) senior bond, with an average life of three years or more. The LCF senior bond tends to have a more limited investor base than the other senior bonds because this class may have greater variability in its expected maturity. One or more subordinated classes also may be offered, usually with ratings from AA to BBB.

The pricing benchmarks for fixed-rate auto ABS depend on the weighted average life (WAL) of the bond. For example, the money market tranche would be priced against an interpolated LIBOR rate. If the WAL is 0.30 years, then the yield would be based on an interpolated LIBOR rate between three and four months. For bonds with average lives of 2.0 years or longer, the swap curve normally would be used as the pricing benchmark for the auto ABS. Bonds with average lives less than 2.0 years use the Eurodollar synthetic forward rate (EDSF), which is the rate implied by the prices of Eurodollar futures. This curve may deviate from the interpolated LIBOR rate implied by the cash market.

Since the underlying loans make payments of principal on a monthly basis, the principal is returned to investors also on a monthly basis. This structural artifact creates a "payment window" for each of the bonds. For example, Class A2

has a principal payment window from month 8 to month 16—a nine-month payment window. This feature is unlike credit card ABS (discussed below), in which the bonds are structured with a bullet payment of principal at the expected maturity date.

Investors generally prefer tighter principal payment windows that allow for less uncertainty as to WAL and valuation. The return of principal to investors can be affected by prepayments and defaults by borrowers, as well as the exercise of the clean-up call option by the issuer. The Class A2 bonds tend to be the largest class in an auto loan ABS deal, and the majority of the total amount of the bonds issued tends to be in the top of the capital structure to minimize the cost of issuance.

EQUIPMENT LOANS AND LEASES

Equipment loans and leases were some of the earliest nonmortgage assets to be securitized, and tend to be structured in a similar way to that used in the auto ABS sector and displayed in the example in Exhibit 34–2. Furthermore, trading in these securities generally use the auto ABS market as a guide to pricing, with equipment ABS normally offering a concession to benchmark auto ABS securities. Equipment loan transactions tend to look much like other types of securitizations in which interest from the loans is used to pay interest to bondholders and principal is used to repay principal. The securitization of lease receivables presents another problem for the deal structure because leases do not carry any sort of explicit interest rate. As a result, the lease collateral pool is discounted at the weighted average coupon of the securities plus any servicing fees and other expenses to create an interest component on the collateral.

Equipment securitizations may be backed by loans or leases of different types of equipment that fall into three broad categories based on the original cost of the equipment. For example, small ticket equipment pools, such as telephone systems, computers, or copying machines, tend to have an original cost of less than $100,000; mid-ticket equipment pools, such as some medical or larger printing equipment, have an original cost of $100,000 to $500,000; and large ticket equipment pools, such as agricultural or construction equipment, have an original cost of greater than $500,000.[1]

From a credit perspective, analysis of equipment ABS may be relatively labor intensive because of the specialized nature of many types of equipment. In addition, residual values of the equipment are important in lease deals because some items, especially certain types of small ticket equipment, may depreciate more quickly than others. The degree to which any residual value realizations have been securitized and included in the cash-flows of the transaction can have a critical impact, particularly for tranches that pay later in the priority of the capital structure.

1. These categories based on dollar size come from Fitch Ratings, *Criteria for Rating Equipment Lease and Loan ABS,* January 25, 2011.

Equipment ABS issuers and sponsors in some cases may also be smaller, specialty finance firms without a corporate credit rating that use securitization for the bulk of their term funding. In other cases, the issuers are large manufacturers with their own corporate credit ratings that use securitization as one method of funding to diversify their sources of credit in the capital markets.

STUDENT LOANS

Student loan ABS became the largest individual sector of the ABS market in the fourth quarter of 2010 at $248 billion. This amount compared with $206 billion for credit cards and $127 billion for autos. The student loan sector saw issuance decline during the financial crisis, but the total amount outstanding stabilized largely because prepayment rates slowed. The character of the student loan market is likely to shift over time as funding for student loans migrates from the private market to direct government lending, which is unlikely to be securitized.

The student loan ABS market became so large in the first place because education costs have increased faster than the ability of students and parents to pay tuition. Some of this funding gap has been filled by student loans made by private lenders and guaranteed by the government, and also by private student loans with no guarantee. The student loan ABS market follows these two broad categories.

Government Guaranteed Student Loans

The Federal Family Education Loan Program (FFELP) provides loans to students and parents for postsecondary education. FFELP loans are originated by a lender, which may be a bank, insurance company, state agency, or not-for-profit student loan company. The loans carry a guarantee from the federal government that covers interest on the loan and repayment of principal up to 97% of the original loan balance. There are four different types of loans available under the FFELP plan: subsidized Stafford, unsubsidized Stafford, PLUS, and consolidation loans. Subsidized Stafford loans are made to students who meet a financial needs test. Unsubsidized Stafford loans are available to students who do not qualify for the subsidized loans or have needs beyond the subsidized loan limits. PLUS loans are made to parents of students. Student borrowers can combine Stafford and PLUS loans into one consolidation loan and make one monthly payment.

A student's status in the school/repayment life cycle is a key factor determining the cash-flows in student loan ABS. When a Stafford loan is made and the student is enrolled in school, the borrower's status is "in school." The *in-school period* does not have a time limit, but would typically be one to four years depending on when the loan was made, the type of school, and the degree pursued. The in-school period is followed by a six-month *grace period* before the loan enters its *repayment period*. During the repayment period, the borrower is responsible for full payments of interest and principal on the student loans.

Borrowers with subsidized Stafford loans do not pay interest or principal during the in-school or grace periods, and the Department of Education makes the interest payments on behalf of the student during these periods. For unsubsidized Stafford loans, accrued interest is capitalized into the unpaid loan balance at the end of the status period. PLUS and consolidation loans enter into repayment of interest and principal 60 days after the funds are distributed to the student.

Once a borrower is in repayment, a loan can go into deferment or forbearance, which allows a borrower to delay payments of interest and principal. *Deferment* allows a borrower to postpone payments due to unemployment, economic hardship, entering public service, or the military. In these circumstances, deferment can be one to three years in length. For a borrower who goes on to further educational programs, there is usually no time limit on their deferment status. *Forbearance* may be used for borrowers who have lost a job or are having some other type of economic hardship. Forbearance may be granted in six- or 12-month periods, but the total time in forbearance cannot exceed three years. Different types of schools may carry different credit or prepayment risks. School types include two-year, four-year, graduate, and proprietary or for-profit schools.

Private Student Loans

The federal government has replaced the FFELP loans with direct lending from the government. Over time, the student loan ABS market should migrate toward more private loan deals. Private student loan ABS has generally been a very small sector in the past; however, as the cost of college rises, students and parents may need to tap other sources of funds to close the gap between cost and savings. Private student loans carry no federal government guarantee to compensate investors against defaults. In this regard, private student loans are more similar to other kinds of consumer credit, and pools of student loans are likely to be originated and serviced like other types of consumer ABS. One important difference, however, is that unlike other kinds of consumer credit, student loan debt cannot be discharged in bankruptcy. This factor provides some additional level of protection in terms of potential recovery on defaulted loans.

Private student loans may be disbursed directly to the student rather than through the financial aid office of the school. Direct-to-consumer (DTC) loans may show higher loss rates because the money never makes it to pay tuition, or because of the potential for fraud. Nevertheless, like government guaranteed student loans, the collateral performance of private student loans depend on a number of characteristics. Investors should look for investors that provide collateral pool information on the key risk factors in order to make an informed investment decision.

Like FFELP loans, the most significant collateral characteristics include the type of loan made for undergraduate, graduate school, proprietary/for profit, or a consolidation loan. The credit quality of the borrower very often using the FICO score is taken under consideration, as is whether the loan is cosigned by a parent or another party that may take responsibility for repaying the loan. As noted, if

the borrower receives the loan directly from the lender, then it may have a higher risk profile than a loan that is channeled through the school. The type of school plays a role in the credit profile if it is a two-year, four-year, or for-profit school. Like other kinds of consumer credit, the loan seasoning can be an indicator of risk. Generally, a pool of loans with more seasoning tends to be less risky than a pool of loans with little or no seasoning. The loan status—in-school, grace, repayment, deferment, or forbearance—with their differing cash-flows may create different risk profiles for a transaction.

Student Loan ABS Structure and Risks

Student loan ABS structures, like all securitizations, are designed to mitigate risks and create a situation in which investors can be repaid and the rating agencies can achieve investment grade ratings on the securities. In student loan ABS, the major risks are credit losses, liquidity, servicing, and interest rate and basis risk. Credit risk can be mitigated through credit enhancement that protects investors against principal writedowns. Excess spread is the first line of defense against credit losses, and is generated when the yield on the loans is greater than the cost of the liabilities in the securitization. Credit enhancement may be in the form of overcollateralization or subordination that is in a position to absorb losses ahead of rated securities.

Liquidity risk can be particularly acute in student loan ABS because pools of student loans may have a substantial number of loans that are not yet in repayment status. Loans that are in-school, grace, deferment, or forbearance may not pay principal or interest and therefore can decrease the cash-flow available for ABS investors. Liquidity support may be provided by a capitalized interest account that can be used to pay interest to bondholders before loans enter their repayment status. In addition, a reserve account may be part of the deal structure to provide liquidity as well as credit enhancement, much as it would in any other sort of ABS deal. Such a reserve account would be funded at closing and have a minimum level to protect investors against losses.

Interest-rate risk and basis risk may be higher in student loan ABS than in most other segments of the ABS market. The reason is that the borrower's interest rate may be either fixed or floating, and if floating it may be linked to a number of benchmarks, including the prime rate, Treasury bill, one-month LIBOR or three-month LIBOR. In most cases, the interest rate on the ABS is based on one- or three-month LIBOR. When both sides of the equation are floating, the interest-rate risk can be mitigated. However, there may be a mismatch in the timing when the interest rates on the loans reset compared with the reset on the ABS. This situation leads to the potential for the collateral pool to provide excess spread.

Servicer risk is an important component of a securitization because the lender originates the collateral, is responsible for adequate underwriting, and then must have the capabilities to collect the interest and principal from borrowers and minimize the losses from defaults. On a student loan ABS deal backed by FFELP

loans, the collateral pool has the benefit of the government guarantee, so losses would be mitigated through the guarantee. However, the servicer must comply with the rules and regulations set down by the Department of Education in order to get the full benefit of the guarantee for the ABS investors. Private student loans do not have the benefit of a government guarantee, so the underwriting and servicing of the loans must stand on the lender/servicer ability to collect on the loans. The ability of borrowers to delay repayment through various stages of the student loan life cycle suggests that the capability of the servicer can play an important role in the long-run quality of student loan ABS.

KEY POINTS

- Securitization is a process where the cash-flows from financial assets—interest and principal—are used to back payments on securities sold to investors.
- Assets securitized are primarily loans and leases, but many other types of receivables and financial obligations, such as accounts receivable or utility charges, have found their way into the ABS market.
- Securitizations are usually structured as bankruptcy-remote vehicles to isolate the assets from any potential bankruptcy of the originator. This bankruptcy remoteness allows the ABS debt to carry credit ratings that may be higher than those of the originator of the assets backing the securities sold to investors. The vast majority of ABS sold to investors, in fact, carry a AAA rating from one or more credit rating agencies.
- Credit enhancement in the form of over-collateralization, excess spread, subordination, and/or cash reserve accounts may be used in combination to protect investors against credit writedowns on their bonds.
- The credit analysis of ABS is based primarily on the delinquencies, defaults, prepayments, and historical cash-flows of the underlying collateral. The credit quality of the originator of the assets plays an indirect role since the servicing of the collateral pool is important for maximizing the value for investors.
- Outside of the credit card ABS sector, the largest segments of the market are auto loans and leases, equipment loans and leases, and student loans.
- The structures of different ABS asset classes will depend upon the cash-flow profile of different kinds of loans or leases. Structures will be put together to mitigate risks that may be unique to each different type of asset class.

CHAPTER
THIRTY-FIVE

COLLATERALIZED LOAN OBLIGATIONS

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

A collateralized debt obligation (CDO) is a structured financial product backed by a diversified pool of one or more types of debt obligations. The pool is usually managed by an asset manager. A CDO issues debt and equity and utilizes the proceeds received to acquire a portfolio of debt obligations. The cash-flows from the pool of debt obligations are distributed to the holders of the CDO's various liabilities in prescribed ways that take into account the relative seniority of those liabilities.

Issuance of CDOs backed by pools of corporate bonds, residential mortgage-backed securities, commercial mortgage-backed securities, and asset-backed securities has ceased, and few market observers believe these types of CDOs will be issued in the future. A CDO backed by a pool of bank loans is called a *collateralized loan obligation* (CLO). This type of CDO continues to be issued and is the subject of this chapter.

The terminology regarding what is a CLO can be confusing. A CLO is a distinct legal entity that, as explained later, is established as a bankruptcy-remote entity and is the issuer of the securities that investors can purchase.[1] The confusion is that the CLO is both the issuer of securities and the securities issued are also referred to as CLOs. That is, a CLO can mean the issuer and the securities issued by the CLO. The context in which CLO is used in the chapter will make it clear how the term is used.

There are four key attributes of a CLO: assets, capital structure, purpose for creation, and credit structure. We briefly describe each in this chapter.[2]

ASSETS

The assets of a CLO are corporate loans, most always performing leveraged loans. As explained in Chapter 13, leveraged bank loans are loans to corporations with a

This chapter greatly benefited from discussions and feedback from Douglas J. Lucas.

1. Typically a CLO is incorporated in the Cayman Islands.
2. For a more detailed discussion of CLOs, see Stephen J. Antczak, Douglas J. Lucas, and Frank J. Fabozzi, *Leveraged Finance: Concepts, Methods, and Trading of High-Yield Bonds, Loans, and Derivatives* (Hoboken, NJ: John Wiley & Sons, 2009).

speculative-grade rating. But some CLOs have been backed by pools of defaulted and distressed loans and some have been backed by a pool of investment-grade loans. Instead of buying loans, some CLOs have gained exposure to loans by selling credit protection on loans or loan obligors via credit default swaps. In these transactions, the CLO obligates itself to pay what is essentially the credit loss associated with a default of a loan.

CAPITAL STRUCTURE

A CLO's capital structure includes senior debt, mezzanine debt, subordinated debt, and equity. The securities issued by a CLO are commonly referred to as *tranches* and labeled in an offering as Class A, Class B, Class C, and so forth going from top (in terms of payment seniority) to the bottom of the capital structure. They range from the most secured triple A rated tranche with the greatest amount of subordination beneath it, to the most levered, unrated equity tranche. A simplified tranche structure for a CLO backed by a pool of leveraged loans is shown in Exhibit 35–1.

A CLO is created so as to be a "bankrupt remote entity," and this is accomplished by establishing a special purpose entity (SPE) that affords that protection. A very important aspect of a CLO's bankruptcy remoteness is the absolute seniority and subordination of the CLO's debt tranches to one another. Even if it is a certainty that some holders of the CLO's debt will not receive their full principal and interest, cash-flows from the CLO's assets are still distributed according to the distribution rules dictated by seniority. The CLO cannot go into bankruptcy, either voluntarily or through the action of an aggrieved creditor. In fact, the need for bankruptcy is obviated because the distribution of the CLO's cash-flows, even if the CLO is insolvent, has already been determined in detail at the origination of the CLO. But within the stipulation of strict seniority, there is great variety in the features of CLO debt tranches. The driving force in creating a CLO structure is to raise funds at the lowest possible cost. This is done so that the CLO's equity holder, who is at the bottom of the chain of seniority, can get the most residual cash-flow.

EXHIBIT 35–1

Simple, Typical CLO Tranche Structure

Tranche	Percent of Capital Structure	Rating	Coupon
Class A	77.50	AAA	LIBOR + 30
Class B	9.00	A	LIBOR + 80
Class C	2.75	BBB	LIBOR + 190
Class D	2.75	BB	LIBOR + 480
Equity	8.00	NR	Residual Cash-Flow

CREATION PURPOSE

CLOs are created for one of two purposes: balance sheet or arbitrage. The latter is the more common purpose.

In the case of a balance sheet CLO, the bank sells loans to a CLO for one or more of the following reasons: (1) reduce the size of its balance sheet, (2) reduce required regulatory capital, (3) reduce required economic capital, or (4) achieve cheaper funding costs. Selling the loans to a CLO removes them from the bank's balance sheet and therefore lowers the bank's regulatory capital requirements. This is true even if the bank is required to buy some of the equity of the newly created CLO.

The motivation for an arbitrage CLO is that an asset manager specializing in loans seeks to augment assets under management and management fees. It is the asset manager who assembles the initial portfolio of an arbitrage CLO and manages it according to prescribed guidelines set forth in the CLO's indenture. Investors wish to have the expertise of an asset manager specializing in leveraged loan portfolio management. Loans are purchased in the marketplace by the asset manager from many different sellers and put into the CLO. CLOs are another means, along with mutual funds and hedge funds, for an asset manager to provide a service to investors. The difference is that instead of all the investors sharing the fund's return in proportion to their investment, investor returns are also determined by the seniority of the CLO tranches they purchase.

These two purposes differentiate CLOs on the basis of how loans are acquired, the motivation for banks to sell loans, and the motivation of asset managers. From the perspective of CLO investors, all CLOs have a number of common purposes. One such purpose is the partitioning and allocation of the credit risk of the pool of loans among investor groups that have different risk appetites. Thus, both a triple A investor and a double B investor can invest in leveraged loans. Often, CLO debt provides a higher spread than comparable investments.

For the equity investor, a CLO provides a leveraged return on a diversified portfolio of leveraged loans without the need to obtain borrowing via repurchase agreements (repos) from a bank. It allows the investor to obtain nonrecourse long-term financing at a fixed spread to LIBOR. The equity investor in a CLO consequently has placed a loss limit equal to the cost of purchasing the equity tranche reduced by the prior distribution of cash from the CLO.

CREDIT STRUCTURES

CLOs have additional structural credit protections beyond the protection afforded by seniority and subordination of the CLO's capital structure. These credit structures fall into the category of either *cash-flow* or *market value* protections. We will only discuss the cash-flow credit structure here because it is the dominant credit enhancement mechanism in CLOs, being roughly 95% of all CLOs. The specifics of a CLO's cash-flow structure determine the risks taken on by various classes of CLO debt and equity and therefore the return profiles of those classes.

It is necessary to understand a CLO's *cash-flow waterfalls* in order to understand the cash-flow credit structure. There are two waterfalls in a cash-flow CLO: one for collateral interest and another for collateral principal. It is the cash-flow waterfalls that dictate the payment priority to the holders of the CLO tranches and thus enforce the seniority of one creditor in the structure over another. The cash-flow waterfalls specify *coverage tests* and the failure of such tests can result in the diversion of collateral cash-flow from subordinated CLO creditors to senior CLO creditors. The most important of these are the *par coverage tests*:

Class A Par Coverage Test = Asset Par/Class A Par
Class B Par Coverage Test = Asset Par/(Class A Par + Class B Par)
and so on, for all of the CLO debt tranches

The par of defaulted loans is reduced or excluded from Asset Par in the numerator of par coverage tests.

Here is a simple, typical *interest waterfall* in which collateral interest is applied to CLO creditors in the following order:

1. To the trustee for base fees and expenses
2. To the asset manager for base fees
3. To Class A for interest expense
4. If Class A coverage tests are failed, to Class A for principal repayment until Class A coverage tests are met
5. To Class B for interest expense
6. If Class B coverage tests are failed, to the senior-most outstanding tranche (which could be Class A or, if Class A has been paid in full, Class B) for principal repayment until Class B coverage tests are met
7. To Class C for interest expense
8. If Class C coverage tests are failed, to the senior-most outstanding tranche for principal repayment until Class C coverage tests are met

   (Steps 7 and 8 are repeated for remaining debt tranches)
9. An additional coverage test that determines whether an amount of collateral interest must be reinvested in additional collateral
10. Additional fees to the trustee
11. Additional fees to the asset manager
12. To the equity tranche, in accordance with any profit sharing agreement with the asset manager

Note that coverage tests force a decision to be made about whether to pay interest to a class or pay down principal on the senior-most outstanding class.

Here is a simple, typical *principal waterfall* in which collateral principal is applied to CLO creditors in the following order:

1. Amounts due in 1 through 8 of the interest waterfall that were not met with collateral interest
2. During the CLO's reinvestment period, to purchase new collateral assets
3. After the reinvestment period, for principal repayment of tranches in order of their priority
4. Amounts due in 9 through 12 of the interest waterfall

The purpose of the diversion of collateral interest is to provide greater protection to senior CLO tranches. The CLO's debt tranches can receive all their principal and interest even if collateral losses exceed the amount of subordination below them in the capital structure. The benefit of coverage tests to senior tranches depends on how soon the tests are breeched. The earlier the diversion of interest to senior tranches occurs, the greater is the collateral interest diverted over the remaining life of the collateral. The amount of cash that can be diverted is smaller if tests fail late in the CLO's life.

However, there are strategies that a CLO manager can employ to circumvent the protection of cash-flow diversion. "Par building" trades artificially improve par coverage tests by replacing relatively high price collateral with relatively low price collateral. For example, suppose that a CLO manager sells $6 million of loans at par and with the proceeds from the sale acquires $7 million par of loans selling at 85%. This action would inflate Asset Par by $1 million in the numerator of the par coverage test. Done in enough size, it could prevent a CLO from violating par coverage tests and keep cash flowing down the CLO's waterfall to the manager and equity holders.

KEY POINTS

- A CLO is a type of CDO in which the pool of assets consists of bank loans, typically leveraged loans.
- A CLO's capital structure includes senior debt, mezzanine debt, subordinated debt, and equity.
- CLOs are created for one of two purposes: balance sheet or arbitrage. Regardless of the purpose for the creation of a CLO, from a CLO investor's perspective the purpose is the partitioning and allocation of the credit risk of the pool of loans among investor groups that have different risk appetites.
- In addition to the protection afforded by seniority and subordination of the CLO's capital structure, there is another structural credit protection that allows the diversion of cash-flow to the senior-most tranche outstanding if prescribed coverage tests are not satisfied.

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PART

FOUR

TERM STRUCTURE OF INTEREST RATES

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CHAPTER
THIRTY-SIX

OVERVIEW OF FORWARD RATE ANALYSIS

ANTTI ILMANEN, PH.D.
Managing Director
AQR Capital Management (Europe) LLP

Over the years, advances have been made in both the theoretical and the empirical analysis of the term structure of interest rates. However, such analysis is often very quantitative, and it rarely emphasizes practical investment applications. In this chapter we briefly describe the computation of par, spot, and forward rates, present a framework for interpreting the forward rates by identifying their main determinants, and develop practical tools for using the information in forward rates in active bond portfolio management.

The three main influences on the Treasury yield-curve shape are (1) the market's expectations of future rate changes, (2) bond risk premiums (expected return differentials across bonds of different maturities), and (3) convexity bias. Conceptually, it is easy to divide the yield-curve (or the term structure of forward rates) into these three components. It is much harder to interpret real-world yield-curve shapes, but the potential benefits are substantial. For example, investors often wonder whether the curve steepness reflects the market's expectations of rising rates or a positive risk premium. The answer to this question determines whether a duration extension increases expected returns. It also shows whether we can view forward rates as the market's expectations of future spot rates. In addition, in this chapter we will explain how the market's curve reshaping and volatility expectations influence the shape of today's yield-curve. These expectations determine the cost of enhancing portfolio convexity via a duration-neutral yield-curve trade.[1]

This chapter is a revised version of a Citigroup (Salomon Brothers) research report. Such report remains the property of Citigroup, and its disclaimers apply. The author wishes to thank Larry Bader, Eduardo Canabarro, Ajay Dravid, Francis Glenister, Ray Iwanowski, Cal Johnson, Tom Klaffky, Rick Klotz, Stan Kogelman, Janet Showers, and Charlie Ye for their helpful comments.

1. Details on each of the three influences on the yield-curve can be found at Antti Ilmanen, "Market's Rate Expectations and Forward Rates," *Journal of Fixed Income* (September 1996), pp. 8–22; Antti Ilmanen, "Does Duration Extension Enhance Long-Term Expected Returns?" *Journal of Fixed Income* (September 1996), pp. 23–36; and Antti Ilmanen, "Convexity Bias in the Yield Curve," Chapter 3 in Narasimgan Jegadeesh and Bruce Tuckman (eds.), *Advanced Fixed-Income Valuation Tools* (New York: Wiley, 2000).

Forward rate analysis also can be valuable in direct applications. Forward rates may be used as break-even rates to which subjective rate forecasts are compared or as relative-value tools to identify attractive yield-curve sectors.[2]

COMPUTATION OF PAR, SPOT, AND FORWARD RATES

At the outset, it is useful to review the concepts yield-to-maturity, par yield, spot rate, and forward rate to ensure that we are using our terms consistently. Appendix 36A is a reference that describes the notation and definitions of the main concepts used in this chapter. Our analysis focuses on government bonds that have known cash-flows (no default risk, no embedded options). *Yield-to-maturity* is the single discount rate that equates the present value of a bond's cash-flows to its market price. *A yield-curve* is a graph of bond yields against their maturities. (Alternatively, bond yields may be plotted against their durations, as we do in many of the exhibits presented in this chapter.) The best-known yield-curves are the on-the-run Treasury curve and the interest-rate-swap curve. On-the-run bonds are the most recently issued government bonds at each maturity sector. Since these bonds are always issued with price near par (100), the on-the-run curve often resembles the *par yield-curve,* which is a curve constructed for theoretical bonds whose prices equal par. The swap curve based on receive-fixed, pay-floating contracts is by construction a par curve.

While the yield-to-maturity is a convenient summary measure of a bond's expected return—and therefore a popular tool in relative-value analysis—the use of a single rate to discount multiple cash-flows can be problematic unless the yield-curve is flat. First, all cash-flows of a given bond are discounted at the same rate, even if the yield-curve slope suggests that different discount rates are appropriate for different cash-flow dates. Second, the assumed reinvestment rate of a cash-flow paid on a given date can vary across bonds because it depends on the yield of the bond to which the cash-flow is attached. In this chapter we will show how to analyze the yield-curve using simpler building blocks—single cash-flows and one-period discount rates—than the yield-to-maturity, an *average* discount rate of multiple cash-flows with various maturities.

A coupon bond can be viewed as a bundle of zero-coupon bonds (zeros). It can be unbundled to a set of zeros that can be valued separately. Then these can be bundled back together into a more complex bond whose price should equal the

2. For a discussion of how to analyze many aspects of yield-curve trades, such as barbell-bullet trades, and a presentation of empirical evidence about their historical behavior, see Antti Ilmanen and Ray Iwanowski, "Dynamics of the Shape of the Yield Curve," *Journal of Fixed Income* (September 1997), pp. 47–60; and Chapter 37 in this Handbook.

sum of the component prices.[3] The *spot rate* is the discount rate of a single future cash-flow such as a zero. Equation (36.1) shows the simple relation between an n-year zero's price P_n and the annualized n-year spot rate s_n.

$$P_n = \frac{100}{(1+s_n)^n} \tag{36.1}$$

A single cash-flow is easy to analyze, but its discount rate can be unbundled even further to one-period rates. A multiyear spot rate can be decomposed into a product of *one-year forward rates,* the simplest building blocks in a term structure of interest rates. A given term structure of spot rates implies a specific term structure of forward rates. For example, if the m-year and n-year spot rates are known, the annualized forward rate between maturities m and n, that is, $f_{m,n}$, is easily computed from Eq. (36.2).

$$(1+f_{m,n})^{n-m} = \frac{(1+s_n)^n}{(1+s_m)^m} \tag{36.2}$$

The forward rate is the interest rate for a loan between any two dates in the future, contracted today. Any forward rate can be "locked in" today by buying one unit of the n-year zero at price $P_n = 100/(1 + s_n)^n$ and by shortselling P_n/P_m units of the m-year zero at price $P_m = 100/(1 + s_m)^m$. (Such a weighting requires no net investment today because both the cash inflow and cash outflow amount to P_n.) The one-year forward rate ($f_{n-1,n}$ such as $f_{1,2}, f_{2,3}, f_{3,4}, \ldots$) represents a special case of Eq. (36.3) where $m = n - 1$. The spot rate represents another special case where $m = 0$; thus $s_n = f_{0,n}$.

To summarize, a par rate is used to discount a set of cash-flows (those of a par bond) to today, a spot rate is used to discount a single future cash-flow to today, and a forward rate is used to discount a single future cash-flow to another (nearer) future date. The par yield-curve, the spot-rate curve, and the forward-rate curve contain the same information about today's term structure of interest rates.[4]

3. Arbitrage activities ensure that a bond's present value is very similar when its cash-flows are discounted using the marketwide spot rates as when its cash-flows are discounted using the bond's own yield-to-maturity. However, some deviations are possible because of transaction costs and other market imperfections. In other words, the term structure of spot rates gives a consistent set of discount rates for all government bonds, but all bonds' market prices are not exactly consistent with these discount rates. Individual bonds may be rich or cheap relative to the curve because of bond-specific-liquidity, coupon, tax, or supply effects.

4. These curves can be computed directly by interpolating between on-the-run bond yields (approximate par curve) or between zero yields (spot curve). Because these assets have special liquidity characteristics, these curves may not be representative of the broad Treasury market. Therefore, the par, spot, or forward rate curve is typically estimated using a broad universe of coupon Treasury bond prices. There are many different curve-fitting techniques, but a common goal is to fit the prices well with a reasonably shaped curve. This chapter does not focus on yield-curve estimation but on the interpretation and practical uses of the curve once it has been estimated.

EXHIBIT 36–1

Par, Spot, and One-Year Forward Rate Curves

If one set of rates is known, it is easy to compute the other sets.[5] Exhibit 36–1 shows a hypothetical example of the three curves. In Appendix 36B, we show how the spot and forward rates were computed based on the par yields.

In this example, the par and spot curves are monotonically upward-sloping, whereas the forward rate curve[6] is first upward-sloping and then inverts (because of the flattening of the spot curve). The spot curve lies above the par curve, and the forward rate curve lies above the spot curve. This is always the case if the spot curve is upward-sloping. If it is inverted, the ordering is reversed: The par curve is highest, and the forward curve lowest. Thus loose characterizations of one curve (e.g., steeply upward-sloping, flat, inverted, humped) generally are applicable to the other curves. However, the three curves are identical only if they are horizontal. The forward rate curve magnifies any variation in the slope of the spot curve. One-year forward rates measure the *marginal* reward for lengthening the maturity of the investment by one year, whereas the spot rates measure an investment's *average* reward from today to maturity n. Therefore, spot rates are (geometric) averages of one or more forward rates. Similarly, par rates are averages of one or more spot rates; thus par curves have the flattest

5. Further, one can use today's spot rates and Eq. (36.2) to back out implied spot curves for any future date and implied future paths for the spot rate of any maturity. It is important to distinguish the implied spot curve one year forward ($f_{1,2}, f_{1,3}, f_{1,4}, \ldots$), a special case of Eq. (36.2) where $m = 1$, from the one-year forward rate curve ($f_{1,2}, f_{2,3}, f_{3,4}, \ldots$). Today's spot curve can be subtracted from the former curve to derive the yield changes implied by the forwards. (This terminology is somewhat misleading because these "implied" forward curves/paths do not reflect only the market's expectations of future rates.)

6. Note that all one-year forward rates actually have a one-year maturity even though in the x axis of Exhibit 36–1 each forward rate's maturity refers to the final maturity. For example, the one-year forward rate between $n - 1$ and n ($f_{n-1,n}$) matures n years from today.

shape of the three curves. In Appendix 36C, we discuss further the relation between spot and forward rate curves.

It is useful to view forward rates as *break-even rates*. The implied spot rates one year forward ($f_{1,2}$, $f_{1,3}$, $f_{1,4}$, . . .) are, by construction, equal to such future spot rates that would make all government bonds earn the same return over the next year as the (riskless) one-year zero. For example, the holding-period return of today's two-year zero (whose rate today is s_2) will depend on its selling rate (as a one-year zero) in one year's time. The implied one-year spot rate one year forward ($f_{1,2}$) is computed as the selling rate that would make the two-year zero's return [the left-hand side of Eq. (36.3)] equal to the one-year spot rate [the right-hand side of Eq. (36.3)]. Formally, Eq. (36.3) is derived from Eq. (36.2) by setting $m = 1$ and $n = 2$ and rearranging.

$$\frac{(1+s_2)^2}{1+f_{1,2}} = 1+s_1 \tag{36.3}$$

Consider an example using numbers from Exhibit 36B–1 in Appendix 36B, where the one-year spot rate (s_1) equals 6% and the two-year spot rate (s_2) equals 8.08%. Plugging these spot rates into Eq. (36.3), we find that the implied one-year spot rate one year forward ($f_{1,2}$) equals 10.20%. If this implied forward rate is exactly realized one year hence, today's two-year zero will be worth 100/1.1020 = 90.74 next year. Today, this zero is worth $100/1.0808^2 = 85.61$; thus its return over the next year would be 90.74/85.61 − 1 = 6%, exactly the same as today's one-year spot rate. Thus 10.20% is the break-even level of the future one-year spot rate. In other words, the one-year rate has to increase by more than 420 basis points (10.20% − 6.00%) before the two-year zero underperforms the one-year zero over the next year. If the one-year rate increases, but by less than 420 basis points, the capital loss of the two-year zero will not fully offset its initial yield advantage over the one-year zero.

More generally, if the yield changes implied by the forward rates are realized subsequently, all government bonds, regardless of maturity, earn the same holding-period return. In addition, all self-financed positions of government bonds (such as long a barbell versus short a bullet) earn zero return; that is, they break even. However, if the yield-curve remains unchanged over a year, each n-year zero earns the corresponding one-year forward rate $f_{n-1,n}$. This can be seen from Eq. (36.2) when $m = n - 1$; $1 + f_{n-1,n}$ equals $(1 + s_n)^n/(1 + s_{n-1})^{n-1}$, which is the holding-period return from buying an n-year zero at rate s_n and selling it one year later at rate s_{n-1}. Thus the one-year forward rate equals a zero's horizon return for an unchanged yield-curve. See Appendix 36C for details.

MAIN INFLUENCES ON THE YIELD-CURVE SHAPE

In this section we describe some economic forces that influence the term structure of forward rates or, more generally, the yield-curve shape. The three main influences are the market's rate expectations, the bond risk premiums (expected return

differentials across bonds), and the so-called convexity bias. In fact, these three components fully determine the yield-curve; it can be shown that the difference between each one-year forward rate and the one-year spot rate is approximately equal to the sum of an expected spot-rate change, a bond risk premium, and the convexity bias.[7] We first discuss separately how each component alone influences the curve shape and then analyze their combined impact.

Expectations

It is clear that the market's expectations of future rate changes are one important determinant of the yield-curve shape. For example, a steeply upward-sloping curve may indicate market expectations of near-term Fed tightening or of rising inflation. However, it may be too restrictive to assume that the yield differences across bonds with different maturities *only* reflect the market's rate expectations. The well-known pure expectations hypothesis has such an extreme implication. The *pure expectations hypothesis* asserts that all government bonds have the same near-term expected return (as the nominally riskless short-term bond) because the return-seeking activity of risk-neutral traders removes all expected return differentials across bonds. Near-term expected returns are equalized if all bonds that have higher yields than the short-term rate are expected to suffer capital losses that offset their yield advantage. When the market expects an increase in bond yields, the current term structure becomes upward-sloping so that any long-term bond's yield advantage and expected capital loss (owing to the expected yield increase) exactly offset each other. Stated differently, if investors expect that their long-term bond investments will lose value owing to an increase in interest rates, they will require a higher initial yield as a compensation for duration extension. Conversely, expectations of yield declines and capital gains will lower current long-term bond yields below the short-term rate, making the term structure inverted.

The same logic—that positive (negative) initial yield spreads offset expected capital losses (gains) to equate near-term expected returns—also holds for combinations of bonds, including duration-neutral yield-curve positions. One example is a trade that benefits from the flattening of the yield-curve between two- and ten-year maturities: selling a unit of the two-year bond, buying a duration-weighted amount (market value) of the ten-year bond, and putting the remaining proceeds from the sale to "cash" (very short-term bonds). Given the typical concave yield-curve shape, such a curve-flattening position earns a negative carry.[8] The trade will be profitable only if the curve flattens enough to offset the impact of the negative carry. Implied forward rates indicate

7. The proof is provided in the appendix to Chapter 37.

8. A concave shape means that the (upward-sloping) yield-curve is steeper in the front end than in the long end. The yield loss of moving from the two-year bond to cash is greater than the yield gain of moving from the two-year bond to the ten-year bond. Thus the yield earned from the combination of cash and tens is lower than the forgone yield from twos.

EXHIBIT 36–2

Yield Curves Given the Market's Various Rate Expectations

how much flattening (narrowing of the two- to ten-year spread) is needed for the trade to break even.

In the same way as the market's expectations regarding the future level of rates influence the *steepness* of today's yield-curve, the market's expectations regarding the future steepness of the yield-curve influence the *curvature* of today's yield-curve. If the market expects more curve flattening, the negative carry of the flattening trades needs to be larger (to offset the expected capital gains), which makes today's yield-curve more concave (curved). Exhibit 36–2 illustrates these points. This figure plots coupon bonds' yields against their durations or, equivalently, zeros' yields against their maturities, given various rate expectations. Ignoring the bond risk premium and convexity bias, if the market expects no change in the level or slope of the curve, today's yield-curve will be horizontal. If the market expects a parallel rise in rates over the next year (but no reshaping), today's yield-curve will be linearly increasing (as a function of duration). If the market expects rising rates *and* a flattening curve, today's yield-curve will be increasing and concave (as a function of duration).[9]

Bond Risk Premium

A key assumption in the pure expectations hypothesis is that all government bonds, regardless of maturity, have the same expected return. In contrast, many theories and empirical evidence suggest that expected returns vary across bonds. We define the *bond risk premium* as a longer-term bond's expected one-period return in excess of the one-period bond's riskless return. A positive bond risk

9. For a detailed treatment of these issues, see Ilmanen, "Market's Rate Expectations and Forward Rates," *op. cit.*

premium would tend to make the yield-curve slope upward. Various theories disagree about the sign (+/–), the determinants, and the constancy (over time) of the bond risk premium. The classic liquidity premium hypothesis argues that most investors dislike short-term fluctuations in asset prices; these investors will hold long-term bonds only if they offer a positive risk premium as a compensation for their greater return volatility. Also, some modern asset-pricing theories suggest that the bond risk premium should increase with a bond's duration, its return volatility, or its covariance with market wealth. In contrast, the preferred-habitat hypothesis argues that the risk premium may decrease with duration; long-duration liability holders may perceive the long-term bond as the riskless asset and require higher expected returns for holding short-term assets. While academic analysis focuses on risk-related premiums, market practitioners often emphasize other factors that cause expected return differentials across the yield-curve. These include liquidity differences between market sectors, institutional restrictions, and supply and demand effects. We use the term *bond risk premium* broadly to encompass all expected return differentials across bonds, including those caused by factors unrelated to risk.

Historical data on U.S. Treasury bonds provide evidence about the empirical behavior of the bond risk premium. For example, the fact that the Treasury yield-curve has been upward-sloping more than 90% of the time in recent decades may reflect the impact of positive bond risk premiums. Historical average returns provide more direct evidence about expected returns across maturities than do historical yields. Even though weekly and monthly fluctuations in bond returns are mostly unexpected, the impact of unexpected yield rises and declines should wash out over a long sample period. Therefore, the *historical average returns* of various maturity sectors over a relatively trendless sample period should reflect the *long-run expected returns*.

Exhibit 36–3 shows the empirical average return curve as a function of average duration and contrasts it with a popular theoretical expected return curve, one that increases linearly with duration. The theoretical bond risk premiums are measured in the exhibit by the difference between the annualized expected returns at various duration points and the annualized return of the riskless one-month bill (the leftmost point on the curve). Similarly, the empirical bond risk premiums are measured by the historical average bond returns (at various durations) in excess of the one-month bill.[10] Historical experience suggests that the bond risk premiums are not linear in duration but that they increase steeply with duration in the

10. The empirical bond risk premiums are based on the compound average returns of various maturity-subsector portfolios of Treasury bills, notes, and bonds between 1952 and 2009. This period does not have an obvious bullish or bearish bias because long-term yields were at broadly similar levels at the beginning and end of the sample. Moreover, the sample period begins just after the "Treasury-Fed accord" ended a decade of regulated (capped) bond yields. Arithmetic average returns would be somewhat higher than these compound average returns (at the longest maturities 0.2-0.4% higher). This evidence is from Chapter 9 in Antti Ilmanen, *Expected Return* (Hoboken, NJ: John Wiley & Sons, 2011), which discusses bond risk premiums but focuses mainly on forward-looking measures of such premiums.

EXHIBIT 36–3

Theoretical and Empirical Bond Risk Premiums

front end of the curve and much more slowly after two years. The concave shape may reflect the demand for long-term bonds from pension funds and other long-duration liability holders.

Exhibit 36–3 may give us the best empirical estimates of the long-run average bond risk premiums at various durations. However, empirical studies also suggest that the bond risk premiums are not constant but vary over time. That is, it is possible to identify in advance periods when the near-term bond risk premiums are abnormally high or low. These premiums tend to be high after poor economic conditions when the yield-curve is steep, amid high inflation expectations and related inflation uncertainty. These premiums tend to be lower and even turn negative when Treasury prices benefit from safe-haven premiums (amid equity market weakness and negative stock-bond correlation, as in 1998 and 2002) or from scarcity premiums (amid fiscal surpluses and expectations of dwindling government bond markets, as in 2000).[11]

Convexity Bias

The third influence on the yield-curve—convexity bias—is probably the least well known. Different bonds have different convexity characteristics, and the convexity differences across maturities can give rise to (offsetting) yield differences. In particular, long-term bonds exhibit very high convexity (see panel *a* of

11. Long-run average return differentials across bonds with different maturities are discussed in Ilmanen, "Does Duration Extension Enhance Long-Term Expected Returns?" *op. cit.* Near-term expected return differentials across bonds and the time variation in the bond risk premiums are discussed in Antti Ilmanen, "Forecasting U.S. Bond Returns," *Journal of Fixed Income* (June 1997), pp. 22–37. A more recent study, Antti Ilmanen, "Stock-Bond Correlations," *Journal of Fixed Income* (September 2003), pp. 55–66, focuses on stock-bond correlation as a determinant of bond risk premium but also discusses other determinants.

EXHIBIT 36–4 (a)

Illustration of Convexity Bias

Exhibit 36–4), which tends to depress their yields. *Convexity bias* refers to the impact these convexity differences have on the yield-curve shape.

Convexity is closely related to the nonlinearity in the bond price-yield relationship. All noncallable bonds exhibit positive convexity; their prices rise more for a given yield decline than they fall for a similar yield increase. All else being equal, positive convexity is a desirable characteristic because it increases bond return (relative to return in the absence of convexity) whether yields go up or down—as long as they move somewhere. Because positive convexity can only improve a bond's performance (for a given yield), more convex bonds tend to have lower yields than less convex bonds with the same duration.[12] In other words, investors tend to demand less yield if they have the prospect of improving their returns as a result of convexity. Investors are primarily interested in expected returns, and these high-convexity bonds can offer a given expected return at a lower yield level.

Panel *b* of Exhibit 36–4 illustrates the pure impact of convexity on the curve shape by plotting the spot-rate curve and the curve of one-year forward rates when all bonds have the same expected return (8%) and the short-term rates are expected

12. The degree of convexity varies across bonds, mainly depending on their option characteristics and durations. Embedded short options decrease convexity. For bonds without embedded options, convexity increases roughly as a square of duration (see Exhibit 36–4). There also are convexity differences between bonds that have the same duration. A barbell position (with very dispersed cash-flows) exhibits more convexity than a duration-matched bullet bond. The reason is that a yield rise reduces the relative weight of the barbell's longer cash-flows (because the present values decline more than those of the shorter cash-flows) and thereby shortens the barbell's duration. The inverse relation between duration and yield level increases a barbell's convexity, limiting its losses when yields rise and enhancing its gains when yields decline. Of all bonds with the same duration, a zero has the smallest convexity because its cash-flows are not dispersed, so its Macaulay duration does not vary with the yield level.

EXHIBIT 36–4 (b)

Pure Impact of Convexity on the Yield-Curve Shape

to remain at the current level. With no bond risk premiums and no expected rate changes, one might expect these curves to be horizontal at 8%. Instead, they slope down at an increasing pace because lower yields are needed to offset the convexity advantage of longer-duration bonds and thereby to equate the near-term expected returns across bonds.[13] Short-term bonds have little convexity, so there is little convexity bias at the front end of the yield-curve, but convexity can have a dramatic impact on the curve shape at very long durations. Convexity bias can be one of the main reasons for the typical concave yield-curve shape (i.e., for the tendency of the curve to flatten or invert at long durations).

The value of convexity increases with the magnitude of yield changes. Therefore, increasing volatility should make the overall yield-curve shape more concave (curved) and widen the spreads between more and less convex bonds (duration-matched coupon bonds versus zeros and barbells versus bullets).[14]

Putting the Pieces Together

Of course, all three forces influence bond yields simultaneously, making the task of interpreting the overall yield-curve shape quite difficult. A steeply upward-sloping curve can reflect either the market's expectations of rising rates or a high

13. Convexity bias is closely related to the distinction between different versions of the pure expectations hypothesis. Earlier we referred to *the* pure expectations hypothesis. In fact, there are alternative versions of this hypothesis that are not exactly consistent with each other. The local-expectations hypothesis (LEH) assumes that "all bonds earn the same expected return over the next period" whereas the unbiased-expectations hypothesis (UEH) assumes that "forward rates equal expected spot rates." In panel *b* of Exhibit 36–4, the LEH is assumed to hold; thus UEH is not exactly true. The expected future short rates are flat at 8% even though the curve of one-year forward rates is inverted. In yield terms, the difference between the LEH and the UEH is the convexity bias.

14. For detailed discussion of this topic, see Ilmanen, "Convexity Bias in the Yield Curve," *op. cit.*

required risk premium. A strongly humped curve (i.e., high curvature) can reflect the market's expectations of either curve flattening or high volatility (which makes convexity more valuable) or even the concave shape of the risk premium curve.

In theory, the yield-curve can be neatly decomposed into expectations, risk premiums, and convexity bias. In reality, exact decomposition is not possible because the three components vary over time and are not observable directly but need to be estimated.[15] Even though an exact decomposition is not possible, the analysis in this chapter should give investors a framework for interpreting various yield-curve shapes. Furthermore, our survey of earlier literature and our new empirical work evaluate which theories and market myths are correct (consistent with data) and which are false. The main conclusions are as follows:

- We often hear that "forward rates show the market's expectations of future rates." However, this statement is true only if no bond risk premiums exist and the convexity bias is very small.[16] If the goal is to infer expected short-term rates one or two years ahead, the convexity bias is so small that it can be ignored. In contrast, our empirical analysis shows that the bond risk premiums are important at short maturities. Therefore, if the forward rates are used to infer the market's near-term rate expectations, some measures of bond risk premiums should be subtracted from the forwards, or the estimate of the market's rate expectations will be strongly upward-biased.
- The traditional term-structure theories make the assumption of a zero risk premium (pure expectations hypothesis) or of a nonzero but *constant* risk premium (liquidity premium hypothesis, preferred-habitat hypothesis), which is inconsistent with historical data. According to the pure expectations hypothesis, an upward-sloping curve should predict increases in long-term rates so that a capital loss offsets the long-term bonds' yield advantage. However, empirical evidence shows that, on average, small declines in long-term rates, which *augment* the long-term bonds' yield advantage, follow upward-sloping curves. The steeper the yield-curve,

15. We show in other studies how interest-rate expectations can be measured using survey data, how bond risk premiums can be estimated using historical return data, and how the convexity bias can be inferred using option prices; see Ilmanen, "Market's Rate Expectations and Forward Rates," *op. cit.*; Ilmanen, "Does Duration Extension Enhance Long-Term Expected Returns?" *op. cit.*; and Ilmanen, "Convexity Bias in the Yield Curve," *op. cit.* Alternatively, all three components could be estimated from the yield-curve if one is willing to impose the structure of some term-structure model.
16. A related assertion claims that if near-term expected returns were not equal across bonds, it would imply the existence of *riskless arbitrage opportunities*. This assertion is erroneous. It is true that if forward contracts were traded assets, arbitrage forces would require their pricing to be consistent with zero prices according to Eq. (36.2). However, the arbitrage argument says nothing about the economic determinants of the zero prices themselves, such as rate expectations or risk premia. The experience of 1994 and 1999 shows that buying long-term bonds is not riskless even if they have higher expected returns than short-term bonds.

the higher is the expected bond risk premium. This finding clearly violates the pure expectations hypothesis and supports hypotheses about time-varying risk premiums.

- Modern term-structure models make less restrictive assumptions than the traditional theories just mentioned. Yet many popular one-factor models assume that bonds with the same duration earn the same expected return. Such an assumption implies that duration-neutral positions with more or less convexity earn the same expected return (because any convexity advantage is *exactly* offset by a yield disadvantage). However, if the market values very highly the insurance characteristics of positively convex positions, more convex positions may earn lower expected returns. Our analysis of the empirical performance of duration-neutral barbell-bullet trades will show that, in the long run, barbells tend to marginally underperform bullets.

USING FORWARD RATE ANALYSIS IN YIELD-CURVE TRADES

Recall that if the local expectations hypothesis holds, all bonds and bond positions have the same near-term expected return. In particular, an upward-sloping yield-curve reflects expectations of rising rates and capital losses, and convexity is priced so that a yield disadvantage exactly offsets the convexity advantage. In such a world, yields do not reflect value, no trades have favorable odds, and active management can add value only if an investor has truly superior forecasting ability. Fortunately, the real world is not quite like this textbook case because expected returns do vary across bonds (see Exhibit 36–3). The main reason is probably that most investors exhibit risk aversion and preferences for other asset characteristics; moreover, investor behavior may not always be fully rational. Therefore, yields reflect value, and certain relative value trades have favorable odds.

The preceding section provided a framework for thinking about the term-structure shapes. In this section we describe practical applications, that is, different ways to use forward rates in yield-curve trades. The first approach requires strong subjective rate views and faith in one's forecasting ability.

Forwards as Break-Even Rates for Active Yield-Curve Views

The forward rates show a path of break-even future rates and spreads. This path provides a clear yardstick for an active portfolio manager's subjective yield-curve scenarios and yield-path forecasts. It incorporates directly the impact of carry on the profitability of the trade. For example, a manager should take a bearish portfolio position only if she expects rates to rise by more than what the forwards imply. However, if she expects rates to rise, but by less than what the forwards

imply (i.e., by less than what is needed to offset the positive carry), she should take a bullish portfolio position. If the manager's forecast is correct, the position will be profitable. In contrast, managers who take bearish portfolio positions whenever they expect bond yields to rise—ignoring the forwards—may find that their positions lose money, because of the negative carry, even though their rate forecasts are correct.

One positive aspect about the role of forward rates as break-even rates is that they do not depend on assumptions regarding expectations, risk premiums, or convexity bias. The rules are simple. If forward rates are realized, all positions earn the same return. If yields rise by more than the forwards imply, bearish positions are profitable, and bullish positions lose money. If yields rise by less than the forwards imply, the opposite is true. Similar statements hold for any yield spreads and related positions, such as curve-flattening positions.

Exhibit 36–5 shows the dollar-swap (par) yield-curve and the implied-swap curves three months forward and 12 months forward as of April 2004. If we believe that forward rates only reflect the market's rate expectations, a comparison of these curves tells us that the market expects rates to rise and the curve to flatten over the next year. Alternatively, the implied yield rise may reflect a bond risk premium, and the implied curve flattening may reflect the value of convexity. Either way, the forward yield-curves reflect the break-even levels between profits and losses.

The information in the forward rate structure can be expressed in several ways. Exhibit 36–5 is useful for an investor who wants to contrast his subjective view of the future yield-curve with an objective break-even curve at some future horizon. Another graph may be more useful for an investor who wants

EXHIBIT 36–5

Current and Forward Par Yield Curves Based on the Dollar-Swap Curve in April 2004

EXHIBIT 36–6

Historical Three-Month Rates and Implied Forward Rate Path Based on the Dollar Swap Curve in April 2004, June 2003, and June 2001

to see the break-even future path of any given-maturity yield (instead of the whole curve) and contrast it with his own forecast, which may be based on a macroeconomic forecast or on the subjective view about the speed of Fed tightening. As an example, Exhibit 36–6 shows such a break-even path of future three-month rates in April 2004. Note that the first point in each implied forward par curve in Exhibit 36–5 is the implied forward three-month rate at a given future date. Therefore, the forward path in Exhibit 36–6 can be constructed by tracing through the three-month points in the three curves of Exhibit 36–5 and through similar curves at other horizons. Because Exhibit 36–6 depicts a rate path over time, the horizontal axis is calendar years and not maturity.

To add perspective, the graph also contains the historical path of the three-month rate over the past decade and the break-even path of the future three-month rates in June 2003 when monetary policy expectations were much more bullish and in June 2001 when market's policy tightening expectations proved immature.

Forwards as Indicators of Cheap Maturity Sectors

The other ways to use forwards require less subjective judgment than the first one. As a simple example, the forward rate curve can be used to identify cheap maturity sectors visually. Abnormally high forward rates are more visible than high spot or par rates because the latter are averages of forward rates.

Exhibit 36–7 shows one real-world example from year 2000 when the par yield-curve was extremely flat (although forwards may be equally useful when the

EXHIBIT 36–7

Par Yields and One-Year Forward Rates Based on the Dollar-Swap Curve in August 2000

par curve is not flat). Even though the par yield-curve was almost horizontal (all par yields were within 15 basis points), the range of one-year forward rates was almost 100 basis points because the forward rate curve magnifies the cheapness/richness of different maturity sectors. High forward rates identify the 9- to 12-year sector as cheap. Forward rates are very low at the long maturities, but this characteristic probably reflects the convexity bias. Recall that forward rates are downward-biased estimates of expected returns because they ignore the convexity advantage, which is especially large at long maturities.

Once an investor has identified a sector with abnormally high forward rates (e.g., between 9 and 12 years), she can exploit the cheapness of this sector by buying a bond that matures at the end of the period (12 years) and by selling a bond that matures at the beginning of the period (9 years). If equal market values of these bonds are bought and sold, or received and paid fixed in swaps, the position captures the cheap forward rate (in this case the 3-year rate 9 years forward). In par-curve terms, the position is exposed to a general increase in rates and a steepening yield-curve. More elaborate trades can be constructed (e.g., by selling both the 9- and 15-year bonds against the 12-year bonds with appropriate weights) to retain level and slope neutrality. To the extent that bumps and kinks in the forward curve reflect temporary local cheapness, the trade will earn capital gains when the forward curve becomes flatter and the cheap sector richens (in addition to the higher yield and rolldown the position earns).

Forwards as Relative-Value Tools for Yield-Curve Trades

Thus far in this chapter forwards are used quite loosely to identify cheap maturity sectors. A more formal way to use forwards is to construct quantitative cheapness indicators for duration-neutral flattening trades, such as barbell-bullet trades. We first introduce some concepts with an example of a market-directional trade.

When the yield-curve is upward-sloping, long-term bonds' yield advantage over the riskless short-term bond provides a cushion against rising yields. In a sense, duration extensions are "cheap" when the yield-curve is very steep and the cushion (positive carry) is large. These trades only lose money if capital losses caused by rising rates offset the initial yield advantage. Moreover, the longer-term bonds' rolling yield advantage[17] over the short-term bond is even larger than their yield advantage. The one-year forward rate ($f_{n-1,n}$) is, by construction, equal to the n-year zero's rolling yield (see Appendix 36C). Thus it is a direct measure of the n-year zero's rolling yield advantage. [Another forward-related measure, the change in the $(n-1)$-year spot rate implied by the forwards ($f_{1,n} - s_{n-1}$) tells how much the yield-curve has to shift to offset this advantage and to equate the holding-period returns of the n-year zero and the one-year zero.]

Because one-period forward rates measure zeros' near-term expected returns, they can be viewed as indicators of cheap maturity sectors. The use of such cheapness indicators does not require any subjective interest-rate view. Instead, it requires a belief, motivated by history, that an unchanged yield-curve is a good base-case scenario.[18] If this is true, long-term bonds have higher (lower) near-term expected returns than short-term bonds when the forward rate curve is upward-sloping (downward-sloping). In the long run, a strategy that adjusts the portfolio duration dynamically based on the curve shape should earn higher average return than constant-duration strategies.[19]

Similar analysis holds for curve-flattening trades. Recall that when the yield-curve is concave as a function of duration, any duration-neutral flattening trade earns a negative carry. Higher concavity (curvature) in the yield-curve indicates less attractive terms for a flattening trade (larger negative carry) and more "implied flattening" by the forwards (that is needed to offset the negative carry).

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17. As bonds age, they roll down the upward-sloping yield-curve and earn some rolldown return (capital gain owing to this yield change) if the yield-curve remains unchanged. A bond's rolling yield, or horizon return, includes both the yield and the rolldown return given a scenario of no change in the yield-curve.
18. The one-period forward rate can proxy for the near-term expected return—albeit with a downward bias because it ignores the value of convexity—*if* the current yield-curve is not expected to change. Empirical studies show that the assumption of an unchanged curve is more realistic than the assumption that forward rates reflect expected future yields. Historically, current spot rates predict future spot rates better than current forward rates do because the yield changes implied by the forwards have not been realized, on average.
19. The historical performance of dynamic strategies that exploit the predictability of long-term bonds' near-term returns is evaluated in Antti Ilmanen, "Forecasting U.S. Bond Returns," *Journal of Fixed Income* (June 1997), pp. 22–37. The dynamic strategies have consistently outperformed static strategies that do not actively adjust the portfolio duration.

EXHIBIT 36–8

Dollar-Swap Curves in October 2003 and in April 2004

Therefore, the amount of spread change implied by the forwards is a useful cheapness indicator for yield-curve trades at different parts of the curve. If the implied change is wide historically, the trade is expensive, and vice versa.

Exhibit 36–8 shows a recent example of negative carry making curve-flattening positions expensive to hold. In October 2003, high yield-curve curvature indicated strong flattening expectations—forwards implied a 50 basis point decline in the 2- to 30-year spread over the coming six months—or high expected volatility (high value of convexity). The barbell (of the 30-year bond and six-month bill) over the duration-matched two-year bullet would become profitable only if the curve flattened even more than the forwards implied or if a sudden increase in volatility occurred. Purely on yield grounds, the two-year bullet (a steepening position) appeared cheap to the barbell. With the benefit of hindsight, we know that the carry/cheapness indicator gave a correct signal in this case. Exhibit 36–8 plots the dollar-swap curves in October 2003 and in April 2004; it is perhaps surprising that a steepening position outperformed amid curve flattening. Even though the yield-curve did flatten (the 2- to 30-year spread actually narrowed by 38 basis points by April 2004), the realized flattening did not match the forward-implied flattening. A steepener's (bullet's) initial carry and rolldown advantage did more than offset the capital losses owing to subsequent curve flattening.[20]

20. We show how to use forward rate analysis to evaluate opportunities like this in Ilmanen, "Market's Rate Expectations and Forward Rates," *op. cit.*; and Ilmanen and Iwanowski, "Dynamics of the Shape of the Yield Curve," *op. cit.*

APPENDIX 36A

Notation and Definitions

P	market price of a bond
P_n	market price of an n-year zero
C	coupon rate (in percent; other rates are expressed as a decimal)
y	annualized yield-to-maturity (YTM) of a bond
n	time-to-maturity of a bond (in years)
s_n	annualized n-year spot rate; the discount rate of an n-year zero
s_{n-1}	annualized $(n-1)$-year spot rate next period; superscript * denotes next period's (year's) value
Δs_{n-1}	realized change in the $(n-1)$-year spot rate between today and next period $(= s^*_{n-1} - s_{n-1})$
$f_{m,n}$	annualized forward rate between maturities m and n
$f_{n-1,n}$	one-year forward rate between maturities $(n-1)$ and n; also, the n-year zero's rolling yield
$f_{1,n}$	annualized forward rate between maturities 1 and n; also called the implied $(n-1)$-year spot rate one year forward
Δf_{n-1}	implied change in the $(n-1)$-year spot rate between today and next period $(= f_{1,n} - s_{n-1})$; also called the break-even yield change (over the next period) implied by the forwards
Δfz_n	implied change in the yield of an n-year zero, a specific bond, over the next period $(= f_{1,n} - s_n)$
FSP	forward-spot premium ($\text{FSP}_n = f_{n-1,n} - s_1$)
h_n	realized holding-period return of an n-year zero [over one period (year)]

Rolling yield	a bond's horizon return given a scenario of unchanged yield-curve; sum of yield and rolldown return
Bond risk premium (BRP)	expected return of a long-term bond over the next period (year) in excess of the riskless one-period bond; for the n-year zero, $\text{BRP}_n = E(h_n - s_1)$
Realized BRP	realized one-year holding-period return of a long-term bond in excess of the one-year bond; also called excess bond return; realized $\text{BRP}_n = h_n - s_1$
Persistence factor (PF)	slope coefficient in a regression of the annual realized BRP_n on FSP_n
Term spread	yield difference between a long-term bond and a short-term bond; for the n-year zero, $= s_n - s_1$
Real yield	difference between a long-term bond yield and a proxy for expected inflation; our proxy is the recently published year-on-year consumer price inflation rate

Inverse wealth	ratio of exponentially weighted past wealth to the current wealth; we proxy wealth W by the stock market level; $= (W_{t-1} + 0.9*W_{t-2} + 0.9^2*W_{t-3} + \cdots)*0.1/W_t$
Duration (Dur)	measure of a bond price's interest rate sensitivity; Dur = $-(dP/dy)*(1/P)$
Convexity (Cx)	measure of the nonlinearity in a bond's P/y relation; Cx = $(d^2P/dy^2)*(1/P)$
Convexity bias (CB)	impact of convexity on the forward rate curve; $CB_n = -0.5*Cx_n*(\text{volatility of } \Delta s_n)^2$

APPENDIX 36B

Calculating Spot and Forward Rates When Par Rates Are Known

A simple example illustrates how spot rates and forward rates are computed on a coupon date when the par curve is known (and coupon payments and compounding frequency are annual). The basis of the procedure is the fact that a bond's price will be the same, the sum of the present values of its cash-flows, whether it is priced via yield-to-maturity—Eq. (36B.1)—or via the spot-rate curve—Eq. (36B.2).

$$P = \frac{C}{1+y} + \frac{C}{(1+y)^2} + \cdots + \frac{C+100}{(1+y)^n} \tag{36B.1}$$

$$P = \frac{C}{1+s_1} + \frac{C}{(1+s_2)^2} + \cdots + \frac{C+100}{(1+s_n)^n} \tag{36B.2}$$

where P is the bond price, C is the coupon rate (in percent), y is the annual yield-to-maturity (expressed as a decimal), s is the annual spot rate (expressed as a decimal), and n is the time-to-maturity (in years). We show only the computation for the first two years, which have par rates of 6% and 8%. For the first year, par, spot, and forward rates are equal (6%). Longer spot rates are solved recursively using known values of the par bond's price and cash-flows and the previously solved spot rates. Every par bond's price is 100 (par) by construction, so its yield (the par rate) equals its coupon rate. Because the two-year par bond's market price (100) and cash-flows (8 and 108) are known, as is the one-year spot rate (6%), it is easy to solve for the two-year spot rate as the only unknown in the following equation:

$$100 = \frac{C}{1+s_1} + \frac{C+100}{(1+s_2)^2} = \frac{8}{1.06} + \frac{108}{(1+s_2)^2} \tag{36B.3}$$

A little manipulation shows that the solution for s_2 is 8.08%. Equation (36B.3) also can be used to compute par rates when only spot rates are known. If the

EXHIBIT 36B–1

Par, Spot, and One-Year Forward Rate Curves

Maturity	Par Rate	Spot Rate	Forward Rate
1	6.00	6.00	6.00
2	8.00	8.08	10.20
3	9.50	9.72	13.07
4	10.50	10.86	14.36
5	11.00	11.44	13.77
6	11.25	11.71	13.10
7	11.38	11.83	12.55
8	11.44	11.88	12.20
9	11.48	11.89	11.97
10	11.50	11.89	11.93

spot rates are known, the coupon rate C—which equals the par rate—is the only unknown in Eq. (36B.3).

The forward rate between one and two years is computed using Eq. (36B.3) and the known one-year and two-year spot rates.

$$(1+f_{1,2})=\frac{(1+s_2)^2}{1+s_1}=\frac{(1.0808)^2}{1.06}=1.1020 \tag{36B.4}$$

The solution for $f_{1,2}$ is 10.20%. The other spot rates and one-year forward rates ($f_{2,3}, f_{3,4}$, etc.) in Exhibit 36B–1 are computed in the same way. These numbers are shown graphically in Exhibit 36–1.

APPENDIX 36C

Relations between Spot Rates, Forward Rates, Rolling Yields, and Bond Returns

Investors often want to make quick "back of the envelope" calculations with spot rates, forward rates, and bond returns. In this appendix we discuss some simple relations between these variables, beginning with a useful approximate relation

between spot rates and one-year forward rates.[21] Equation (36.2) showed exactly how the forward rate between years m and n is related to m- and n-year spot rates. Equation (36C.1) shows the same relation in an approximate but simpler form; this equation ignores nonlinear effects such as the convexity bias. The relation is exact if spot rates and forward rates are continuously compounded.

$$f_{m,n} \approx \frac{ns_n - ms_m}{n-m} \tag{36C.1}$$

For one-year forward rates ($m = n - 1$), Eq. (36C.1) can be simplified to

$$f_{n-1,n} \approx s_n + (n-1)(s_n - s_{n-1}) \tag{36C.2}$$

Equation (36C.2) shows that the forward rate is equal to an n-year zero's one-year horizon return given an unchanged yield-curve scenario: a sum of the initial yield and the rolldown return [the zero's duration at horizon (n – 1) multiplied by the amount the zero rolls down the yield-curve as it ages]. This horizon return is often called the *rolling yield.* Thus the one-year forward rates proxy for near-term expected returns at different parts of the yield-curve if the yield-curve is expected to remain unchanged. We can gain intuition about the equality of the one-year forward rate and the rolling yield by examining the n-year zero's realized holding-period return h_n over the next year, in Eq. (36C.3). The zero earns its initial yield s_n plus a capital gain/loss that is approximated by the product of the zero's year-end duration and its realized yield change.

$$h_n \approx s_n + (n-1) \times (s_n - s^*_{n-1}) \tag{36C.3}$$

where s^*_{n-1} is the (n – 1)-year spot rate next year. If the yield-curve follows a random walk, the best forecast for s^*_{n-1} is (today's) s_{n-1}. Therefore, the n-year zero's expected holding period return is exactly the one-year forward rate in Eq. (36C.2). The key question is whether it is more reasonable to assume that the current spot rates are the optimal forecasts of future spot rates than to assume that forwards are the optimal forecasts. Empirical evidence suggests that the "random walk" forecast of an unchanged yield-curve is more accurate than the forecast implied by the forwards.

Equation (36C.2) shows that the (one-year) forward rate curve lies above the spot curve as long as the latter is upward-sloping (and the rolldown return is positive). Conversely, if the spot curve is inverted, the rolldown return is negative, and the forward rate curve lies below the spot curve. If the spot curve is first rising and then declining, the forward rate curve crosses it from above at its peak. Finally, the forward rate curve can become downward-sloping even when the spot curve is upward-sloping if the spot curve's slope is first steep and then flattens

21. These relations are discussed in more detail in the appendix to Ilmanen, "Market's Rate Expectations and Forward Rates," *op. cit.*

(reducing the rolldown return). The following calculations illustrate this point and show that the approximation is good—within a few basis points from the correct values (10.20 – 13.07 – 14.36 – 13.77) in Exhibit 36B–1.

$$f_{1,2} \approx 8.08 + 1 * (8.08 - 6.00) = 8.08 + 2.08 = 10.16;$$

$$f_{2,3} \approx 9.72 + 2 * (9.72 - 8.08) = 9.72 + 3.28 = 13.00;$$

$$f_{3,4} \approx 10.86 + 3 * (10.86 - 9.72) = 10.86 + 3.42 = 14.28; \text{ and}$$

$$f_{4,5} \approx 11.44 + 4 * (11.44 - 10.86) = 11.44 + 2.32 = 13.76.$$

KEY POINTS

- Yield-curve or the term structure of interest rates can be depicted in several interchangeable ways, including the par curve, the spot curve, and the forward rate curve.
- The main drivers of the yield-curve are the market's rate expectations, required bond risk premiums, and convexity bias.
- A steeply upward-sloping yield-curve may reflect the market forecast of rising future short-term rates, or exceptionally high bond risk premiums, or some combination of these two. The pure expectations hypothesis assumes the first term drives yield-curve fluctuations, while empirical evidence suggests that the second term matters more. In reality, both matter.
- Forward rates can be useful tools for bond investors in break-even analysis (how much yields need to shift over a given horizon to just offset certain assets' initial yield advantage?). and in relative value analysis (what is the expected return of a zero-coupon bond if the curve remains unchanged?).
- Treasury analysis can focus on duration extensions and yield level changes or on duration-neutral strategies and yield-curve shape changes.

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CHAPTER
THIRTY-SEVEN

A FRAMEWORK FOR ANALYZING YIELD-CURVE TRADES

ANTTI ILMANEN, PH.D.
Managing Director
AQR Capital Management (Europe) LLP

In Chapter 36, it was explained that the shape of the yield-curve depends on three main determinants: the market's rate expectations, the required bond risk premia, and the convexity bias. In this chapter we show how to decompose the forward rate curve into these three determinants. Even though we cannot observe these determinants directly, the decomposition can clarify our thinking about the yield-curve.

Our analysis also produces direct applications—it provides a systematic framework for relative-value analysis of noncallable government bonds. Analogous to the decomposition of forward rates, the total expected return of any government bond position can be viewed as the sum of a few simple building blocks: (1) the yield income, (2) the rolldown return, (3) the value of convexity, and (4) the duration impact of the rate view. A further term should be added for bonds that trade "special" in the repo market and for bonds that trade very rich or cheap against the fitted curve.

The following observations motivate this decomposition. A bond's near-term expected return is a sum of its horizon return given an unchanged yield-curve and its expected return from expected changes in the yield-curve. The first item, the horizon return, is also called the *rolling yield* because it is a sum of the bond's yield income and the rolldown return (the capital gain that the bond earns because its yield declines as its maturity shortens and it "rolls down" an upward-sloping yield-curve). The second item, the expected return from expected changes in the yield-curve, can be approximated by duration and convexity effects. The duration impact is zero if the yield-curve is expected to remain unchanged, but it may be the main source of expected return if the rate predictions are based on an investor's or economist's market view or on a quantitative forecasting model.

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The value of convexity is always positive and depends on the bond's convexity and on the perceived level of yield volatility.

We argue that both prospective and historical relative-value analysis should focus on near-term expected-return differentials across bond positions instead of on yield spreads. The former measures are more comprehensive in the sense that they take into account all sources of expected return. Moreover, they provide a consistent framework for evaluating all types of government bond positions. We also show, with practical examples, how various expected-return measures are computed and how our framework for relative-value analysis is related to the better-known scenario analysis.

FORWARD RATES AND THEIR DETERMINANTS

Chapter 36 shows that the yield-curve can be represented in either par rates, spot rates, or forward rates. Whichever representation is used, there are three main determinants of the yield-curve that we discuss next.

How Do the Main Determinants Influence the Yield-Curve Shape?

We describe here how the market's rate expectations, the required bond risk premia,[1] and the convexity bias influence the term structure of interest rates. The market's expectations regarding the future interest-rate behavior probably are the most important influences on today's term structure. Expectations for parallel increases in yields tend to make today's term structure linearly upward sloping, and expectations for falling yields tend to make today's term structure inverted. Expectations for future curve flattening induce today's spot- and forward-rate curves to be concave (functions of maturity), and expectations for future curve steepening induce today's spot- and forward-rate curves to be convex.[2] These are the facts, but what is the intuition behind these relationships?

The traditional intuition is based on the pure expectations hypothesis. In the absence of risk premia and convexity bias, a long rate is a weighted average of the expected short rates over the life of the long bond. If the short rates are expected to rise, the expected average future short rate (i.e., the long rate) is

1. The *bond risk premium* is defined as a bond's expected (near-term) holding-period return in excess of the riskless short rate. Historical experience suggests that long-term bonds command some risk premium because of their greater perceived riskiness. However, our term *bond risk premium* also covers required return differentials across bonds that are caused by other reasons than risk, such as liquidity differences, supply effects, or the market sentiment.
2. A concave (but upward-sloping) curve has a steeper slope at short maturities than at long maturities; thus a line connecting two points on the curve is always below the curve. A convex (but upward-sloping) curve has a steeper slope at long maturities than at short maturities; thus a line connecting two points on the curve is always above the curve.

higher than the current short rate, making today's term structure upward-sloping. A similar logic explains why expectations of falling rates make today's term structure inverted. However, this logic gives few insights about the relation between the market's expectations regarding future curve reshaping and the curvature of today's term structure.

Another perspective to the pure expectations hypothesis may provide a better intuition. The absence of risk premia means that all bonds, independent of maturity, have the same near-term expected return. Recall that a bond's holding-period return equals the sum of the initial yield and the capital gains/losses that yield changes cause. Therefore, if all bonds are to have the same expected return, initial yield differentials across bonds must offset any expected capital gains/losses. Similarly, each bond portfolio with expected capital gains must have a yield disadvantage relative to the riskless asset. If investors expect the long bonds to gain value because of a decline in interest rates, they accept a lower initial yield for long bonds than for short bonds, making today's spot- and forward-rate curves inverted. Conversely, if investors expect the long bonds to lose value because of an increase in interest rates, they demand a higher initial yield for long bonds than for short bonds, making today's spot- and forward-rate curves upward-sloping. Similarly, if investors expect the curve-flattening positions to earn capital gains because of future curve flattening, they accept a lower initial yield for these positions. In such a case, barbells would have lower yields than duration-matched bullets (to equate their near-term expected returns), making today's spot- and forward-rate curves concave. A converse logic links the market's curve-steepening expectations to convex spot- and forward-rate curves.

The preceding analysis presumes that all bond positions have the same near-term expected returns. In reality, investors require higher returns for holding long bonds than short bonds. Many models that acknowledge bond risk premia assume that they increase linearly with duration (or with return volatility) and that they are constant over time. Empirical evidence contradicts both assumptions.[3] Historical average returns increase substantially with duration at the front end of the curve but only modestly beyond intermediate durations. Thus the bond risk premia make the term structure upward-sloping and concave, on average. Moreover, it is possible to forecast when the required bond risk premia are abnormally high or low. Thus the time variation in the bond risk premia can cause significant variation in the shape of the term structure.

Convexity bias refers to the impact that the nonlinearity of a bond's price/yield-curve has on the shape of the term structure. This impact is very small at the front end but can be quite significant at very long durations. A positively convex price/yield-curve has the property that a given yield decline raises the bond price more than a yield increase of equal magnitude reduces it. All else

3. This evidence is discussed in Antti Ilmanen, "Does Duration Extension Enhance Long-Term Expected Returns?" *Journal of Fixed Income* (September 1996), pp. 23–36; and Antti Ilmanen, "Forecasting U.S. Bond Returns," *Journal of Fixed Income* (June 1997), pp. 22–37.

equal, this property makes a high-convexity bond more valuable than a low-convexity bond, especially if the volatility is high. It follows that investors tend to accept a lower initial yield for a more convex bond because they have the prospect of enhancing their returns as a result of convexity. Because a long bond exhibits much greater convexity than a short bond, it can have a lower yield and yet offer the same near-term expected return. Thus, in the absence of bond risk premia, the convexity bias would make the term structure inverted. In the presence of positive bond risk premia, the convexity bias tends to make the term structure humped—because the negative effect of convexity bias overtakes the positive effect of bond risk premia only at long durations. An increase in the interest-rate volatility makes the bias stronger and thus tends to make the term structure more humped.

The three determinants influence the shape of the term structure simultaneously, making it difficult to distinguish their individual effects. Despite a widespread misconception, the shape of the term structure does not reflect only the market's rate expectations. Forward rates are good measures of the market's rate expectations only if the bond risk premia and the convexity bias can be ignored. This is hardly the case, even though a large portion of the short-term variation in the shape of the curve probably reflects the market's changing expectations about the future level and shape of the curve. The steepness of the curve on a given day depends mainly on the market's view regarding the rate direction, but in the long run, the impact of positive and negative rate expectations largely washes out. Therefore, the average upward slope of the yield-curve is mainly attributable to positive bond risk premia. The curvature of the term structure may reflect all three components. On a given day, the spot-rate curve is especially concave (humped) if market participants have strong expectations of future curve flattening or of high future volatility. In the long run, the reshaping expectations should wash out, and the average concave shape of the term structure reflects the concavity of the risk premium curve and the convexity bias.

Decomposing Forward Rates into Their Main Determinants

Conceptually, each one-period forward rate can be decomposed to three parts: the impact of rate expectations, the bond risk premium, and the convexity bias. So far this statement is just an assertion. In this subsection we show intuitively why this relationship holds between the forward rates and their three determinants. We provide a more formal derivation in Appendix 37A (where we take into account the fact that the analysis is not instantaneous but that yield changes occur over a discrete horizon, during which invested capital grows). In Appendix 37B we tie some loose strings together by summarizing various statements about the forward rates and by clarifying the relations between these statements.

EXHIBIT 37–1

Splitting a Zero-Coupon Bond's One-Period Yield Change into Two Parts

Exhibit 37–1 shows how the yield change of an n-year zero-coupon bond over one period (dashed arrow) can be split to the rolldown yield change and the one-period change in an $n-1$ year constant-maturity spot rate $s_{n-1}(\Delta s_{n-1} = s^*_{n-1} - s_{n-1})$ (two solid arrows).[4] A zero-coupon bond's price can be split in a similar way (see Appendix 37A). Thus an n-year zero's holding-period return over the next period h_n is

$$\begin{aligned} h_n &= \text{return if the curve is unchanged} + \text{return from the curve changes} \\ &= \text{rolling yield} + \text{percentage price change (at horizon)} \\ &\approx \text{(one-period) forward rate} + [(-\text{duration} \times \Delta s_{n-1}) \\ &\quad + (0.5 \times \text{convexity} \times \Delta s_{n-1})^2] \end{aligned} \tag{37–1}$$

Equation (37–1) is based on the following relations. First, a bond's one-period horizon return given an unchanged yield-curve is called the *rolling yield.* A zero-coupon bond's rolling yield equals the one-period forward rate ($f_{n-1,n}$). For example, if the four-year (five-year) constant-maturity rate remains unchanged at 9.5% (10%) over the next year, a five-year zero bought today at 10% can be sold next year at 9.5% as a four-year zero; then the bond's horizon return is $1.10^5/1.095^4 - 1 = 0.1202 = 12.02\%$, which is the one-year forward rate between four- and five-year maturities [see Eq. (37–11) in Appendix 37B]. The second source of a zero's holding-period return, the price change caused by the yield-curve

4. All rates and returns in this chapter are expressed in percentage terms (200 basis points = 2%).

shift, is approximated very well by duration and convexity effects for all but extremely large yield-curve shifts.

It is more interesting to relate the forward rates to expected returns and expected rate changes than to the realized ones. We take expectations of both sides of Eq. (37–1), split the bond's expected holding-period return into the short rate and the bond risk premium, and recall that $E(\Delta s_{n-1})^2 \approx [\text{vol}(\Delta s_{n-1})]^2$. Then we can rearrange the equation to express the one-period forward rate as a sum of the other terms:

$$\begin{aligned}\text{Forward rate} \approx\ &\text{short rate} + \text{duration} \times E(\Delta s_{n-1}) \\ &+ \text{bond risk premium} + \text{convexity bias}\end{aligned} \tag{37–2}$$

where bond risk premium = $E(h_n - s_1)$, and convexity bias $\approx -0.5 \times$ convexity $\times$ $[\text{vol}(\Delta s_{n-1})]^2$.

If we move the short rate to the left-hand side of the equation, we decompose the "forward-spot premium" $(f_{n-1,n} - s_1)$ into a rate-expectation term, a risk-premium term, and a convexity term (see Eq. 37–10 in Appendix 37A). We interpret the expectations in Eq. (37–2) as the market's rate and volatility expectations and as the expected risk premium that the market requires for holding long-term bonds. The market's expectations are weighted averages of individual market participants' expectations.

Some readers may wonder why our analysis deals with forward rates and not with the more familiar par and spot rates. The reason is the simplicity of the one-period forward rates. A one-period forward rate is the most basic unit in term-structure analysis, the discount rate of one cash-flow over one period. A spot rate is the average discount rate of one cash-flow over many periods, whereas a par rate is the average discount rate of many cash-flows—those of a par bond—over many periods. All the averaging makes the decomposition messier for the spot rates and the par rates than it is for the one-period forward rate in Eq. (37–2). However, because the spot and the par rates are complex averages of the one-period forward rates, they too can be decomposed conceptually into the three main determinants.

Because the approximate decomposition in Eq. (37–2) is derived mathematically without making specific economic assumptions, it is true in general. In reality, however, it is hard to make this decomposition because the components are not observable and because they vary over time. Further assumptions or proxies are needed for such a decomposition. In Exhibit 37–2 we use historical average returns to compute the bond risk premia and historical rate volatilities to compute the convexity bias—together with the observable market forward rates (as of April 2004)—and back out the only unknown term in Eq. (37–2): the expected spot-rate change times duration. We also could divide this term by duration to infer the market's rate expectations. The rate expectations that we back out in Exhibit 37–2 suggest that the market expects rising short rates but less than forwards imply.

If bond risk premia vary over time, the use of historical average risk premia may be misleading. As an alternative, we can use survey data or rate predictions

EXHIBIT 37–2

Decomposing Forward Rates into Their Components Using Historical Average Risk Premia and Volatilities

Note: The one-year forward rates are based on the dollar swap curve in April 2004. The bond risk premia are based on the historical arithmetic average returns of various maturity-subsector bond portfolios between 1972–2001, expressed in excess of the riskless one-year return. The convexity bias is based on the historical volatilities of various maturity swaps in 2004. The rate expectation term for each duration is then backed out as the difference—one-year forward rate – one-year spot rate – bond risk premium – convexity bias.

based on a quantitative forecasting model to proxy for the market's rate expectations. In Exhibit 37–3, we use a hypothetical consensus interest-rate forecast that predicts a bear flattening (yields rising 100 basis points at the two-year maturity and 20 basis points at ten years). In addition, we use implied volatilities from swaption prices to compute the convexity bias. These components can be used together with the one-year forward rates to back out estimates of the unobservable bond risk premia.

A comparison of Exhibits 37–2 and 37–3 shows that the two decompositions look similar at short durations but different at intermediate and long durations. The similarity of the convexity bias components in these two exhibits suggests that the use of historical or implied volatilities makes little difference, at least in this case. The hypothetical survey's yield-curve view implies a relatively poor performance of intermediate-duration assets (low expected excess return) and a good performance by the longest assets (whose yields are expected to be stable). Because the forward-rate curve is the same

EXHIBIT 37–3

Decomposing Forward Rates into Their Components Using Hypothetical Survey Rate Expectations and Implied Volatilities

Note: The one-year forward rates are based on the dollar swap curve in April 2004. The market's rate expectations are proxied by a hypothetical consensus interest-rate forecast. The convexity bias is based on the implied basis point volatilities from swaption prices. The bond risk premium for each duration is then backed out as the difference—one-year forward rate – one-year spot rate – expected rate change × duration – convexity bias.

in both exhibits, any smaller predicted rate increases lead to higher bond risk premia in Exhibit 37–3 than in Exhibit 37–2.[5]

Exhibits 37–2 and 37–3 are snapshots of the forward rates and their components on one date. A comparison of similar decompositions over time would provide insights into the relative variability of each component. In Exhibit 37–4, we try to illustrate the impact of changing rate expectations and risk premia on the steepness of the U.S. Treasury bill curve based on a semiannual survey of economists' rate forecasts. The exhibit shows that the forwards almost always implied larger increases in the three-month rate than the market expected, based on surveys of bond market analysts. The difference is proportional to the required bond risk premium of longer bills over shorter bills (because bills exhibit negligible convexity, its impact can be ignored). This difference clearly varies over time.

The time variation in the survey-based bond risk premium in Exhibit 37–4 appears economically reasonable. It fell secularly from the early 1980s to late 1990s, perhaps reflecting the trend decline in inflation expectations and in level-dependent

5. We hasten to point out that these calculations are quite imprecise, especially at long durations. Even an error of a couple of basis points in our proxy for the market's rate expectation will have a large impact on any long bond's expected return (and thus on the estimated bond risk premium) because the expected yield change is scaled up by duration. Such sensitivity reduces the usefulness of this decomposition at long durations.

EXHIBIT 37–4

Forward-Implied Yield Changes versus Survey-Expected Yield Changes in the Treasury Bill Market, 1981–2002

Note: Forward-implied yield change is the difference between the implied three-month rate six months forward ($f_{0.5,\ 0.75}$) and the current three-month rate ($s_{0.25}$) based on market data (fitted Treasury yield-curves). Survey-expected yield change is the difference between the expected three-month rate six months ahead [$E(s_{0.25})$] and the current three-month rate, where the market's rate expectation is proxied by the mean in the *Wall Street Journal's* semiannual survey of economist forecasts. The difference between the forward-implied yield change and the survey-expected yield change is proportional to the bond risk premium.

inflation uncertainty. Besides the lower inflation risk premium, improving fiscal prospects likely contributed to this trend decline. The bond risk premium also exhibited cyclic fluctuations that are related to the direction of consensus rate predictions and thus the central bank's policy tightening and easing cycles. Finally, the bond risk premium turned slightly negative during the flight to quality in late 1998, arguably reflecting government bonds' role as safe-haven assets.[6]

DECOMPOSING EXPECTED RETURNS OF BOND POSITIONS

Our framework for decomposing the yield-curve also provides a framework for systematic relative-value analysis of government bonds with known cash-flows. We can evaluate all bond positions' expected returns comprehensively yet with simple and intuitive building blocks. We emphasize that relative-value

6. Here we analyze the bond risk premium at money market maturities, but we find similar patterns for the 10-year Treasury in Antti Ilmanen, "Stock-Bond Correlations," *Journal of Fixed Income* (September 2003), pp. 55–66.

analysis should be based on near-term expected return differentials, not on yield spreads, which are only one part of them. That is, total-return investors should care more about expected returns than about yields. Thus our approach brings fixed income investors closer to mean-variance analysis in which various positions are evaluated based on the trade off between their expected return and return volatility.

Five Alternative Expected-Return Measures

Equation (37–1) shows that a zero's holding-period return is a sum of its return given an unchanged yield-curve and its return caused by the changes in the yield-curve. The return given an unchanged yield-curve is called the *rolling yield* because it is a sum of the zero's yield and the rolldown return. The return caused by changes in the yield-curve can be approximated well by duration and convexity effects. Taking expectations of Eq. (37–1) and splitting the rolling yield into yield income and rolldown return, the near-term expected return of a zero is

$$\begin{aligned}\text{Expected return} = {} & \text{yield income} + \text{rolldown return} + \text{value of convexity} \\ & + \text{expected capital gain from the rate "view"}\end{aligned}$$

[For details, see Eq. (37–8) in Appendix 37A or the notes below Exhibit 37–5.] A similar relation holds approximately for coupon bonds, and we will describe the three-month expected return of some on-the-run Treasury bonds as the sum of the four preceding components.[7]

This framework is especially useful when evaluating positions of two or more government bonds, such as duration-neutral barbells versus bullets. We first compute expected return separately for each component and then compute the portfolio's expected return by taking a market-value weighted average of all the components' expected returns.

7. However, certain modifications are needed when we analyze coupon bonds' instead of zeros' expected returns—and the approximation will be somewhat worse. We use each bond's rolling yield to measure the horizon return given an unchanged yield-curve; this measure no longer equals the one-period forward rate. We also use the end-of-horizon duration and convexity, as well as the change in the constant-maturity rate of a constant-coupon curve at horizon, and we adjust the duration and convexity effects for the fact that the bond's value increases to (1 + rolling yield/100) by the end of the horizon. Besides the approximation error of ignoring higher-order terms than duration and convexity effects, another source of error exists for coupon bonds: The reinvestment-rate assumptions vary across bonds. Recall that the calculation of the yield-to-maturity implicitly assumes that all cash-flows are reinvested at the bond's yield-to-maturity. This fact may lead to exaggerated estimates of yield income for long-term bonds if the yield-curve is upward-sloping, a problem common to all expected-return measures that use the concept of yield-to-maturity. Even though our approach of using bond-specific yields does not ensure internal consistency of the reinvestment-rate assumptions across bonds, any inconsistencies should have a relatively small impact on the overall level of bonds' expected returns.

It may be helpful to show step by step how the expected-return measures are improved, starting from simple yields and moving toward more comprehensive measures:

- A bond's *yield income* includes coupon income, accrued interest, and the accretion/amortization of price toward par value. Yield-to-maturity is the correct return measure if all interim cash-flows can be reinvested at the yield and the bond can be sold at its purchasing yield.[8] Yield ignores the rolldown return the bond earns if the yield-curve stays unchanged.
- *Rolling yield* is a better expected-return proxy if an unchanged curve is a reasonable base case. Yet it ignores the value of convexity and thus implicitly assumes no rate uncertainty. Thus the rolling yield measures expected return if no curve change and no volatility are expected.
- Combining the rolling yield with the value of convexity improves the expected-return measure further. This is so because it can be shown that a bond's convexity-adjusted expected return equals the sum of the rolling yield and the value of convexity. This measure recognizes the impact of rate uncertainty but implies that no change is expected in the yield-curve.[9] Empirical evidence suggests that an unchanged yield-curve is often a reasonable base "view."[10]
- If investors want, they can replace the prediction of an unchanged curve with some other rate (or spread) "view." One possibility is to use survey-based information of the market's current rate forecasts; such an approach may be useful for backing out the market's required return for each bond. Alternatively, investors may ignore the market view and input either their own rate views or an economist's subjective rate forecasts or rate predictions from some quantitative model.[11] The impact of any rate view is approximated by the expected yield change scaled by duration [see Eq. (37–10) in Appendix 37A], which may be added

8. The yield-to-maturity of a single cash-flow is unambiguous, whereas the yield of a portfolio of multiple cash-flows is a more controversial measure. The duration-times-market-value weighted yield is a good proxy for a portfolio's true yield-to-maturity (internal rate of return). Capital gains are well-approximated by the product of minus duration and the change in such a yield measure. However, a portfolio's market-value weighted yield may be a better estimate of the portfolio's *likely yield income over a short horizon* (its near-term expected return) than is its yield-to-maturity. The yield-to-maturity weighs longer cash-flows more heavily and is more influenced by the built-in reinvestment-rate assumptions.
9. See Antti Ilmanen, "Convexity Bias in the Yield Curve," Chapter 3 in Narasimgan Jegadeesh and Bruce Tuckman (eds.), *Advanced Fixed-Income Valuation Tools* (New York: Wiley, 2000).
10. See Antti Ilmanen, "Market's Rate Expectations and Forward Rates," *Journal of Fixed Income* (September 1996), pp. 8–22.
11. For example, one can use the predictors identified in Antti Ilmanen, "Forecasting U.S. Bond Returns," *Journal of Fixed Income* (June 1997), pp. 22–37.

to the convexity-adjusted expected return. The sum gives us the "expected return with a view"—the four-term expected return measure in Eq. (37–3). However, this equation is a perfect description of expected returns only for bonds that lie on the fitted curve. Thus the preceding relative-value measures ignore "local" or bond-specific richness or cheapness relative to the curve.

- Many technical factors can make a specific bond "locally" rich or cheap (relative to adjacent-maturity bonds), or they can make a whole maturity sector rich or cheap relative to the fitted curve. Such factors include supply effects (temporary price pressure on a sector caused by new issuance), demand effects (maturity limitations or preferences of important market participants—for example, the richness of quarter-end bills), liquidity effects (lower transaction costs for on-the-runs versus off-the-runs, for ten-year bonds versus eight-year bonds, for Treasury bills versus duration-matched coupon bonds, etc.), coupon effects (motivated by tax benefits, accounting rules, etc.), and above all, the financing effects (the "special" repo income that is common for on-the-runs).[12] Fortunately, it is easy to add to the four-term expected-return measures the financing advantage and two local cheapness measures—the spread off the fitted curve and the expected cheapening toward the fitted curve. The five-term expected-return measures are comprehensive measures of total expected returns—ignoring small approximation errors, they incorporate all sources of expected return for noncallable government bonds.[13]

As a numerical illustration, Exhibit 37–5 shows the various expected-return measures for three bonds (the three-month Treasury bill and the five- and ten-year on-the-run Treasury notes) and for the barbell combination of the three-month bill

12. Whether such local cheapness effects appear as deviations from a fitted yield-curve or as "wiggles" or "kinks" in the fitted curve depends on the curve-estimation technique. Recall that all curve-estimation techniques try to fit bond prices well while keeping the curve reasonably shaped. If the goodness of fit is heavily weighted, all bonds have small or no deviations from the fitted curve. However, a close fit may lead to "unreasonably" jagged forward-rate curves. Based on Eq. (37–2), the forward-rate curve should be smooth rather than jagged because maturity-specific expectations of rate or volatility behavior are hard to justify and because arbitrageurs presumably are quick to exploit any abnormally large expected-return differentials between adjacent-maturity bonds.

13. In our analysis we include the local effects into the expected bond returns separately as a fifth term. As an alternative, we could include the financing advantage (repo income) and the spread off the curve in the yield income, and we could include the expected cheapening in the roll-down return. "Rich" bonds, such as the on-the-runs, are unlikely to roll down the fitted curve if the overall curve remains unchanged. More likely, they eventually will lose their relative richness. It may be reasonable to assume that an on-the-run bond's yield advantage and *expected* cheapening roughly offset its *expected* financing advantage. For other issues than on-the-runs, it is often reasonable to assume (or better, estimate) some reversal toward the issue's "normal" cheapness spread versus the fitted curve.

EXHIBIT 37–5

Three-Month Expected Return Measures and Their Components, as of April 2004

Maturity	0.25	5	10	Barbell
Yield income	**0.259%**	**0.881%**	**1.128%**	**0.742%**
+ *Rolldown return*	*0.000*	*0.321*	*0.281*	*0.156*
= **Rolling yield**	**0.259**	**1.203**	**1.409**	**0.898**
+ *Value of convexity*	*0.000*	*0.047*	*0.129*	*0.072*
= **Convexity-adj. expected return**	**0.259**	**1.250**	**1.538**	**0.970**
+ *Duration impact of the "view"*	*0.000*	*–1.315*	*–1.579*	*–0.879*
= **Expected return with a view**	**0.259**	**–0.065**	**–0.041**	**0.092**
+ *Total local rich/cheap effect*	*0.000*	*0.023*	*0.010*	*0.006*
= **Total expected return**	**0.259**	**-0.042**	**-0.031**	**0.097**
Background Information				
Par yield	1.05	3.59	4.600	NA
Rolldown yield change	NA	–0.074	–0.036	NA
Duration now	0.249	4.54	7.94	4.53
Duration at horizon	0.000	4.33	7.79	4.33
Convexity now	0.002	0.24	0.76	0.42
Convexity at horizon	0.000	0.22	0.73	0.40
Yield volatility	NA	0.656	0.592	NA
Yield change "view"	+0.20	+0.30	+0.20	NA
On-the-run yield	1.00	3.56	4.46	NA
Financing advantage	NA	0.175	0.225	0.13
Spread to the par curve	NA	–0.007	–0.035	–0.02
Expected cheapening return	NA	–0.145	–0.180	–0.10

NA, not available.

Note: Barbell is a combination of 0.56 unit of the ten-year par bond and 0.44 unit of the three-month bond; these weights duration-match the barbell with the five-year par bond bullet. Yield income is the return that a par bond earns over three months if it can be sold at its yield and if any cash-flows are reinvested at the yield. The yields are compounded semiannually and based on the Citigroup Treasury Model's par yield-curve. Rolldown return is the capital gain that a bond earns from the rolldown yield change. Rolling yield is a bond's horizon return given an unchanged yield-curve. Value of convexity is approximated by 0.5 × convexity at horizon × (yield volatility)^2 × (1 + rolling yield/100), where yield volatility is the basis-point yield volatility over a three-month horizon. The latter is computed by multiplying the on-the-run bond's relative yield volatility—implied volatility based on the price of a three-month OTC option written on this bond—by its yield level and dividing by two (for deannualization). For the three-year bond, we interpolate between the implied volatilities of on-the-run twos and fives. Duration impact of the "view" is (– duration at horizon) × (expected change in a constant-maturity rate over the next three months) × (1 + rolling yield/100). In this example, the "view" reflects the market's yield-curve expectations, broadly based on a *Consensus Forecasts* report. The "expected return with a view" measures the expected return for a hypothetical par bond that lies exactly on the model curve, ignoring any local cheapness or financing advantage of actual bonds. We can add to this four-term measure a fifth component called the *total local rich/cheap effect*. It is the sum of three additional sources of return for specific bonds: (1) the financing advantage (the difference between the three-month term repo rate for general collateral and the three-month special term repo rate for the on-the-run bond, divided by four for deannualization), (2) the spread between the on-the-run bond yield and the model par yield, divided by four for deannualization, and (3) the bond's expected cheapening as it loses the richness associated with the on-the-run status.

and the ten-year bond. In this example we use as much market-based data as possible, for example, implied volatilities, not historical, to estimate the value of convexity and the "view" (rate predictions) based on survey evidence of the market's rate expectations, not on a quantitative forecasting model. All the numbers are based on the market prices as of April 22, 2004.

The top panel of Exhibit 37–5 shows how nicely the different components of expected returns can be added to each other. Moreover, the barbell's expected return measures are simply the market-value weighted averages of its components' expected returns. In this case, the yield income, the rolldown return, and the value of convexity are all higher for the longer bonds. In contrast, the duration impact of the market's rate view is negative because the consensus forecast indicates that the market expected rising rates over the next quarter. The local rich/cheap effect is marginally positive for the five- and ten-year notes; the reason is that the negative yield spread and the expected cheapening are not sufficient to offset the high repo market advantage. Based on "viewless" expected-return measures, the five-year bullet looks more attractive than the barbell, thanks to its carry and rolldown advantage. However, if we impose a consensus curve-flattening view (30 basis point rise in five-year rates versus 20 basis point rise in ten-year rates), the broad expected-return measures favor the barbell over the bullet.

Exhibit 37–6 shows the five different expected-return curves plotted on the three bonds' durations. In this case, the simplest expected-return measure (yield

EXHIBIT 37–6

Expected Returns of a Three-Month Bill, a Five-Year Bond, and a Ten-Year Bond, in April 2004

income) and the most comprehensive measure (total expected return) look very different, thanks to the strong bear-flattening view on yield-curve reshaping. In general, the relative importance of the five components may be dramatically different from that in Exhibit 37–5. The longer the asset's duration and the shorter the investment horizon, the greater is the relative importance of the duration impact and the smaller is the impact of yield income. It is worth noting that realized returns can be decomposed in the same way as the expected returns and that the duration impact typically dominates the realized returns even more.[14]

The total expected returns, if estimated carefully, should produce the most useful signals for relative-value analysis because they include all sources of expected returns. Yield spreads may be useful signals, but they are only a part of the picture. Therefore, we advocate the monitoring of broader expected-return measures relative to their history as cheapness indicators—just as yield spreads often are monitored relative to their history.

The components of expected returns just discussed are not new. However, few investors have combined these components into an integrated framework and based their historical analysis on broad expected-return measures. An additional useful feature of this framework is that all types of government bond trades can be evaluated consistently within it: the portfolio-duration decision (market-directional view), the maturity-sector positioning and barbell-bullet decision (curve-reshaping view), and the individual-issue selection (local cheapness view). With small modifications, the framework can be extended to include the cross-country analysis of currency-hedged government bond positions. Other possible future extensions include the analysis of foreign-exchange exposure and the analysis of spread positions between government bonds and other fixed income assets.

We finish with some reservations. Even if two investors use the same general framework and the same type of expected-return measure, they may come up with different numbers because of different data sources and different estimation techniques. The whole analysis can be made with any raw material; we emphasize the importance of good-quality inputs. Various candidates for the raw material include on-the-run and off-the-run government bonds, STRIPS, Eurodeposits, swaps, and Eurodeposit futures. [This multitude, of course, opens the possibility of trading between these curves if we can assess how various characteristics (say, convexity) are priced in each curve.] The most common approach is first to estimate the spot curve (or discount function) using a broad universe of coupon government bonds as the raw material and then to compute the forward rates and other relevant numbers. In European bond markets, the liquid swap curve (using cash Eurodeposits and swaps as the raw material) has

14. Realized returns can be split into an expected part and an unexpected part, and both parts can be decomposed further. Equation (37–3) describes the decomposition of the expected part, while the unexpected part can be split into duration and convexity effects. This type of return attribution can have a useful role in risk management and performance evaluation, but these two activities are not our focus in this chapter.

gained more of a benchmark status. Of course, some credit and tax-related spread may exist between the swap curve and the government bond yield-curve. Recently, yet another approach has become popular: Eurodeposit futures prices are used as the raw material. In this case, the forward rates are computed by adjusting for the convexity difference between a futures contract and a forward contract, and only then are spot rates computed from the forwards. Some components of expected returns are easier to measure—and less debatable—than others. The yield income is relatively unambiguous. The rolldown return and the local rich/cheap effects depend on the curve-fitting technique. The value of convexity depends on the volatility input and thus on the volatility estimation technique. The rate "view," the fourth term, can be based on various approaches, such as quantitative modeling or subjective forecasting, that rely on fundamental or technical analysis. Even the quantitative approach is not purely objective because infinitely many alternative forecasting models and estimation techniques exist. Forecasting rate changes is, of course, the most difficult task, as well as the one with greatest potential rewards and risks. Forecasting changes in yield spreads may be almost as difficult. The short-term returns of most bond positions depend primarily on the duration impact (rate changes or spread changes). However, even if investors cannot predict rate changes, they may earn superior returns in the long run—and with less volatility—by systematically exploiting the more stable sources of expected-return differentials across bonds: yields, rolldown returns, value of convexity, and local rich/cheap effects. More generally, while the total expected return differentials are, in theory, better relative-value indicators than the yield spreads, in practice, measurement errors conceivably can make them so noisy that they give worse signals. Therefore, it is important to check with historical data that any supposedly superior relative value tools would have enhanced the investment performance, at least in the past.

Link to Scenario Analysis

Many active investors base their investment decisions on subjective yield-curve views, often with the help of scenario analysis. Our framework for relative-value analysis is closely related to scenario analysis. It may be worthwhile to explore the linkages further.

An investor can perform the scenario analysis of noncallable government bonds in two steps. First, the investor specifies a few yield-curve scenarios for a given horizon and computes the total return of her bond portfolio—or perhaps just a particular trade—under each scenario. Second, the investor assigns subjective probabilities to the different scenarios and computes the probability-weighted expected return for her portfolio. Sometimes the second step is not completed, and investors only examine qualitatively the portfolio performance under each scenario. However, we advocate performing this step because investors can gain valuable insights from it. Specifically, the probability-weighted expected return is the "bottom line" number a total return manager should care about. By assigning probabilities to scenarios,

investors also can explicitly back out their implied views about the yield-curve reshaping and about yield volatilities and correlations.

In scenario analysis, investors define the mean yield-curve view and the volatility view implicitly by choosing a set of scenarios and by assigning them probabilities. In contrast, our framework for relative-value analysis involves explicitly specifying one yield-curve view (which corresponds to the probability-weighted mean yield-curve scenario) and a volatility view (which corresponds to the dispersion of the yield-curve scenarios). Either way, the yield-curve view determines the duration impact, and the volatility view determines the value of convexity.

Exhibit 37–7 presents a portfolio that consists of five equally weighted zero-coupon bonds with maturities of one to five years and (annually compounded) yields between 6% and 7%. The portfolio's maturity—and its Macaulay duration—initially

EXHIBIT 37–7

Scenario Analysis and Expected Bond Returns

	Bond Portfolio					
Initial maturity	1	2	3	4	5	3
Horizon maturity	0	1	2	3	4	2
Initial yield	6.00%	6.25%	6.50%	6.75%	7.00%	
Yield-change scenarios (of 1–5 year constant-maturity rates)						
Bear	1.00	1.00	1.00	1.00	1.00	
Bull	–1.00	–1.00	–1.00	–1.00	–1.00	
Neutral	0.00	0.00	0.00	0.00	0.00	
Bear-flattener	1.00	0.875	0.75	0.625	0.50	
Bull-steepener	–0.50	–0.375	–0.25	–0.125	0.00	
One-year returns in each scenario						
Bear	6.00	5.51	5.02	4.53	4.05	5.02
Bull	6.00	7.51	9.04	10.59	12.15	9.06
Neutral	6.00	6.50	7.00	7.50	8.01	7.00
Bear-flattener	6.00	5.51	5.26	5.26	5.51	5.51
Bull-steepener	6.00	7.01	7.76	8.26	8.51	7.51
Assign equal probability (0.2) to each scenario and back out various statistics						
Mean return	6.00	6.41	6.82	7.23	7.65	6.82
Vol. of return	0.00	0.80	1.52	2.17	2.78	1.45
Mean yield change	0.10	0.10	0.10	0.10	0.10	
Vol. of Yield Change	0.80	0.76	0.72	0.69	0.66	

is three. Over a one horizon, each zero's maturity shortens by one year. We specify five alternative yield-curve scenarios over the horizon: parallel shifts of +100 basis points and −100 basis points, no change, a yield increase combined with a curve flattening, and a yield decline combined with a curve steepening (see Exhibit 37–8). We compute the one-year holding-period returns for each asset and for the portfolio under each scenario. In particular, the neutral scenario shows the rolling yield that each zero earns if the yield-curve remains unchanged. We can evaluate each scenario separately. However, such analysis gives us limited insight—for example, the last column in Exhibit 37–7 shows just that bearish scenarios produce lower portfolio returns than bullish scenarios.

In contrast, if we assign probabilities to the scenarios, we can back out many numbers of potential interest. We begin with a simple example in which we use only the two first scenarios, parallel shifts of 100 basis points up or down. If we assign these scenarios equal probabilities (0.5), the expected return of the portfolio is 7.04% (= 0.5 × 5.02 + 0.5 × 9.06). On average, these scenarios have no view about curve changes, yet this expected return is 4 basis points higher than the expected portfolio return given no change in the curve (i.e., the 7% rolling yield computed in the neutral scenario). This difference reflects the value of convexity. If we use only one scenario, we implicitly assume zero volatility, which leads to downward-biased expected-return estimates for positively convex bond positions. If we use the two first scenarios (bear and bull), we implicitly assume a 100 basis point yield volatility; this assumption may or may not be reasonable, but it certainly is more reasonable than an assumption of no volatility. This example highlights the importance of using multiple scenarios to recognize the value of convexity. (The value is small here, however, because we focus on short-duration assets that have little convexity.)

Now we return to the example with all five yield-curve scenarios in Exhibit 37–8. As an illustration, we assign each scenario the same probability (p_i = 0.2). Then it is easy to compute the portfolio's probability-weighted expected return:

$$E(h_p) = \sum_{i=1}^{5} p_i \times h_i = 0.2 \times (5.02 + 9.06 + 7.00 + 5.51 + 7.51) = 6.82 \qquad (37\text{–}3)$$

Given these probabilities, we can compute the expected return for each asset, and it is possible to back out the implied yield-curve views. The lower panel in Exhibit 37–7 shows that the mean yield change across scenarios is +10 basis points for each rate (because the bear-flattener and the bull-steepener scenarios are not quite symmetric in magnitude in this example), implying a mild bearish bias but no implied curve-steepness views. In addition, we can back out the implied basis point yield volatilities (or return volatilities) by measuring how much the yield-change (or return) outcomes in each scenario deviate from the mean. These yield volatility levels are important determinants of the value of convexity. The last line in Exhibit 37–7 shows that the volatilities range from 80 to 66 basis points, implying an inverted term structure of volatility. Finally, we can compute implied correlations between

EXHIBIT 37–8

Various Yield-Curve Scenarios

various maturity-yield changes; the curve behavior across the five scenarios is so similar that all correlations are 0.92 or higher (not shown). Note that all correlations would equal 1.00 if only the first three scenarios were used; the imperfect correlations arise from the bear-flattener and the bull-steepener scenarios.

Whenever an investor uses scenario analysis, he should back out these implicit curve views, volatilities, and correlations—and check that any biases are reasonable and consistent with his own views. Without assigning the probabilities to each scenario, this step cannot be completed; then the investor may overlook hidden biases in his analysis, such as a biased curve view or a very high or low implicit volatility assumption that makes positive convexity positions appear too good or too bad. If investors use quantitative tools—such as scenario analysis, mean-variance optimization, or the approach outlined in this chapter—to evaluate expected returns, they should recognize the importance of their rate views in this process. Strong subjective views can make *any* particular position appear attractive. Therefore, investors should have the discipline and the ability to be fully aware of the views that are input into the quantitative tool.

In addition to the implied curve views, we can back out the four components of expected returns discussed earlier. In this example, we only analyze bonds that lie "on the curve" and thus can ignore the fifth component, the local rich/cheap effects. First, we measure the yield income from the portfolio by a market-value weighted-average yield of the five zeros, which is 6.50%. Second, each asset's rolldown return is the difference between the horizon return given an unchanged yield-curve and the yield income. Exhibit 37–7 shows that the horizon return for the portfolio is 7% in the neutral scenario; thus the portfolio's (market-value

weighted average) rolldown return is 50 basis points (= 7% – 6.5%). Note that the rolldown return is larger for longer bonds, reflecting the fact that the same rolldown yield change (25 basis points) produces larger capital gains for longer bonds. Third, the value of convexity for each zero can be approximated by 0.5 × convexity at horizon × (basis point yield volatility)^2 × (1 + rolling yield/100). Using the implicit yield volatilities in Exhibit 37–7, this value varies between 0.6 and 4.5 basis points across bonds. The portfolio's value of convexity is a market-value weighted average of the bond-specific values of convexity, or roughly 2 basis points. Fourth, the duration impact of the rate "view" for each bond equals (– duration at horizon) × (expected yield change) × (1 + rolling yield/100). The last term is needed because each invested dollar grows to (1 + rolling yield/100) by the end of horizon when the repricing occurs. The core of the duration impact is the product of duration and expected yield change. The expected yield change refers to the change (over the investment horizon) in a constant-maturity rate of the bond's horizon maturity. In Exhibit 37–7, all rates are expected to increase by 10 basis points, and the duration impact on specific bonds' returns varies between 0 and –40 basis points. The portfolio's duration impact is a market-value weighted average of bond-specific duration impacts, or about –20 basis points.

The four components add up to the total probability-weighted expected return of 6.82% (= 6.50% + 0.50% + 0.02% – 0.20%). Decomposing expected returns into these components should help investors to better understand their own investment positions. For example, they can see what part of the expected return reflects static market conditions and what part reflects their subjective market view. Unless they are extremely confident about their market view, they can emphasize the part of expected-return advantage that reflects static market conditions. In our example, the duration effect is small because the implied rate view is quite mild (10 basis points), and the one-year horizon is relatively long (the "slower" effects need time to accrue). With a shorter horizon and stronger rate views, the duration impact easily would dominate the other effects.

APPENDIX 37A

Decomposing the Forward Rate Structure into Its Main Determinants

In this appendix we show how the forward rate structure is related to the market's rate expectations, bond risk premia, and convexity bias. In particular, the holding-period return of an n-year zero-coupon bond can be described as a sum of its horizon return given an unchanged yield-curve and the end-of-horizon price change that is caused by a change in the $n - 1$ year constant-maturity spot rate (Δs_{n-1}). The horizon return equals a one-year forward rate, and the end-of-horizon price

change can be approximated by duration and convexity effects. These relations are used to decompose near-term expected bond returns and the one-period forward rates into simple building blocks. All rates and returns used in the following equations are compounded annually and expressed in percentage terms.

$$\frac{h_n}{100} = \frac{P^*_{n-1} - P_n}{P_n} = \frac{(P^*_{n-1} - P_{n-1}) + (P_{n-1} - P_n)}{P_n}$$
$$= \left(\frac{\Delta P_{n-1}}{P_{n-1}} \times \frac{P_{n-1}}{P_n} - 1\right) + \left(\frac{P_{n-1}}{P_n} - 1\right) \tag{37–4}$$

where h_n is the one-period holding-period return of an n-year bond, P_n is its price (today), P^*_{n-1} is its price in the next period (when its maturity is $n - 1$), and $\Delta P_{n-1} = P^*_{n-1} - P_{n-1}$. The second term on the right-hand side of Eq. (37–4) is the bond's rolling yield (horizon return). The first term on the right-hand side of Eq. (37–4) is the instantaneous percentage price change of an $n - 1$ year zero multiplied by an adjustment term P_{n-1}/P_n.[15]

Equation (37–5) shows that the zero's rolling yield (P_{n-1}/P_n) equals, by construction, the one-year forward rate between $n - 1$ and n. Moreover, the adjustment term equals one plus the forward rate.

$$1 + \frac{f_{n-1,n}}{100} = \frac{\left(1 + \frac{s_n}{100}\right)^n}{\left(1 + \frac{s_{n-1}}{100}\right)^{n-1}} = \frac{P_{n-1}}{P_n} \tag{37–5}$$

Equation (37–6) shows the well-known result that the percentage price change ($\Delta P/P$) is closely approximated by the first two terms of a Taylor series expansion, duration and convexity effects.

$$100 \times \frac{\Delta P}{P} \approx -\text{dur} \times (\Delta s) + 0.5 \times Cx \times (\Delta s)^2 \tag{37–6}$$

where

$$\text{dur} \equiv -\frac{dP}{ds} \times \frac{100}{P} \qquad \text{and} \qquad Cx \equiv \frac{d^2P}{d^2s} \times \frac{100}{P}$$

Plugging Eqs. (37–5) and (37–6) into Eq. (37–4), we get

$$h_n \approx f_{n-1,n} + \left(1 + \frac{f_{n-1,n}}{100}\right)[-\text{dur}_{n-1}(\Delta s_{n-1}) + 0.5Cx_{n-1}(\Delta s_{n-1})^2] \tag{37–7}$$

15. The adjustment term is needed because the bond's instantaneous price change occurs at the end of horizon, not today. The value of the bond position grows from one to P_{n-1}/P_n at the end of horizon if the yield-curve is unchanged. The end-of-horizon value (P_{n-1}/P_n) would be subject to the yield shift at horizon.

Even if the yield-curve shifts occur during the horizon, for performance calculation purposes, the repricing takes place at the end of horizon. This disparity causes various differences between the percentage price changes in Eqs. (37–6) and (37–7). First, the amount of capital that experiences the price change grows to $(1 + f_{n-1,n}/100)$ by the end of horizon. Second, the relevant yield change is the change in the $n - 1$ year constant-maturity rate, not in the n-year zero's own yield (the difference is the rolldown yield change).[16] Third, the end-of-horizon (as opposed to the current) duration and convexity determine the price change.

The realized return can be split into an expected part and an unexpected part. Taking expectations of both sides of Eq. (37–7) gives us the n-year zero's expected return over the next year:

$$E(h_n) \approx f_{n-1,n} + \left(1 + \frac{f_{n-1,n}}{100}\right)[-\text{dur}_{n-1}E(\Delta s_{n-1}) + 0.5Cx_{n-1}E(\Delta s_{n-1})^2] \tag{37–8}$$

Recall from Eq. (37–5) that the one-period forward rate equals a zero's rolling yield, which can be split to yield and rolldown return components. In addition, the expected yield change squared is approximately equal to the variance of the yield change or the squared volatility $E(\Delta s_{n-1})^2 \approx [\text{vol}(\Delta s_{n-1})]^2$. This relation is exact if the expected yield change is zero. Thus the zero's near-term expected return can be written (approximately) as a sum of the yield income, the rolldown return, the value of convexity, and the expected capital gains from the rate "view" (see Eq. 37–3).

We can interpret the expectations in Eq. (37–8) to refer to the market's rate expectations. Mechanically, the forward rate structure and the market's rate expectations on the right-hand side of Eq. (37–8) determine the near-term expected returns on the left-hand side. These expected returns should equal the required returns that the market demands for various bonds if the market's expectations are internally consistent. These required returns, in turn, depend on factors such as each bond's riskiness and the market's risk-aversion level. Thus it is more appropriate to think that the market participants, in the aggregate, *set the bond market prices* to be such that given the forward rate structure and the consensus rate expectations, each bond is expected to earn its required return.[17]

16. If we used bonds' own yield changes in Eq. (37–7), these yield changes would include the rolldown yield change. In this case, we should not use the forward rate (which includes the impact of the rolldown yield change on the return, in addition to the yield income) as the first term on the right-hand side of Eq. (37–7). Instead, we would use the spot rate.

17. Individual investors also can use Eq. (37–8), but the interpretation is slightly different because most of them are so small that they cannot influence the market rates; thus they are "price takers." Any individual investor can plug her subjective rate expectations into Eq. (37–8) and back out the expected return given these expectations and the market-determined forward rates. These expected returns may differ from the required returns that the market demands; this discrepancy may prompt the investor to trade on her view.

Subtracting the one-period riskless rate (s_1) from both sides of Eq. (37–8), we get

$$E(h_n - s_1) \approx (f_{n-1,n} - s_1) + \left(1 + \frac{f_{n-1,n}}{100}\right)[-\text{dur}_{n-1}E(\Delta s_{n-1}) + 0.5Cx_{n-1}\text{vol}(\Delta s_{n-1})^2] \quad (37\text{–}9)$$

We define the bond risk premium as $BRP_n \equiv E(h_n - s_1)$ and the forward-spot premium as $FSP_n \equiv f_{n-1,n} - s_1$. The forward-spot premium measures the steepness of the one-year forward rate curve (the difference between each point on the forward rate curve and the first point on that curve), and it is closely related to simpler measures of yield-curve steepness. Rearranging Eq. (37–9), we obtain

$$FSP_n \approx BRP_n + \left(1 + \frac{f_{n-1,n}}{100}\right)[\text{dur}_{n-1}E(\Delta s_{n-1}) - 0.5Cx_{n-1}\text{vol}(\Delta s_{n-1})^2] \quad (37\text{–}10)$$

In other words, the forward-spot premium is approximately equal to a sum of the bond risk premium, the impact of rate expectations (expected capital gain/loss caused by the market's rate "view"), and the convexity bias (expected capital gain caused by the rate uncertainty). Unfortunately, none of the three components is directly observable.

The analysis thus far has been very general, based on accounting identities and approximations, not on economic assumptions. Various term-structure hypotheses and models differ in their assumptions. Certain simplifying assumptions lead to well-known hypotheses of the term-structure behavior by making some terms in Eq. (37–10) equal zero—although fully specified term-structure models require even more specific assumptions. First, if constant-maturity rates follow *a random walk,* the forward-spot premium mainly reflects the bond risk premium but also the convexity bias [$E(\Delta s_{n-1}) = 0 \Rightarrow FSP_n \approx BRP_n + CB_{n-1}$]. Second, if the *local-expectations hypothesis* holds (all bonds have the same near-term expected return), the forward-spot premium mainly reflects the market's rate expectations but also the convexity bias [$BRP_n = 0 \Rightarrow FSP_n \approx \text{dur}_{n-1}E(\Delta s_{n-1}) + CB_{n-1}$]. Third, if the *unbiased-expectations hypothesis* holds, the forward-spot premium only reflects the market's rate expectations [$BRP_n + CB_{n-1} = 0 \Rightarrow FSP_n \approx \text{dur}_{n-1}E(\Delta s_{n-1})$]. The last two cases illustrate the distinction between two versions of the pure expectations hypothesis.

APPENDIX 37B

Relating Various Statements about Forward Rates to Each Other

We make several statements about forward rates—describing, interpreting, and decomposing them in various ways. The multitude of these statements may be confusing; therefore, we now try to clarify the relationships between them.

We refer to the spot curve and the forward curves on a given date as if they were unambiguous. In reality, different analysts can produce somewhat different estimates of the spot curve on a given date if they use different curve-fitting techniques or different underlying data (asset universe or pricing source). We acknowledge the importance of these issues—having good raw material is important to any kind of yield-curve analysis—but here we ignore these differences. We take the estimated spot curve as given and focus on showing how to interpret and use the information in this curve.

In contrast, the relations between various depictions of the term structure of interest rates (par, spot, and forward rate curves) are unambiguous. In particular, once a spot curve has been estimated, any forward rate can be computed mathematically by using Eq. (37–11):

$$\left(1+\frac{f_{m,n}}{100}\right)^{n-m}=\frac{\left(1+\frac{s_n}{100}\right)^n}{\left(1+\frac{s_m}{100}\right)^m} \tag{37–11}$$

where $f_{m,n}$ is the annualized $n - m$ year interest rate m years forward and s_n and s_m are the annualized n-year and m-year spot rates, expressed in percent. Thus a one-to-one mapping exists between forward rates and *current* spot rates. The statement "the forwards imply rising rates" is equivalent to saying that "the spot curve is upward sloping," and the statement "the forwards imply curve flattening" is equivalent to saying that "the spot curve is concave." Moreover, an unambiguous mapping exists between various types of forward curves, such as the implied spot curve one year forward ($f_{1,n}$) and the curve of constant-maturity one-year forward rates ($f_{n-1,n}$).

The forward rate can be the agreed interest rate on an *explicitly* traded contract, a loan between two future dates. More often the forward rate is defined *implicitly* from today's spot curve based on Eq. (37–11). However, arbitrage forces ensure that even the explicitly traded forward rates would equal the implied forward rates and thus be consistent with Eq. (37–11). For example, the implied one-year spot rate four years forward (also called the one-year forward rate four years ahead, $f_{4,5}$) must be such that the equality $(1 + s_5/100)^5 = (1 + s_4/100)^4(1 + f_{4,5}/100)$ holds. If $f_{4,5}$ is higher than this, arbitrageurs can earn profits by short selling the five-year zeros and buying the four-year zeros and the one-year forward contracts four years ahead, and vice versa. Such activity should make the equality hold within transaction costs.

Forward rates can be viewed in many ways: the arbitrage interpretation, the break-even interpretation, and the rolling yield interpretation. According to the arbitrage interpretation, implied forward rates are such rates that would ensure the absence of riskless arbitrage opportunities between spot contracts (zeros) and forward contracts if the latter were traded. According to the break-even interpretation of forward rates, implied forward rates are such *future* spot rates that would equate holding-period returns across bond positions. According to the rolling-yield interpretation, the one-period forward rates show the one-period horizon

returns that various zeros earn if the yield-curve remains unchanged. Each interpretation is useful for a certain purpose: active view taking relative to the forwards (break-even), relative-value analysis given no yield-curve views (rolling yield), and valuation of derivatives (arbitrage).

All these interpretations hold by construction (from Eq. 37–11). Thus they are not inconsistent with each other. For example, the one-period forward rates can be interpreted and used in quite different ways. The implied one-year spot rate four years forward ($f_{4,5}$) can be viewed as either the break-even one-year rate *four years into the future* or the rolling yield of a five-year zero *over the next year.* Both interpretations follow from the equality $(1 + s_5/100)^5 = (1 + s_4/100)^4(1 + f_{4,5}/100)$. This equation shows that the forward rate is the break-even one-year reinvestment rate that would equate the returns between two strategies (holding the five-year zero to maturity versus buying the four-year zero and reinvesting in the one-year zero when the four-year zero matures) over a five-year horizon. [Rewriting the equality as $(1 + s_4/100)^4 = (1 + s_5/100)^5/(1 + f_{4,5}/100)$ gives a slightly different viewpoint; the forward rate also is the break-even selling rate that would equate the returns between two strategies (holding the four-year zero to maturity versus buying the five-year zero and selling it after four years as a one-year zero) over a four-year horizon.] Finally, rewriting the equality as $1 + f_{4,5}/100 = (1 + s_5/100)^5/(1 + s_4/100)^4$ shows that the forward rate is the horizon return from buying a five-year zero at rate s_5 and selling it one year later as a four-year zero at rate s_4 (thus the constant-maturity four-year rate is unchanged from today). Our analysis focuses on the last (rolling-yield) interpretation.

Interpreting the one-period forward rates as rolling yields enhances our understanding about the relation between the curve of one-year forward rates ($f_{0,1}, f_{1,2}, f_{2,3}, \ldots, f_{n-1,n}$) and the implied spot curve one year forward ($f_{1,2}, f_{1,3}, f_{1,4}, \ldots, f_{1,n}$). The latter "break-even" curve shows how much the spot curve needs to shift to cause capital gains/losses that exactly offset initial rolling-yield differentials across zeros and thereby equalize the holding-period returns. Thus a steeply upward-sloping curve of one-period forward rates requires, or "implies," a large offsetting increase in the spot curve over the horizon, whereas a flat curve of one-period forward rates only implies a small "break-even" shift in the spot curve.[18] A similar link exists for the rolling-yield differential between a duration-neutral barbell versus bullet and the break-even yield-spread change (curve-flattening) that is needed to offset the bullet's rolling-yield advantage. These examples provide insight as to why an upward-sloping spot curve implies rising rates and why a concave spot curve implies a flattening curve.

18. In Chapter 36, we describe one common way to use the break-even forward rates. Investors can compare their subjective views about the yield-curve at some future date (or about the path of some constant-maturity rate over time) to the forward rates and directly determine whether bullish or bearish strategies are appropriate. If the rate changes that the forwards imply are realized, all bonds earn the riskless return [because $(1 + s_n/100)^n/(1 + f_{1,n}/100)^{n-1} = 1 + s_1/100$]. If rates rise by more than that, long bonds underperform short bonds. If rates rise by less than that, long bonds outperform short bonds because their capital losses do not quite offset their initial yield advantage.

Appendix 37A showed that forward rates can be decomposed conceptually into three main determinants (rate expectations, risk premia, and convexity bias). One might hope that the arbitrage, break-even, or rolling-yield interpretations could help us in backing out the relative roles of rate expectations, risk premia, and convexity bias in a given day's forward rate structure. However, such hope is in vain. The three interpretations hold quite generally because of their mathematical nature. Thus they do not guide us in decomposing the forward rate structure.

Therefore, even when two analysts agree that today's forward rate structure is an approximate sum of three components, they may disagree about the relative roles of these components. We can try to address this question empirically. It is closely related to the question about the forward rates' ability to forecast future rate changes and future bond returns. Ignoring convexity bias, if the forwards primarily reflect rate expectations, they should be unbiased predictors of future spot rates (and they should tell little about future bond returns). However, if the forwards mainly reflect required bond risk premia, they should be unbiased predictors of future bond returns (and they should tell little about future rate changes).[19,20]

Finally, our analysis does not reveal the fundamental economic determinants of the required risk premia or the market's rate expectations—nor does it tell us to what extent the nominal rate expectations reflect expected inflation and expected real rates. Macroeconomic news about economic growth, inflation rates, budget deficits, and so on can influence both the required risk premia and the market's rate expectations. More work clearly is needed to improve our understanding about the mechanisms of these influences.

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19. We present some empirical evidence indicating that the forward rates are better predictors of future bond returns than of future rate changes in Antti Ilmanen, "Market's Rate Expectations and Forward Rates," *Journal of Fixed Income* (September 1996), pp. 8–22. This evidence also suggests that the current spot curve is a better predictor of the next-period spot curve than is the implied spot curve one period forward. These findings imply that the rolling yields are reasonable proxies for the near-term expected bond returns—although even rolling yields capture a very small part of the short-term realized bond returns. Note that the poorer the forwards are in predicting future rate changes, the better they are in predicting bond returns—because then the implied rate changes that would offset initial yield advantages tend to occur more rarely. Note also that some investors may not care whether the forwards' ability to predict bond returns reflects rational risk premia or the market's inability to forecast rate changes; they want to earn any predictable profit irrespective of its reason.
20. One common misconception is that the forward rates are used in the valuation of swaps, options, and other derivative instruments *because* the forwards are good predictors of future spot rates. In fact, the forwards' ability to predict future spot rates has nothing to do with their usefulness in derivatives pricing. Unlike forecasting returns, the valuation of derivatives is based on arbitrage arguments. For example, traders theoretically can construct, by dynamic hedging, a riskless combination of a risky long-term bond and an option written on it. The price of the option should be such that the hedged position earns the riskless rate—otherwise, a riskless arbitrage opportunity arises. The forward rates are central in this valuation because the traders can lock in these rates for future periods in their hedging activity. This arbitrage argument implies that the yield-curve option pricing models should be calibrated to be consistent with the market forward rates *in spite of* the fact that the forwards are quite poor predictors of future spot rates.

KEY POINTS

- Yield-curve or forward rates can be decomposed into three main determinants: the market's rate expectations, required bond risk premiums, and convexity bias.
- In an analogous fashion, the expected return of a position in a (default-free) bond—or in a long-short position across such bonds—can be decomposed into a few building blocks: the yield income and so-called rolldown return, the value of convexity, and the duration impact of a curve view.
- The first three components of the expected return amount to the reasonably predictable "viewless" part, while the last component is the least certain but dominates realized returns.
- The above decompositions provide a useful framework for analyzing the attractiveness of yield-curve trades. For analyzing the attractiveness of individual issues, the local richness of a bond relative to the curve and its richness in the repo market are important additional considerations.

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CHAPTER
THIRTY-EIGHT

EMPIRICAL YIELD-CURVE DYNAMICS AND YIELD-CURVE EXPOSURE

WESLEY PHOA, PH.D.
Senior Vice President
Capital International Research, Inc.

While there are many factors that can influence the yield on a specific bond, one of the most important driving factors—especially for high-quality bonds—is the behavior of the benchmark (Treasury) yield-curve. Individual bond yields tend to move along with the yield-curve. For example, if the 10-year Treasury yield moves up or down, other bonds with maturities close to 10 years will tend to follow suit. Thus, the return on a bond portfolio is linked to movements in the Treasury yield-curve: as the yield-curve moves up and down (or tilts or changes shape in more complicated ways), the bonds in the portfolio tend to track comparable maturity Treasury yields, thus affecting the mark-to-market return of the portfolio. This sensitivity to yield-curve shifts is referred to as the *yield-curve exposure* or the *interest rate risk* of a bond or a portfolio of bonds; in order to understand and measure it, we first need to understand the ways in which the yield-curve can shift. This topic is the subject of this chapter.

FUNDAMENTAL DETERMINANTS OF YIELD-CURVE DYNAMICS

Treasury yields do not move around in a completely uncorrelated fashion. If they did, it would be impossible to analyze the interest rate risk of a bond portfolio in any meaningful way; even the notion of portfolio duration would be meaningless. Thus, in order to begin analyzing a bond portfolio, we need to make some assumption about the relationship between shifts in Treasury yields of different maturities. For example, we might try to identify the most important kinds of yield-curve shifts that can occur.

The simplest possible assumption is that all Treasury yields always move in parallel. For example, if the 30-year Treasury yield rises by 10 basis points (bp), then the 10-, five-, and two-year Treasury yields must also rise by 10 bp.

Thus, all Treasury yields are perfectly correlated, and equally volatile. Under this assumption, any two Treasury bond portfolios with the same duration are equivalent. The truth is obviously more complicated than this. Bond yields need not always move in parallel, so there can be a big difference between two portfolios with the same duration. For example, if one has more of a barbell profile than the other, it will outperform if the yield-curve flattens. There is more to yield-curve risk than duration.

We need to find some way of understanding the yield-curve that recognizes that different kinds of yield-curve shifts occur, and that fits them into some systematic framework. There are at least four approaches that we could take:

1. We could make some arbitrary set of assumptions based purely on intuition; this intuition would presumably be derived from market experience.
2. We could devise a plausible mathematical model of the yield-curve and derive the possible yield-curve shifts that could occur if the model happened to conform to reality.
3. We could carry out an economic analysis of how investor expectations about economic fundamentals should drive bond yields and then identify the different kinds of shifts in the yield-curve that would result from changes in economic expectations.
4. We could look at historical shifts in Treasury bond yields and apply some statistical method to identify the different basic kinds of yield-curve shifts that have occurred in the past.

All four methods have pitfalls. Our intuitions might be wrong. There is no guarantee that a mathematical model, no matter how elegant, will be realistic. Economic arguments might be fallacious, or might overlook relevant noneconomic factors; and statistical methods often give spurious results, or even inconsistent results depending on what data is used.

In this chapter, we will adopt the following strategy. First, recognizing that investors' economic expectations do play a large part in determining bond yields, we construct an economic argument that tells us what the yield-curve should look like and what kind of important yield-curve shifts should be possible. Next, we carry out a statistical analysis of historical Treasury bond yields, using our economic conclusions to cross-check the results and help determine which of these results are meaningful. Since we are unlikely to detect all relevant phenomena if we only use a single method of analysis, we must try to analyze the data in alternative ways.

Economic versus Noneconomic Factors in Yield-Curve Dynamics

Bond yields are determined by investor expectations. The obvious questions, then, are: What expectations are relevant? What is the precise relationship between these

expectations—which are not directly observable—and observed bond yields? And finally, how does this help us understand the dynamics of the yield-curve?

It is natural to focus on *economic* expectations. Writing during the Depression, Keynes focused on expectations about future economic growth, demand, and output, and also about the desire for liquidity arising from uncertainty about the future—a more subtle form of expectation. Since the 1970s, it has been more fashionable to focus on expectations about future inflation, although the old Keynesian ideas have recently been revived in an attempt to understand yield-curve dynamics when the central bank is using unconventional policy tools.[1] At a minimum, both growth and inflation matter.

So we provisionally take a straightforward economic approach and simply make the assumption that forward interest rates, and thus current bond yields, are broadly determined by investors' expectations about:

1. Real interest rates, which are determined by expected real returns on capital, and
2. Inflation, i.e., changes in the "price level"; however one wants to define that term.

Note that investors would not assume that either the real interest rate or inflation will remain constant. Both rates might be expected to rise or fall over time. However, given the lack of ability to make detailed forecasts more than one or two years forward, investors would probably assume that beyond this time horizon, both real rates and inflation tend to some long-term "equilibrium" levels when forming their expectations. The situation is pictured in Exhibit 38–1.

The concept of the real interest rate roughly corresponds to the real growth rate of the economy, or the real growth in output. We have not spelled out the precise relationship between expected future interest rates and current bond yields, but we assume that there is a fixed relationship between expected future interest rates and current forward rates; and of course, knowing the current forward curve is the same as knowing current bond yields. The relationship between expected future rates and forward rates actually depends on expected volatility, and the precise nature of that relationship is model-dependent. Here we simply assume that when expected future rates move, forward rates move by the same amount. This turns out to be a reasonable assumption except at extremely long forward dates.

An example may help. In our framework, the long bond yield is determined by the expected long-term real interest rate plus the expected long-term inflation rate. In the late 1980s and early 1990s, Australian long bond yields were largely driven by fluctuations in the current account deficit, which affects expectations

1. Ben Bernanke, "Deflation: Making Sure 'It' Doesn't Happen Here," Remarks before the National Economists Club, Washington, DC, November 21, 2002; http://www.federalreserve.gov/boarddocs/speeches/2002/20021121/default.htm.

EXHIBIT 38–1

How Economic Expectations Determine Expected Future Interest Rates

about real interest rates. By contrast, from 1994 onward, Australian long bond yields have more often been driven by fluctuations in the Consumer Price Index (CPI), which affect investor expectations about inflation.

In the context of the U.S. bond markets, Frankel warned against focusing solely on inflationary expectations and emphasized the fact that—contrary to Fama's assertion in 1975—real interest rates are not constant. For example, "when nominal interest rates rose sharply at the beginning of [the 1980s], it was not because expected inflation was rising. Rather contraction of monetary policy had succeeded in raising the real interest rate."[2] More recently, the existence of inflation-linked Treasury securities has enabled us directly to observe fluctuations in long-term real interest rates, and these have sometimes been as volatile as long-term inflation expectations.

Note that in our framework, the slope of the yield-curve has a natural interpretation. If investors believe that real interest rates or inflation will rise from their current levels, the curve will slope upward, whereas if investors believe they will fall, it will slope downward. That is, the yield-curve has a slope because the economy is not generally believed to be in static equilibrium.

The other reason that the yield-curve might slope upward is that investors demand a risk premium for holding bonds, the so-called term premium, which

2. Jeffrey A. Frankel, *J Financial Markets and Monetary Policy* (Cambridge, MA: MIT Press, 1995), p. xii.

EXHIBIT 38–2

A Macro-economic Model of Adjustment in the Price Level and Interest Rates

Constants

$\bar{\pi}$	expected long-term inflation rate
$\bar{e}$	expected long-term real interest rate

Time-varying quantities

r	short-term nominal interest rate
$\bar{y}$	log of potential output (capacity)
y	log of actual output (utilization)
m	log of the money supply
p	log of the price level

Equations

IS	$y-\bar{y}=-\psi\left(\left(r-\frac{dp}{dt}\right)-\bar{e}\right)$	the current output gap is determined by the current real interest rate gap
LM	$m-p=y-\lambda r$	real money demand is determined by real income and the nominal interest rate
CU	$\frac{dp}{dt}=\rho(y-\bar{y})+\bar{\pi}$	current inflation is determined by long run inflation and the current output gap
MP	$\frac{dm}{dt}=\bar{\pi}+\frac{d\bar{y}}{dt}$	money supply growth is determined by potential output growth and long run inflation

rises with maturity. Empirical studies have shown that, although there does appear to be a risk premium for bonds versus Treasury bills, beyond about two years the risk premium is much less dependent on maturity (i.e., it usually has a much flatter term structure); so as a first approximation, it may be more helpful to think of the term premium as primarily consisting of a general bond market risk premium or liquidity premium versus the short term money market, rather than a duration risk premium.[3]

Note that the term premium is not directly observable, but must be estimated via a term structure model; and its behavior turns out to be linked to economic variables. Thus, the simple model in Exhibit 38–2 certainly does not capture all of the economic determinants of the yield-curve. But these topics are beyond the scope of this chapter.[4]

3. *Ibid.*, p. 134; and Antti Ilmanen, "Does Duration Extension Enhance Long-Term Expected Returns?" *Journal of Fixed Income* 6, No. 2 (September 1996), pp. 23–36.
4. For more information, see Don H. Kim and Athanasios Orphanides, "The Bond Market Term Premium: What Is It, and How Can We Measure It?" *BIS Quarterly Review* (June 2007), pp. 27–40.

The Shape of the Yield-Curve

Now that we have a picture of what kinds of economic expectations determine bond yields, we can go on to investigate how changes in economic expectations cause shifts in the yield-curve. It is convenient to use a simple economic model of the yield-curve originally proposed by Frankel.[5]

Let r_0 be the current short-term nominal interest rate, let $\bar{\pi}$ be the expected long term inflation rate, and let $\bar{e}$ be the expected long-term real interest rate. Then, by definition, the expected long-term nominal interest rate is $\bar{\pi}+\bar{e}$. It is usually the case that $r_0 \neq \bar{\pi}+\bar{e}$, but it seems reasonable to assume that investors expect the future interest rate $r = r_t$ $(t > 0)$ to approach $\bar{\pi}+\bar{e}$ as time passes. In fact, under some realistic economic assumptions, one can show that there is a constant κ such that:

$$\frac{dr}{dt} = -\kappa(r - (\bar{\pi}+\bar{e}))$$

The macroeconomic model that Frankel used to derive this relationship is shown in Exhibit 38–2; it corresponds fairly closely with "standard undergraduate macroeconomics." It is fairly straightforward to derive the above formula with $\kappa = \rho\gamma/(\psi\gamma+\lambda)$, where $\gamma := \psi/(1-\psi\rho)$. However, a similar relationship appears to hold in a fairly wide variety of models of the economy, including ones that permit random shocks to the level and trend of the money supply. Thus the conclusion appears to be quite general.

The basic intuition is that interest rates take time to adjust to their expected long-term level because prices are sticky. Anyway, given r_0, the current short-term interest rate, it is easy to determine it, the expected short-term interest rate at time t:

$$r_t = (1-\exp(-\kappa t))(\bar{\pi}+\bar{e}) + r_0 \exp(-\kappa t).$$

It is convenient to write this in the form:

$$r_t = (\bar{\pi}+\bar{e}) - \exp(-\kappa t)((\bar{\pi}+\bar{e}) - r_0).$$

That is, a rational investor would expect the short-term interest rate to asymptotically approach some long-term equilibrium level $\bar{\pi}+\bar{e}$, and the expected path of future short-term rates can be described by an exponential curve. There are also other ways to arrive at this conclusion.

The economic model need not be "true" for this description of expected interest rates to hold. All we need to assume is that investors implicitly—although perhaps incorrectly—have this kind of economic model in mind when forming expectations about future interest rates. This seems to be a reasonable assumption, given the plausibility of the model and the generality of its assumptions.

5. Frankel, *Financial Markets and Monetary Policy,* pp. 115–116.

The coefficients in this equation are not directly observable, but could be estimated from the current yield-curve. The term $\bar{\pi}+\bar{e}$ is the expected long-term nominal interest rate in equilibrium, which will be reflected in current long bond yields, while the term $(\bar{\pi}+\bar{e})-r_0$ is the spread between current nominal rates and the long-term equilibrium rate, which will be reflected in the slope of the yield-curve.

The correct interpretation of the current short term nominal interest rate r_0 is somewhat more subtle than it appears. The model describes an economy that, although not static—adjustment in interest rates takes time because prices are sticky—is moving along an equilibrium path toward a long-term steady state. This is a reasonable way to derive a medium- or long-term economic forecast, say more than two years out. In the near term, however, we know that the economy can behave in a more complex way, and we can make much more detailed forecasts about the economy that do not rely on a simple equilibrium model; the same applies to interest rates in the near term.

Thus it would be incorrect to identify r_0 with an actual current short-term interest rate, e.g., the Fed Funds rate or the three-month T-bill yield. A more appropriate interpretation, due to Richard Mason, is as follows: r_0 is "extrapolated back" from the medium- to long-term equilibrium interest rate forecasts embodied in the current yield-curve; that is, it is what the current short-term interest rate would have to be for the economy to be currently in equilibrium, i.e., to currently conform to the model. In a sense, r_0 is where the bond market thinks short-term interest rates should be, based on the economic fundamentals—and this need not coincide with their actual levels, particularly if there is disagreement between the Fed and the markets,[6] or if the zero bound constraint is binding on short term interest rates (i.e., the optimal policy rate would otherwise be negative).

Although the interpretation seems odd at first, it is suggestive. It implies that when attempting to estimate the model, we can and should exclude money market yields from the estimation process and use only bond yields. It also tells us that any information about yield-curve shifts that the model gives us will apply to bond yields, not to money market yields.

The model predicts three kinds of observable shifts in the yield-curve:

1. Level shifts, which result from changes in the expected long-term rate $\bar{\pi}+\bar{e}$;
2. Slope shifts, which result from changes in r_0, or rather $(\bar{\pi}+\bar{e})-r_0$; and,
3. "Curvature shifts," which result from changes in κ.

In other words, level shifts arise from changes in long-term expectations; slope shifts arise from changes in expectations about monetary policy in the near term; and "curvature shifts" theoretically occur when investors believe that there has been a secular change in the economy, e.g., which makes prices inherently

6. For more discussion, see Wesley Phoa, "Can You Derive Market Volatility Forecasts from the Observed Yield-Curve Convexity Bias?" *Journal of Fixed Income* 7, No. 1 (June 1997), pp. 43–54.

more sticky. The model implicitly predicts that while level shifts and slope shifts can occur all the time, "curvature shifts" should be much more rare. In fact, in the real world it is unlikely that curvature shifts occur for the economic reasons suggested by the model. Noneconomic explanations, such as supply/demand imbalances at particular points on the yield-curve, are a more plausible explanation for curvature changes. We will discuss curvature shifts further below, but for the moment we concentrate on level shifts and slope shifts.

The idea of focusing on a "long rate" and a "spread" is far from new, and all we have done here is given some theoretical justification for it. Note that so far, we have no reason to assume that level shifts and slope shifts, of the form implied by the model, should be uncorrelated. In fact, the correlation would depend on investors' views about the nature of monetary policy. If the Fed were generally regarded as being slow to move, then a rise in long-term inflation or real rate expectations would generally be accompanied by a steepening in the yield-curve, while a fall in long bond yields would generally be accompanied by a flattening; thus the correlation would be positive.

The model makes an interesting prediction about slope shifts. In periods when κ is stable, all slope shifts should follow the same pattern. Slope shifts always "look the same," except for a scaling factor. In other words, on different days one might observe slope shifts that look like any of the thin solid lines in Exhibit 38–3, but not like the thin dotted line. (The latter kind of shift is possible,

EXHIBIT 38–3

"Typical" Yield-Curve Slope Shifts and an "Atypical" Slope Shift

but would have to be interpreted as a slope shift plus a curvature shift.) As we are about to see, this prediction is broadly consistent with the empirical data, but with some interesting qualifications.

EMPIRICAL ANALYSIS OF YIELD-CURVE DYNAMICS

We just used a macroeconomic model of the yield-curve to argue that shifts in bond yields should not be totally chaotic but that, since they are driven by changing economic expectations, they should be systematic and classifiable. More specifically, the most important kinds of yield-curve shifts should be level shifts and slope shifts. Can we verify this prediction by analyzing random yield-curve shifts that have occurred historically?

Using Principal Component Analysis to Identify Yield-Curve Shifts

There is a way to apply a purely statistical analysis to historical bond yields to extract "fundamental yield-curve shifts." This was first done by Litterman and Scheinkman, using a very standard statistical method called principal component analysis.[7] Before applying this analysis to bond yields, we briefly describe the intuition behind it by looking at a physical example taken from Jennings and McKeown.[8] Although there are other ways to motivate principal component analysis, I think the physical analogy is an attractive one.

Consider a plank fixed to a wall. In what ways can this cantilever vibrate? It is intuitively clear that it can only vibrate at certain "natural frequencies," or "vibration modes"; that is, any observed vibration is a combination of these vibration modes.

In fact, one can calculate that there are three of these modes, as shown in Exhibit 38–4. Note the scale of each of the diagrams, which indicates the relative importance of each mode: the second mode has less than a twentieth the amplitude of the first mode, and the third mode is ten times smaller again. It would probably not be visible to the naked eye.

Now, suppose that we knew no physics, and wanted to work out what these vibration modes were just by observing the behavior of the plank. It is reasonable to hope that we could carry out the following procedure:

1. Attach sensors 5-, 10-, and 15-m along the plank—making the assumption that measuring the displacement of the plank at just these points gives us enough information about the whole plank.

7. Robert Litterman and José Scheinkman, "Common Factors Affecting Bond Returns," *Journal of Fixed Income* 1, No. 1 (June 1991), pp. 54–61.
8. See Chapter 6 in Alan Jennings and J. J. McKeown, *Matrix Computation, 2nd Edition* (Chichester, UK: Wiley, 1992).

EXHIBIT 38–4

Vibration Modes of the Cantilever

2. Give the plank a lot of random whacks, and for each whack measure the amplitude of the observed vibration at each sensor.
3. Work out the 3×3 covariance matrix of these amplitudes. The diagonal will show the relative size of the displacements, whereas the other matrix elements will show whether the sensors tend to move in the same direction. In this case, all the correlations will be strongly positive, but none of them will be equal to one.
4. Extract the vibration modes by somehow "decomposing" this covariance matrix.

It turns out that if A is the covariance matrix, then the vibration modes are the eigenvectors of A, and the eigenvalues tell us how important each vibration mode is. (Recall that a vector u called an eigenvector of A, with associated eigenvalue λ, if it solves the equation $Au = \lambda u$; there are standard numerical methods for finding all the eigenvectors and eigenvalues of a matrix. Also, one can prove that any two eigenvectors are orthogonal, i.e., correspond to uncorrelated modes, and in fact that the eigenvectors form an orthogonal basis.) The required "decomposition" thus amounts to finding the eigenvectors of A.

Thus, to determine the dynamics of the cantilever, it is in principle not necessary to know any physics—only matrix algebra. In practice, of course, things are unlikely to be so easy. Small measurement errors might lead to errors in the covariance matrix, and hence in the numerically computed eigenvectors and eigenvalues. The first vibration mode will be hard to miss, but the second might

be difficult to detect. The third is so small, relatively speaking, that any measurement error at all will probably swamp it. Also note that since the eigenvectors are orthogonal by construction, they correspond to uncorrelated or independent vibration modes.

We can apply exactly the same method to analyzing the dynamics of the yield-curve: identify some "key points" (standard bond maturities that represent key liquidity points); look at historical yield shifts at each of these points; compute the covariance matrix of yield shifts; and compute its eigenvectors and eigenvalues. Each eigenvector should correspond to a fundamental yield-curve shift, and by definition these fundamental shifts are uncorrelated. The eigenvalues are weights, which tell us the relative importance of each of these shifts; and the actual yield-curve shift on any specific day is a linear combination of fundamental shifts.

Our economic analysis might lead us to expect that the most important fundamental shift will turn out to be a parallel shift, whereas the second most important will turn out to be a slope shift. But we are not certain that this will be the case; for example, since the parallel and slope shifts predicted by the model are not necessarily uncorrelated, they will both turn out to be linear combinations of the fundamental shifts identified by the statistical analysis, which are by definition uncorrelated. However, since the correlation is low, we might hope that the two most important fundamental shifts would closely resemble a parallel shift and a slope shift.

Note that on its own the economic analysis tells us nothing about the relative importance of these two different kinds of yield-curve shift; and we do not know what other kinds of shifts there might be. Here the statistical analysis should yield some valuable insights. However, since the results of this empirical analysis might depend on the dataset used, it is important to test their robustness by running the analysis on a variety of datasets.

The results of a principal component analysis may depend on which bond yields we feed into the analysis. For example, if we include a large number of money market yields, we are more likely to pick up yield-curve shifts specifically affecting the money market curve, and we will give a lower weighting to yield-curve shifts affecting midrange bonds, or perhaps fail to detect such shifts at all. Thus, as with any statistical analysis, we must be careful to select the most "relevant" observables. For most bond investors, this means using bond yields in preference to money market yields.

Finally, a technical point: We use the correlation matrix rather than the covariance matrix in our analysis. This corresponds to scaling away differences in yield volatility at different points in the yield-curve.[9] The fundamental yield shifts identified by a principal component analysis of U.S. Treasury yields are shown in Exhibit 38–5. Only the first four eigenvectors are shown; the others have

9. For a further discussion of this point, see Roger Lord and Antoon Pelsser, "Level-Slope-Curvature—Fact or Artefact," *Applied Mathematical Finance* 14, No. 2 (2007), pp. 105–130.

EXHIBIT 38–5

Principal Component Analysis of U.S. Treasury Yields, 1993–2011

negligibly small weights. One can make the following remarks about these empirically observed fundamental yield-curve shifts:

1. The dominant fundamental shift is an empirical level shift (thick solid line), a nearly parallel shift in yields across the whole curve. This explains around 85% of observed variation in yields.
2. The next most important fundamental shift is an empirical slope shift [thin solid line], in which the yield-curve pivots around the five-year point. This explains around 10% of observed variation in yields, and seems to have become slightly more important in recent years.
3. The third most important fundamental shift is an empirical curvature shift (dashed line), sometimes called a "butterfly shift," in which three- to six-year bond yields move relative to shorter and longer bonds. The precise nature and importance of a curvature shift seems to vary from period to period, and curvature shifts explain less than 3% of observed yield shifts.
4. The remaining shifts identified by the principal component analysis—such as the fourth eigenvector, the only remaining one that is shown in the exhibit (as a dotted line)—seem to have no meaningful interpretation,

and are probably due to statistical noise. They vary depending on the dataset.

How robust are these findings? One important check is to determine whether the observed dynamics have varied over time. We can do this by carrying out the same analysis using different time periods; this is done in the three panels of Exhibit 38–6, which compare the first, second, and third eigenvalues (i.e., level, slope, and curvature shifts) observed in five different time periods, corresponding to different monetary policy regimes in the United States:

- 1953–1966: A period of low inflation and conservative Fed policy, largely under Chairman Martin
- 1967–1979: A period of loose monetary policy and accelerating inflation, under Burns and Miller
- 1980–1992: A period of tight monetary policy and disinflation, under Volcker (including an initial period in which monetary aggregates were being targeted aggressively)
- 1993–2008: A period of moderate inflation and conventional Fed policy, under Greenspan and Bernanke (involving fed funds targeting broadly consistent with the Taylor rule, and with increasing transparency over time)

EXHIBIT 38–6A

Parallel Shifts in U.S. Treasury Curves, Different Time Periods

EXHIBIT 38–6B

Slope Shifts in U.S. Treasury Curves, Different Time Periods

EXHIBIT 38–6C

"Curvature Shifts" in U.S. Treasury Curves, Different Time Periods

- 2009–2011: A period of near-zero short-term interest rates with a binding zero bound, and unconventional Fed policy under Bernanke (involving a large expansion of the Fed's balance sheet), following the global financial crisis

The results can be broadly summarized as follows:

- In all periods, the three most important eigenvectors seem to correspond to level, slope, and curvature shifts.
- The importance of the level shift is fairly constant over time, with a weight over 90% in all periods except the last, in which the weight is around 82%. The shape of the level shift is also fairly constant over time, being nearly parallel in every period except the last, in which it involves a smaller shift at the short end of the curve. This presumably reflects the fact that the short end of the curve was pinned by the zero interest rate target.
- The importance of the slope shift is fairly constant over time, with a weight between 5% and 10% in all periods except the last, in which the weight is around 15%. The shape of the slope shift is remarkably constant over time, except in the last period.
- The weight of the "curvature" shift is less than 4% in all periods, and the peak of the hump varies in different periods, moving between the three- and five-year part of the curve.

It is tempting to conclude that because parallel shifts account for such a large proportion of variance in Treasury yields, slope shifts and other kinds of shifts are not important. This is incorrect. The reason is that most bond investors are evaluated against a benchmark rather than on the basis of total return. An investor who is tracking benchmark duration closely has, by definition, nearly the same exposure to parallel shifts as the benchmark; but exposure to yield-curve slope may be quite different; for example, if the portfolio has a barbell profile. In this case yield-curve slope shifts would play a major role, sometimes the primary role, in determining relative performance.

Incidentally, the appearance of level, slope, and curvature shifts in the analysis are not empirical accidents. Lord and Pelsser show that they follow from mathematical properties of the correlation matrix.[10] For example, if all the correlations are positive then the most important eigenvalue will always be a level shift, in the sense that yields at all maturities move in the same direction; and if the correlation curves become flatter for longer maturities (Exhibit 38–9), then the second most important eigenvalue will be a slope shift. However, this says nothing about the shape of these shifts; for example, it does not tell us that the level shift must be parallel rather than having a more complex shape as it did in

10. *Ibid.*

the case of the U.S. Treasury curve in the 2009–2011 period. So the mathematics does not obviate the need to carry out the principal components analysis.

Our analysis so far has focused on the U.S. Treasury market. It is logical to ask whether similar results hold for other bond markets—and also whether the apparent change in behavior in the most recent period has any analog in different markets. Since the earlier arguments about how interest rate expectations determine the shape of the yield-curve should apply equally to most market economies, one would expect the term structure dynamics in different developed countries to be broadly similar. This turns out to be the case, although there are minor differences that have an interesting interpretation.

Exhibit 38–7a shows the results of a principal components analysis carried out on Euro Area Government bond yields (specifically, the German bund curve). The results are quite similar to the full period U.S. Treasury analysis, although the hump of the "curvature" shift seems to occur at a longer maturity point. Note that the level shift is nearly parallel in nature.

Exhibit 38–7b shows the results of a principal components analysis carried out on Japanese Government bond yields. The results are quite similar to the U.S. Treasury analysis during the period 2009–2011, with a comparable downward bend at the short end of the level shift. This is unsurprising, since during the period analyzed, the zero bound was also binding on the Bank of Japan's short-term interest

EXHIBIT 38–7A

Principal Component Analysis of Euro Area Government Bond Yields, 2000–2011

EXHIBIT 38–7B

Principal Component Analysis of Japanese Government Bond Yields, 2000–2011

rate target, and it was engaged in unconventional monetary policy (quantitative easing) during much of this period.[11]

Overall, we can conclude that:

1. Level and slope shifts, taken together, do a good job at describing the bulk of yield-curve risk.
2. "Curvature" shifts explain much of the rest, but the nature of a curvature shift is more elusive.
3. Yield-curve dynamics may be a little different during periods of unconventional monetary policy, or when the zero bound is binding.

Implications for Portfolio Risk Management

It has been argued that if level shifts are not parallel, then duration is an inappropriate portfolio risk measure. The effective duration of a portfolio measures its sensitivity to a parallel shift in the yield-curve; arguably, it should be replaced

11. For more discussion of global yield-curve dynamics, see Wesley Phoa, "Yield-Curve Risk Factors: Domestic and Global Contexts," in Lev Borodovsky and Marc Lore (eds.), *The Practitioner's Handbook of Financial Risk Management* (Woburn, MA: Butterworth-Heinemann, 2000).

with a "level duration" that measures its sensitivity to the empirical level shift, which is not perfectly parallel. The natural counterargument is that duration is more widely understood and easier to calculate. Moreover, since a U.S. level shift is approximately parallel, one would get a similar answer anyway. Note that for maturities of three years and greater, even level shifts in periods of unconventional monetary policy look roughly parallel. It is only shorter maturities that don't move in parallel. Thus, even under these conditions, a parallel shift is a reasonable proxy for a level shift when one is analyzing portfolios which do not contain many short maturity bonds.

On a more fundamental level, we argued earlier in this chapter that if we interpret yield-curve shifts as arising mostly from changes in economic expectations, it is natural to focus on parallel shifts and slope shifts—in which "slope" refers to the spread between the short rate and the long bond yield. We also observed that there was no reason to expect these parallel shifts and slope shifts to be uncorrelated. Now the factors identified by a principal component analysis must, by definition, be uncorrelated. This means that the first two principal components—the empirical level and slope shifts—should be interpreted as certain linear combinations of the economically meaningful parallel and slope shifts. That is, the fact that the empirical factors are forced to be uncorrelated means that they may not be intrinsically meaningful.

For example, if inflation is unusually volatile and there is a high correlation between rises in inflationary expectations and monetary tightenings—that is, if tightenings tend to occur in response to market perceptions of inflationary pressures, and to overshoot them—the empirical level shift would not look parallel. Thus the nature of the empirical level shift—unlike the economically meaningful parallel and slope shifts—depends on whether unusual economic circumstances may have influenced monetary policy during the period being studied.

When monitoring interest rate risk, it is preferable to focus on economically meaningful parallel shifts and slope shifts, which may have non-zero correlation, rather than the empirical level shifts and slope shifts identified by principal component analysis. That is, rather than constructing new risk measures from the principal components, one should continue to use duration, and supplement it with a "slope duration" derived from the economic analysis.

Note that unlike parallel duration, there is no "standard" definition of slope duration. A convenient definition of "slope duration" might be calculated as follows: Let a "slope shift" correspond to a shift with the same shape as the second principal component in Exhibit 38–5, but translated and scaled so that the two-year point shifts by 100 bp and the 30-year point remains unchanged. (It should also be smoothed somewhat.) Given a bond, compute its value after this slope shift has been applied to the current yield-curve. The percentage change from the original price is the slope duration of the bond.

Other definitions are possible. For example, one could alternatively let a "slope shift" be any of the empirical slope shifts shown in Exhibit 38–6b, and the chosen shift could be translated and scaled so that the six-month yield moves by

100 bps and the 10-year yield remains unchanged. The precise choice doesn't matter as long as it's applied consistently. The important thing is to apply a consistent definition of slope shift to different bonds, and at different times.

Exhibit 38–8 shows ordinary durations and slope durations for outstanding noncallable Treasury bonds, using our suggested definition of slope duration. (The graphs are not perfectly smooth curves because of the differing bond coupon rates.) Note that while parallel duration rises with maturity, slope duration is highest for bonds with a maturity of around seven years. The reason is that the yields of longer bonds are not greatly affected by a yield-curve slope shift.

A word on curvature shifts and other less significant yield-curve shifts (such as "hump shifts," curvature shifts affecting very short maturities when these are included in the data set). These crop up persistently in principal component analyses, and thus it is tempting to regard them as "fundamental" factors on a par with level and slope shifts—but that happen to be much less important. This is not quite the case. As we saw earlier in this chapter, level and slope shifts have a natural economic meaning, and the form of a level shift or a slope shift tends to be quite stable over time.

By contrast, a curvature shift or a hump shift generally has no economic interpretation, and the region of the yield-curve most affected by such a shift can vary widely. For example, a hump in the money market curve is usually the result of a sophisticated market prediction about future monetary policy, and might

EXHIBIT 38–8

Ordinary (Parallel) Durations and Slope Durations of Selected Noncallable Treasuries

center on around (say) the 9-, 12-, or 18-month part of the yield-curve, depending on circumstances Similarly, curvature shifts generally arise because of supply/demand imbalances that affect very particular parts of the yield-curve. For example, in late 1995, three-year Australian Government bond yields were driven down by swap market activity arising from Australian issuance in the Japanese market and from specific deals related to the privatization of the Victorian power industry; three-year yields were specifically affected because of Japanese retail demand for three-year investments and because of the nature of the privatization deals being arranged. In different circumstances it might have been the two-, or five-year, part of the curve that was most affected. It was not useful to regard this phenomenon as a "curvature shift" in some generic sense.

The practical conclusion for portfolio risk management is as follows. It makes sense to measure portfolio "level risk" and "slope risk" in a consistent way, as these correspond to fundamental interest rate risk factors. The meaning of a level shift or a slope shift does not change over time. However, it is not advisable to take an equally rigid approach to measuring "curvature risk" or "hump risk," since curvature or hump shifts do not have any fundamental significance, but occur for more specific reasons, and take different forms at different times. Thus, one must adopt a more flexible approach to monitoring this kind of yield-curve reshaping risk. We will explore this further later in the chapter.

BEYOND LEVEL AND SLOPE RISK

It was just suggested that, when monitoring overall portfolio interest rate risk, it is most important to focus on parallel duration and slope duration. For example, these two risk measures capture the effects of long/short duration bets, and of steepening/flattening trades. Since the other principal components have such a low weight, and we argued that measuring curvature risk and hump risk was problematic, one might think that only parallel and slope risk matter. Unfortunately, this is not quite the case. In practice, these two risk factors are not comprehensive.

Empirical Correlations versus Theoretical Correlations

There is a certain kind of risk that is obscured by principal component analysis: the risk that, perhaps for an event-specific reason, a specific part of the yield-curve will shift. The behavior of the three-year part of the Australian yield-curve in late 1995, discussed above, is an example. This had a significant impact on bond returns during that period. But if this precise yield-curve shift did not happen repeatedly, it would not appear statistically significant when carrying out a principal component analysis using five or ten years of data. A more recent example would be the behavior of the five-year U.S. Treasury note during 2010, as it richened dramatically relative to other maturities, then cheapened even more rapidly.

How can we determine what is lost when we focus only on parallel duration and slope duration? To answer this question, Rebonato and Cooper compared (a)

EXHIBIT 38–9

Empirical Correlations of Different Treasury Yields

the empirical correlations of changes in different bond yields, with (b) the correlations predicted if only parallel shifts and slope shifts had occurred.[12]

Exhibit 38–9 shows empirical correlations for one-, five-, or 30-year Treasury yield as a function of the yield to which this is being compared. For example, the five-year yield has a correlation of around 0.95 with both the three- and seven-year yield, but only 0.90 with the 30-year yield and only 0.85 with the one-year yield. Note that the correlations fall away sharply as we move away from the specified bond.

Exhibit 38–10 shows what these correlations would have been if only parallel shifts and slope shifts had occurred. Note that they fall away much more gradually as we move away from the specified bond. That is, the theoretical correlation between nearby bonds is much higher than the empirical correlation. This shows that focusing only on parallel risk and slope risk understates the basis risk between two nearby bonds; it suggests that (say) the five-year bond and the seven-year bond should be much closer substitutes than they actually are.

The pattern of gradually declining correlations observed in Exhibit 38–10 is not an accident. Rebonato and Cooper proved mathematically that if you assume only two kinds of yield-curve shift, the correlation functions must behave like this. This may be viewed as a kind of converse to the results of Lord and Pelsser mentioned earlier.

12. Riccardo Rebonato and Ian Cooper, "The Limitations of Simple Two-Factor Interest Rate Models," *Journal of Financial Engineering* 5, No. 1 (March 1996), 1–16.

EXHIBIT 38–10

Theoretical Correlations of Different Treasury Yields, Two Factor Model

What is the appropriate way to monitor maturity-specific risks that do not correspond to fundamental yield-curve shifts that occur repeatedly? At the moment, the most useful tool seems to be the concept of partial duration, which measures exposure to a yield change at a single point on the yield-curve. We briefly review this concept. To compute, for example, a five-year partial duration, shift the five-year point of the yield-curve by 100 bps, and recompute the value of the bond. The percentage change from the original price is the partial duration.[13] (There are other possible definitions. For example, it is also common to apply a shift to the zero coupon yield-curve rather than the benchmark or par yield-curve. There is also no standard set of maturity points used to calculate partial durations.)

There are a number of important observations to make about the concept of partial duration:

- The yield-curve shifts used in the definition of partial duration are not economically meaningful; in fact, they are highly unrealistic. Therefore, single partial durations do not have any economic interpretation, and are purely tools, "building blocks" of yield-curve risk.
- The definition of a specific partial duration may depend on the set of yield-curve maturity points chosen. For example, the value and meaning

13. For more details, see Thomas Ho, "Partial Durations: Measures of Interest Rate Risk," *Journal of Fixed Income* 1, No. 2 (September 1992), pp. 29–44.

of the 10-year partial duration will differ depending on whether the adjacent grid points are at 5 and 30 years, or at 7 and 20 years.

- The definition of a specific partial duration also depends on how yields are interpolated between maturity points. The above examples assume linear interpolation, but different methods could be used.
- Care must be taken when computing partial durations for securities with interest-rate sensitive cash flows, particularly adjustable-rate mortgages (ARMs) with reset caps or floors. This is because shifting a single maturity point of the observed yield-curve corresponds to a much more complex and extreme displacement in the forward curve, and since cap and floor valuation is highly sensitive to the forward curve, the results can be numerically unstable.

These observations partly explain why partial durations can often look somewhat unintuitive. Parallel and slope durations are easy to interpret, whereas interpreting partial durations takes some experience. Exhibit 38–11 shows examples of partial durations for some different kinds of securities. Ordinary (parallel) durations and slope durations are also shown, and securities with similar durations are grouped together. Here are some observations about these numbers:

- Compared with bonds with more concentrated cash flows, bonds with spread-out cash flows have lower slope duration and have partial durations that are more spread out over the maturity points used. "Bonds with more spread-out cash flows" include bonds with higher coupons and amortizing bonds.
- The same applies to callable bonds, whose cash flows are "spread out" in the sense that they vary in different interest rate environments. Thus, the callable municipal bond with a 30-year maturity and a 10-year call date has partial durations at both of those maturity points, and lower slope duration than the comparable duration serial.
- *A fortiori*, the same also applies to mortgage pools, which are both amortizing and have option-like cash flows, varying under different interest rate environments due to different prepayment speeds.

Partial durations permit investors to match yield-curve exposures very precisely, and are particularly useful in asset/liability management. However, the precise way in which partial durations are used vary from investor to investor. In fact, a useful application of partial durations is to compute approximate sensitivities to arbitrary yield-curve shifts, such as those identified by a principal component analysis.

Various methods have been proposed for computing "yield-curve reshaping durations" in specific cases; for example, the approach of Willner[14] represents

14. Ram Willner, "A New Tool for Portfolio Managers: Level, Slope and Curvature Durations," *Journal of Fixed Income* 6, No. 1 (June 1996), pp. 48–59.

EXHIBIT 38–11

Comparison of Yield-Curve Risk Measures for Different Security Types

		Durations		Partial durations			
	Security Type	**parallel**	**slope**	**2-year**	**5-year**	**10-year**	**30-year**
US TREASURY NOTE 4.625% 02-15-17	*non-callable, coupon-bearing*	5.4	3.4	*0.1*	*4.2*	*1.1*	*0.0*
US TREASURY BOND 8.875% 08-15-17	*non-callable, coupon-bearing*	5.2	3.2	*0.2*	*3.6*	*1.4*	*0.0*
FNCI 3.0 AB2139 01-01-26	*fixed-rate mortgage pool*	5.2	2.8	*0.6*	*1.6*	*2.8*	*0.2*
US TREASURY NOTE 2.125% 12-31-15	*non-callable, coupon-bearing*	4.7	3.2	*0.1*	*4.6*	*0.0*	*0.0*
FNCI 3.5 AE3992 10-01-25	*fixed-rate mortgage pool*	4.8	2.7	*0.7*	*1.6*	*2.3*	*0.2*
US TREASURY NOTE 2.75% 10-31-13	*non-callable, coupon-bearing*	2.6	2.4	*2.0*	*0.6*	*0.0*	*0.0*
FNCL 5.5 851568 03-01-36	*fixed-rate mortgage pool*	2.7	1.6	*0.7*	*0.9*	*0.8*	*0.3*
FNMA POOL #AC3014 ARH5 WP 3.561% 10-01-39	*hybrid ARM mortgage pool*	2.5	2.0	*1.3*	*1.0*	*0.1*	*0.1*
US TREASURY NOTE 3.5% 05-15-20	*non-callable, coupon-bearing*	8.1	3.5	*0.0*	*1.1*	*7.0*	*0.0*
US TREASURY COUPON STRIPS .0% 02-15-19	*non-callable, zero coupon*	8.2	3.9	*–0.3*	*3.0*	*5.5*	*0.0*
FNCL 3.5 AE7613 11-01-40	*fixed-rate mortgage pool*	7.7	2.8	*0.4*	*1.1*	*4.2*	*2.0*
TEAC GAS PROJ REV SER C (GOS) SF 5.0% 02-01-27	*non-callable, coupon-bearing*	10.7	3.2	*0.1*	*0.3*	*7.6*	*2.7*
SC PUB SER SANTEE COOPER SF 5.5% 01-01-38	*callable, coupon-bearing*	10.8	2.8	*0.1*	*0.9*	*5.4*	*4.4*
GOLDEN STATE TOBACCO REFG SER A-1 SF (T) 5.00% 06-01-33	*non-callable, amortizing*	10.8	2.8	*0.2*	*0.6*	*5.7*	*4.3*

yield-curve displacements using an explicit functional form, following Nelson and Siegel.[15] Implementing this approach on a portfolio level involves considerable additions and modifications to one's existing portfolio analytical system. Also, it is not obvious how to measure exposure to an arbitrary reshaping; for example, different kinds of curvature shift, or the nonparallel level shifts observed in periods of unconventional monetary policy.

There is a more straightforward method for computing the sensitivity of a bond or bond portfolio to an arbitrary yield-curve reshaping. For any given reshaping, this exposure is approximately equal to a fixed linear combination of the bond's partial durations. This suggests that it may be better to regard partial durations as providing a general tool for decomposing arbitrary "relevant" or "meaningful" yield-curve reshapings.

Idiosyncratic Behavior at the Short End of the Curve

The analysis of correlations showed that there are maturity-specific risks not captured by parallel risk and slope risk. There are two other sources of additional risk: "money market risk" and "long end risk." These arise because both the short and long ends of the curve can move independently of the 2- to 10-year section of the yield-curve. Note that idiosyncratic shifts in the short or long end of the curve may not be detected by the principal component analysis unless several observations from the short or long end of the curve are included. For example, if the dataset for a principal components analysis only includes a single long bond yield observation, a statistically significant "long end" factor is unlikely to be detected. Similarly, the dynamics of the very short end of the yield-curve is not likely to be well described by an analysis that uses very few maturity points in that region of the curve. (Recall also that the theoretical analysis of yield-curve dynamics at the beginning of this chapter should not be expected to tell us much about dynamics at the very short end of the curve.)

Note that the precise behavior of money market yields may vary widely from country to country, depending on central bank operating procedures and other idiosyncratic factors. For example, the monetary authorities in the United States and Australia attempt to make relatively smooth adjustments in monetary policy, thus the very short end of the curve (0–three months) is often less volatile than longer money market yields (say, 6–18 months). On the other hand, the Reserve Bank of New Zealand had at times often permitted much more volatility in overnight to three-month yields. The point is that, while the economic factors driving bond yields are generally the same in different countries, the factors driving money market yields are not. They depend on the character of monetary policy in each country.

15. Charles R. Nelson and Andrew F. Siegel, "Parsimonious Modeling of Yield-Curves," *Journal of Business* 60, No. 4 (1987), pp. 473–489.

EXHIBIT 38–12

Principal Component Analysis of USD LIBOR Rates, 1991–2011

When attempting to analyze the behavior of money market yields, it is important to take two precautions. First, because rates corresponding to maturities of less than one month have extremely volatile yields, these should usually be excluded from any statistical analysis. Second, because the behavior of the short end of the curve depends on the current character of monetary policy, it does not make sense to use datasets spanning several monetary regimes.

Bearing this in mind, Exhibit 38–12 focuses purely on the short end. It shows the results of a principal components analysis carried out on LIBOR rates with maturities from one to 12 months. Note that:

- The analysis identifies level, slope and curvature shifts as before.[16] However, the level shift is not perfectly parallel. This is observed using a 20-year analysis period, so it is not due to the fact that Fed policy was unconventional. Rather, it is probably due to inertia in very short-term interest rates. The Fed tends to make only gradual changes to overnight rates.
- And, the "curvature shift" peaks at the three-month maturity point, so it is obviously unrelated to the "curvature shift" observed in the analysis of U.S. Treasury curve dynamics.

16. The mathematical reasons for this, explained by Lord and Pelsser, "Level-Slope-Curvature—Fact or Artefact," apply in this case.

It is hard to draw any definitive conclusions about the dynamics of short maturity yields, particularly since a shift in the nature of monetary policy may make any previous conclusions invalid. Probably the best one can do is to monitor carefully chosen partial durations. In any case, the dollar risk is much lower than for bonds, and investors often have much less flexibility in their money market holdings than in their bond holdings; so in practice there is perhaps more tolerance for error.

As an aside, note that many empirical studies of interest rate dynamics have focused solely on T-bill yields. The above analysis shows that the relevance of such studies to understanding bond yields is dubious. The bond curve must be analyzed separately from the money market curve.

KEY POINTS

- Yield-curve shifts are not always parallel. It is thus inadvisable to use the conventional notion of duration as the only measure of interest rate risk.
- Both theoretical and empirical analyses suggest that the two most important kinds of yield-curve shift are parallel shifts and slope shifts.
- The forms of these shifts can be identified empirically using principal components analysis. They are more or less uniform over time, except during periods when short-term interest rates are at the zero bound.
- The risk measures corresponding to these two kinds of yield-curve shift are conventional (parallel) duration and slope duration. Taken together, these capture most but not all of a portfolio's yield-curve risk exposure.
- "Curvature shifts" appear to be important, but do not have a clear economic interpretation and are less uniform over time; a better way to monitor exposure to more complex yield-curve shifts is via partial durations.

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CHAPTER
THIRTY-NINE

TERM STRUCTURE MODELING WITH NO-ARBITRAGE INTEREST RATE MODELS

GERALD W. BUETOW, JR., PH.D., CFA
Chief Investment Officer
Innealta Capital

BRIAN J. HENDERSON, PH.D., CFA
Assistant Professor of Finance
The George Washington University

Interest rate models are important tools used by practitioners for purposes including pricing of fixed income securities, pricing interest rate contingent claims, and evaluation of interest rate risk. Although there are many interest rate models, the models vary by their assumptions regarding interest rate dynamics and their degree of specificity. Due to differing assumptions about the interest rate process, each model has different properties that have important implications for their use in valuation. The models range from fairly simplistic to highly mathematical and complex, reflecting the tradeoff between analytical tractability and how closely the model captures interest rate dynamics.

The focus in this chapter is on *no-arbitrage* interest rate models. This term means that the models are fit to the current term structure so that valuing bonds with the model results in prices that are consistent with market prices. In addition to no-arbitrage models, another class of interest rate models called *equilibrium models,* begin with a stochastic differential process and develop pricing mechanisms under a general equilibrium framework. Our focus on no-arbitrage models stems from the fact that these models seem to be the most widely accepted among practitioners.

In general, interest rate models begin with a stochastic differential equation (SDE) to describe the dynamics of an interest rate. One-factor models represent the short rate of interest, whereas multifactor models incorporate a SDE for additional interest rates. Obtaining closed-form solutions to interest rate models requires the use of stochastic calculus. Instead of assuming the reader is versed in stochastic calculus, we present the models in the most tractable way possible.

In this chapter, we illustrate several no-arbitrage interest rate models. Our presentation focuses on the important characteristics of each model with an emphasis on the key assumptions driving the models and the properties of the models that reflect these assumptions. Although more sophisticated models exist, the models presented in this chapter are built on the same intuition and algebraic properties as more sophisticated models.

For interest rate models to be useful for practical purposes, it is helpful to adapt them to a recombining lattice structure. This usually translates into binomial or trinomial trees. After presenting the models and highlighting their important properties, we illustrate the models using lattices. The lattice approach is a useful tool for pricing interest rate contingent claims such as callable bonds and swaptions and for evaluating interest rate risk exposure.

INTRODUCTION TO MODELS OF THE SHORT RATE

We present five no-arbitrage models of the short rate in this section. Our focus is on the assumptions behind each of the models and the implications of those assumptions on the resulting rate scenarios. In the next section we build on these ideas by presenting the models fit to binomial lattices to illustrate the important properties.

Ho-Lee Model

The first no-arbitrage interest rate model was that of Ho and Lee.[1] The model assumes that the short-rate follows the stochastic process:

$$dr = \theta(t)dt - \sigma dz \tag{39.1}$$

This continuous-time process expresses the short-rate dynamics as a combination of an expected component and a random shock. The term $\theta(t)dt$ is the expected change component that is also referred to as the drift in the short rate. This component is the source of important characteristics, such as mean reversion, driving the expected change in interest rates. The drift parameter is a function of time and its value comes from the current term-structure through the process of fitting the model to the no-arbitrage constraints, which we will illustrate below.

The second component in the continuous time process is the source of risk and is the product of σ and dz. This component is important since it drives the distributional characteristics of the interest rate. The Ho-Lee interest rate model assumes the level of risk is constant through time and is referred to as a normal process since z is a Weiner process that is distributed normally. The term $dz = \varepsilon\sqrt{dt}$ is distributed normally since ε comes from a standard normal distribution with

1. Thomas Ho and Sang Lee, "Term Structure Movements and Pricing Interest Rate Contingent Claims," *Journal of Finance* (1986), pp. 1011–1029.

zero mean and unit standard deviation. Thus, the Ho-Lee process models the short rate as normally distributed. As we will see shortly, this means that negative interest rates are possible in the model.

We develop a discrete numerical approximation to generate approximate interest rates. Denoting the exact solution to the stochastic differential equation at time t_k as $r(t_k)$, the numerical algorithm generates solutions denoted r_k that approximate the exact solutions $r(t_k)$. For very small discrete time steps, where Δt is close to zero, we have $dt \approx \Delta t = t_{k+1} - t_k$. This leads to an approximation for the interest rate where $dr \approx \Delta r = r(t_{k+1}) - r(t_k) \approx r_{k+1} - r_k$. Using the discrete approximation, we are able to write the approximation for the Ho-Lee model for the interest rate movement from time k to $k + 1$ as:

$$r_{k+1} = r_k + \theta_k \tau + \sigma_k \Delta z_k \tag{39.2}$$

where $t_k = k\tau$, and Δz_k is a numerical (discrete) approximation of dz. Substituting $dz = \varepsilon\sqrt{dt}$, the equation becomes:

$$r_{k+1} = r_k + \theta_k \tau + \sigma_k \varepsilon_k \sqrt{\tau} \tag{39.3}$$

where ε_k is a random number drawn from the standard normal distribution $N(0,1)$. We denote the time step between time t_k and the starting point as τ. Examining the above equation, it is clear that the short rate's mean may grow very large over time; this happens for certain θ where $\theta_k \tau$ can become large. Additionally, it is clear that for large volatility shocks, the short rate dynamics can be heavily influenced by volatility and the random shock component may be very large. Thus, there are two primary shortcomings of the Ho and Lee model: The interest rate can exhibit uncontrolled growth and negative interest rates are possible.

Hull-White Model

The stochastic process for the Hull-White interest rate model is[2]:

$$dr = (\theta - \phi r)dt + \sigma dz \tag{39.4}$$

The process in (39.4) is similar to the Ho-Lee process in (39.1) in that the volatility is assumed to be constant through time and the rates are distributed normally. Additionally, negative interest rates are possible in the Hull-White model. The drift term in the Hull-White process differs from Ho-Lee process. Note that if θ equals zero, then the Hull-White model reduces to the Ho-Lee model. The drift term in the Hull-White model captures the mean-reversion property of interest rates and is an attempt to control the uncontrolled growth of the short rate that is possible in the Ho-Lee model.

2. John Hull and Alan White, "Pricing Interest Rate Derivative Securities," *Review of Financial Studies* (1990), 3, pp. 573–592, and "One Factor Interest Rate Models and the Valuation of Interest Rate Derivative Securities," *Journal of Financial and Quantitative Analysis* (1993), pp. 235–254.

If we define the long run target short rate as $\mu = \theta/\phi$, then we can rearrange the drift term in equation (39.4) to be $\phi(\mu - r)$. When the short-rate is below the target rate μ, then in future periods the rate drifts upwards toward that target rate. Conversely, in periods when the short rate is greater than the target rate, the drift term pulls future rates back toward the target rate. The parameter ϕ controls the speed of mean-reversion. If ϕ is close to zero, the speed at which the short rate tends toward the target rate is slower than cases in which ϕ is close to one. Positive mean-reversion occurs when ϕ takes a positive value. Negative mean reversion is possible when ϕ takes a negative value, but results in exponential growth in the short rate through time. Another important feature of mean-reversion is that the drift toward the target rate is determined partially by how far the short rate is from the target rate, the drift being larger when the short rate is further from the target. In the case of negative mean-reversion, this second effect amplifies the exponential growth of the short rate.

Applying the discrete approximation for the Hull-White stochastic process, as described for the Ho-Lee model, we obtain the following approximation:

$$r_{k+1} = r_k + (\theta_k - \phi_k r_k)\tau + \sigma_k \varepsilon_k \sqrt{\tau} \tag{39.5}$$

The numerical approximation for the Hull-White process, like the Ho-Lee process, models the short rate as normally distributed. The normality assumption is evident since ε_k is a random number drawn from the standard normal distribution $N(0,1)$. Additionally, it is clear that short rates can become negative, particularly when the assumed level of volatility is large.

Due to the additional parameters of the model, the algebra required to fit the Hull-White process to the lattice involves a variable time step. The variable time step is an undesirable property, requiring a spline methodology to engineer equal time steps. Using a trinomial lattice instead of a binomial lattice will introduce an additional degree of freedom allowing the solutions to have fixed time steps between nodes. Thus, when we present the model lattices, we will present the trinomial model for the Hull-White model.

Kalotay-Williams-Fabozzi Model

The Kalotay-Williams-Fabozzi (KWF) model is analogous to the Ho-Lee model as the stochastic process has a constant drift, does not include mean-reversion, and exhibits constant volatility.[3] However, the incremental distinction is that the model treats the natural logarithm of the interest rate as normally distributed. Although the natural logarithm of the short rate may be negative, the short rate itself does not turn negative in this model, unlike the Ho-Lee and Hull-White models. Specifically, the differential process for the KWF model is:

$$d\ \ln(r) = \phi dt + \sigma dz \tag{39.6}$$

3. Andrew Kalotay, George Williams, and Frank J. Fabozzi, "A Model for the Valuation of Bonds and Embedded Options," *Financial Analysts Journal* (May-June 1993), pp. 35-46.

We can see that this equation is identical to the Ho-Lee model if $\mu = \ln(r)$ and we re-write the process as:

$$d\ \mu = \phi dt + \sigma dz \tag{39.7}$$

Since μ follows a normal process, $\ln(r)$ follows a normal process, implying that r follows a lognormal process. Although μ may become negative as in the Ho-Lee and Hull-White processes, r may not become negative. To illustrate, note that since $\mu = \ln(r)$ then $r = e^{\mu}$ which shows that r is always positive and the KWF model circumvents one of the problems from the Ho-Lee and Hull-White models, namely negative interest rates.

The discrete form approximation for the KWF model is:

$$\mu_{k+1} = \mu_k + \theta_k \tau + \sigma_k \varepsilon_k \sqrt{\tau} \tag{39.8}$$

Since $\mu = \ln(r)$ we re-write the equation as:

$$r_{k+1} = r_k e^{\theta_k \tau + \sigma_k \varepsilon_k \sqrt{\tau}} \tag{39.9}$$

From this equation, we see that when θ is positive, the short rate grows through time and is unbounded. Similarly, if θ is negative, the short rate decays toward zero. Like the Ho-Lee model, short rates in the KWF model exhibit potential unbounded growth, but the KWF model circumvents the negative short rates plaguing the Ho-Lee and Hull-White models. Additionally, the short rate is distributed log normally as opposed to normally.

Black-Karasinski Model

The interest rate process in the Black-Karasinski model takes the following form[4]:

$$d\ \ln(r) = (\theta - \phi\ \ln(r))dt + \sigma dz \tag{39.10}$$

If we again let $\mu = \ln(r)$ and re-write the process, we obtain:

$$d\mu = (\theta - \phi\ \mu)dt + \sigma dz \tag{39.11}$$

Note that this expression is the Hull-White interest rate process, and that since μ has those same properties as the rate in the Hull-White model, it is distributed normally and r is distributed log normally. Since $r = e^{\mu}$, the interest rate in the Black-Karasinski process is greater than zero, which is the advantage of this model over the Hull-White model.

4. F. Black and P. Karasinski, "Bond and Option Pricing when Short Rates are Lognormal," *Financial Analyst Journal* (July-August 1991), pp. 52–59.

Compared with the Kalotay-Williams-Fabozzi model, the Black-Karasinski model also includes mean-reversion of the interest rate. Similar to the Hull-White model's extension of the Ho-Lee model, the Black-Karasinski model is an extension of the log normal KWF model to incorporate the mean-reversion property of interest rates. Similar to the Hull-White model, the parameter ϕ controls the growth of the short rate. The drift in the short term rate from each period to the next is determined by the speed of mean-reversion parameter and the distance of the rate from the target rate.

Next, we discretize the process using the same approach illustrated above for the other models:

$$\mu_{k+1} = \mu_k + (\theta_k - \phi_k r_k)\tau + \sigma_k \varepsilon_k \sqrt{\tau} \tag{39.12}$$

Since $\mu = \ln(r)$ we re-write the equation as:

$$r_{k+1} = r_k e^{(\theta_k - \phi_k \ln r_k)\tau + \sigma_k \varepsilon_k \sqrt{\tau}} \tag{39.13}$$

Note the similarity of these equations and Equation (39.5) for the Hull-White model. Both models incorporate mean-reversion in the drift term but the main difference comes from the distributional assumption since the Hull-White is normal and Black-Karasinski is lognormal.

Black-Derman-Toy Model

Similar to the Black-Karasinski model, the Black-Derman-Toy (BDT) interest rate model combines mean-reversion and the lognormal distribution of the short rate.[5] The important incremental contribution is that in the BDT model, mean reversion is determined endogenously, which is to say that it is determined based on the model's input parameters. The mathematics behind this model make it the most complicated of the models we present. The short rate in the model follows the following process:

$$d\ \ln(r) = \left(\theta(t) + \frac{\sigma'(t)}{\sigma(t)} \ln(r)\right) dt + \sigma(t) dz \tag{39.14}$$

If we again let $\mu = \ln(r)$ and re-write the process, we obtain:

$$\mu = \left(\theta(t) + \frac{\sigma'(t)}{\sigma(t)} \mu\right) dt + \sigma(t) dz \tag{39.15}$$

Equation (39.15) is strikingly similar to the Black and Karasinski model in Equation (39.11), and the only difference between the two comes from the mean

5. Fischer Black, Emanuel Derman, and William. Toy, "A One Factor Model of Interest Rates and Its Application to the Treasury Bond Options," *Financial Analyst Journal* (January-February 1990), pp. 33–39.

reversion parameter. In this model, mean reversion is endogenous to the model since it is determined by the assumed volatility of the short rate. The mechanics of mean reversion in this model should be similar, where the short rate is mean reverting when the term $\sigma'(t)$ is less than zero. Conversely, when $\sigma'(t)$ is positive, implying $\sigma(t)$ is increasing, the short rate grows without mean reverting. Note that if the volatility is constant, the derivative is zero and the mean-reversion term is zero. In the case of constant volatility, the KWF model is a special case of the BDT model.

Next, we discretize the BDT interest rate process using the same approach as for the other models:

$$\mu_{k+1} = \mu_k + \left(\theta_k - \frac{\sigma'(t)}{\sigma(t)} r_k\right)\tau + \sigma_k \varepsilon_k \sqrt{\tau} \tag{39.16}$$

Since $\mu = \ln(r)$ we re-write the equation as:

$$r_{k+1} = r_k e^{\left(\theta_k - \frac{\sigma'(t)}{\sigma(t)} \ln r_k\right)\tau + \sigma_k \varepsilon_k \sqrt{\tau}} \tag{39.17}$$

BINOMIAL INTEREST RATE LATTICES

In this section, we present binomial lattice representations of the interest rate models. In the binomial lattice, the interest rate may make one of two possible moves over discrete points in time. For our purposes, we present lattices where the length of each time step is six months. Exhibit 39–1 illustrates a four-period binomial tree. Note that at each node the interest rate takes either an up-step or a down-step. The size of each step is determined by the properties of the interest rate model. Additionally, notice that the tree recombines, meaning that an up-step followed by a down-step produces the same rate as a down-step followed by an up-step. Recombination is a common assumption in binomial trees and results from the imposition of additional algebraic constraints. The numerical methods required to fit the interest rate models to binomial trees are beyond the scope of

EXHIBIT 39–1

The Binomial Lattice of Forward Rates

this chapter, but we present binomial lattice representations of the model to illustrate the important features of the interest rate models. Buetow and Sochacki present a thorough discussion of the numerical methodologies involved with fitting the models to binomial trees.[6]

The no-arbitrage property of the term structure models presented in this chapter comes from the fact that the model rates match the properties of the current term structure. For example, denoting the current one-period (six-month) spot rate as $r_{1,0}$, the two-period spot rate as z, and the implied forward rate as f_1, we can illustrate the no-arbitrage property using the binomial lattice. The two possible values for the interest rate next period in the binomial lattice are $r_{1,1}$ and $r_{2,1}$, and the no-arbitrage property is satisfied by the following constraint, which requires the one period spot rate, followed by the one-period rate at the next time step, $r_{1,1}$ or $r_{2,1}$, to be equal to the two-period spot rate:

$$\left(1+\frac{1}{2}z\right)^2=\left(1+\frac{1}{2}r_0\right)\left[p_u\left(1+\frac{1}{2}r_{1,1}\right)+p_d\left(1+\frac{1}{2}r_{2,1}\right)\right] \tag{39.18}$$

where p_u and p_d are the probabilities of the up and down move, respectively. Imposing the no-arbitrage constraint ensures that pricing straight bonds using the interest rate lattice generates prices that are consistent with the observed spot curve produced from market prices. Due to this property, the no-arbitrage models have practical appeal and are useful for pricing and risk-management purposes.

Exhibit 39–2 presents the Ho-Lee binomial lattice where the term structure is flat at 2% and volatility is constant. In Panel A of the exhibit, volatility is 1% and in Panel B, volatility is 10%. There are several important features of the Ho-Lee model evident in the binomial lattices. First, the one-period interest rate may be negative, which results from the fact that in the Ho-Lee process, the rate is distributed normally and is unbounded. In fact, it can be demonstrated that the spread between the high and low rates in the Ho-Lee lattice equals $2\times k\times\sigma\sqrt{\tau}$, where k is time (in years) and τ is the length of the time step. This algebraic relation demonstrates that the spread, or distance, between the highest possible rate and the lowest at each time step is an increasing function of time and often produces negative rates. Additionally, the level of volatility drives the spread. To illustrate, panel B of Exhibit 39–2 presents the Ho-Lee lattice where volatility is 10%. The greater dispersion of rates resulting from the greater volatility is immediately evident and illustrates that rates in this model may be very large and frequently negative. Despite the undesirable economic interpretation of negative rates, they are not detrimental to the model since bond prices computed from the binomial trees are the average over the possible future short paths, averaging across all rates.

6. See Gerald W. Buetow and James Sochacki, *Binomial Interest Rate Models*, AIMR Research Foundation, 2001.

EXHIBIT 39–2

The Ho-Lee Binomial Interest Rate Lattice

Panel A: Flat Term Structure at 2% and 1% Constant Volatility

									8.48%
								7.75%	
							7.02%		7.06%
						6.29%		6.33%	
					5.57%		5.60%		5.65%
				4.85%		4.88%		4.92%	
			4.14%		4.16%		4.19%		4.23%
		3.42%		3.44%		3.47%		3.50%	
	2.71%		2.72%		2.74%		2.78%		2.82%
2.00%		2.01%		2.02%		2.05%		2.09%	
	1.30%		1.31%		1.33%		1.36%		1.40%
		0.59%		0.61%		0.64%		0.67%	
			−0.11%		−0.08%		−0.05%		−0.01%
				−0.80%		−0.78%		−0.74%	
					−1.50%		−1.47%		−1.42%
						−2.19%		−2.15%	
							−2.88%		−2.84%
								−3.57%	
									−4.25%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

(Continued)

EXHIBIT 39–2

The Ho-Lee Binomial Interest Rate Lattice (*Continued*)

Panel B: Flat Term Structure at 2% and 10% Constant Volatility

									76.72%
								67.44%	
							58.40%		62.58%
						49.61%		53.30%	
					41.06%		44.26%		48.44%
				32.75%		35.46%		39.16%	
			24.70%		26.92%		30.12%		34.30%
		16.88%		18.61%		21.32%		25.01%	
	9.32%		10.55%		12.77%		15.98%		20.15%
2.00%		2.74%		4.47%		7.18%		10.87%	
	−4.82%		−3.59%		−1.37%		1.83%		6.01%
		−11.40%		−9.67%		−6.96%		−3.27%	
			−17.73%		−15.51%		−12.31%		−8.13%
				−23.82%		−21.10%		−17.41%	
					−29.65%		−26.45%		−22.27%
						−35.25%		−31.55%	
							−40.59%		−36.41%
								−45.70%	
									−50.56%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

The Ho-Lee process models the short rate as distributed normally. This is evident in the binomial lattice representation since the rates are symmetrical around the mean rate. For example, the distance between rates $r_{1,2}$ and $r_{2,2}$ is identical to the distance between $r_{2,2}$ and $r_{3,2}$.

Another important property of the Ho-Lee model is that the drift term is related to the slope of the current term structure. This property is illustrated in panel A of Exhibit 39–3 where the term structure slopes upward and the forward curve is increasing by 15 basis points each period and volatility is constant at 10%. This example corresponds to a "normal" term structure since it is positively sloped. The positive drift term is evident and we note that the spread or dispersion between the nodes is identical to that in Panel B of Exhibit 39–2. The difference comes from the positive drift term. In some cases, since the drift is proportional to time and grows unboundedly, this term can become quite large. Correspondingly, when the drift term is positive, there are fewer negative interest rates in the lattice. Panel B of Exhibit 39–3 presents the Ho-Lee model for an inverted term structure where the forward curve decreases by 15 basis points each period and volatility is again 10%. Again, the spread between the highest and lowest rate is identical since the volatility is 10% and volatility drives the spread in the Ho-Lee model. Additionally, we can see that the drift term is negative and all rates in the Ho-Lee model shift down by that negative drift term compared with the flat or normal term structure scenarios.

We now turn to the KWF binomial lattice. Recall that this model is analogous to a log-normal version of the Ho-Lee model. It is also a special case of the BDT model when volatility is assumed to be positive and constant. Panel A of Exhibit 39–4 presents the KWT binomial lattice for the scenario where the term structure is flat at 2% and volatility is a constant 10%. This scenario is directly comparable to the scenario is Exhibit 39–2 panel B for the Ho-Lee model and there are two important distinctions between the two lattices. First, the log-normal distribution in the KWT model restrains the interest rate paths from becoming negative. Since the Ho-Lee model is distributed normally, negative rates are possible, but the log-normal distribution of the KWT model restricts rates to be positive. Second, the spread of possible rates at the same volatility level are smaller than in the Ho-Lee model. Whereas the rates are distributed normally around the center nodes in the Ho-Lee model, in the KWT model the rates are distributed asymmetrically around the center node and are skewed toward higher rates. This property illustrates the importance of the distributional assumptions stemming from the models' differential processes.

Exhibit 39–5 presents the KWT lattices for two additional scenarios to cover a normal term structure and an inverted term structure. Panel A presents the normal term structure scenario in which rates are increasing at 15 basis points per period and volatility is constant at 10%. Note that the rates grow larger over time which is the impact of the drift term. Panel B presents the lattice for the inverted term structure scenario in which the rates decrease by 10 basis points per period and volatility is again constant at 10%. Note that the rates grow

EXHIBIT 39–3

Ho-Lee Binomial Lattice under Normal and Inverted Term Structures

Panel A: Normal Term Structure and 10% Constant Volatility

									79.33%
								69.77%	
							60.45%		65.18%
						51.38%		55.63%	
					42.54%		46.31%		51.04%
				33.94%		37.23%		41.49%	
			25.59%		28.40%		32.17%		36.90%
		17.48%		19.80%		23.09%		27.34%	
	9.62%		11.45%		14.25%		18.03%		22.76%
2.00%		3.34%		5.66%		8.95%		13.20%	
	–4.52%		–2.69%		0.11%		3.89%		8.61%
		–10.80%		–8.48%		–5.19%		–0.94%	
			–16.84%		–14.03%		–10.26%		–5.53%
				–22.62%		–19.33%		–15.08%	
					–28.17%		–24.40%		–19.67%
						–33.48%		–29.22%	
							–38.54%		–33.81%
								–43.37%	
									–47.95%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

(Continued)

EXHIBIT 39–3

Ho-Lee Binomial Lattice under Normal and Inverted Term Structures (*Continued*)

Panel B: Inverted Term Structure and 10% Constant Volatility

									74.13%
								65.12%	
							56.36%		59.99%
						47.84%		50.98%	
					39.58%		42.21%		45.85%
				31.57%		33.70%		36.84%	
			23.80%		25.44%		28.07%		31.71%
		16.29%		17.42%		19.56%		22.69%	
	9.02%		9.66%		11.29%		13.93%		17.56%
2.00%		2.14%		3.28%		5.42%		8.55%	
	−5.12%		−4.48%		−2.85%		−0.21%		3.42%
		−12.00%		−10.86%		−8.73%		−5.59%	
			−18.63%		−16.99%		−14.35%		−10.72%
				−25.00%		−22.87%		−19.73%	
					−31.13%		−28.50%		−24.86%
						−37.01%		−33.88%	
							−42.64%		−39.00%
								−48.02%	
									−53.15%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

EXHIBIT 39–4

The Kalotay-Williams-Fabozzi Binomial Interest Rate Lattice

Panel A: Flat Term Structure at 2% and 10% Constant Volatility

									3.71%
								3.46%	
							3.23%		3.22%
						3.02%		3.00%	
					2.82%		2.80%		2.79%
				2.63%		2.62%		2.61%	
			2.45%		2.44%		2.43%		2.42%
		2.29%		2.28%		2.27%		2.26%	
	2.14%		2.13%		2.12%		2.11%		2.10%
2.00%		1.99%		1.98%		1.97%		1.96%	
	1.86%		1.85%		1.84%		1.83%		1.83%
		1.73%		1.72%		1.71%		1.70%	
			1.61%		1.60%		1.59%		1.58%
				1.49%		1.49%		1.48%	
					1.39%		1.38%		1.38%
						1.29%		1.28%	
							1.20%		1.19%
								1.11%	
									1.04%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

(Continued)

EXHIBIT 39–4

The Kalotay-Williams-Fabozzi Binomial Interest Rate Lattice (*Continued*)

Panel B: Flat Term Structure at 2% and 20% Constant Volatility

									6.64%
								5.80%	
							5.07%		5.00%
						4.43%		4.36%	
					3.88%		3.81%		3.76%
				3.39%		3.34%		3.28%	
			2.97%		2.92%		2.87%		2.83%
		2.60%		2.56%		2.51%		2.47%	
	2.28%		2.24%		2.20%		2.16%		2.13%
2.00%		1.96%		1.93%		1.89%		1.86%	
	1.72%		1.69%		1.66%		1.63%		1.60%
		1.48%		1.45%		1.42%		1.40%	
			1.27%		1.25%		1.22%		1.20%
				1.09%		1.07%		1.05%	
					0.94%		0.92%		0.90%
						0.81%		0.79%	
							0.69%		0.68%
								0.60%	
									0.51%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

EXHIBIT 39–5

Kalotay-Williams-Fabozzi Binomial Lattice; Normal and Inverted Term Structures

Panel A: Normal Term Structure and 10% Constant Volatility

									8.75%
								7.64%	
							6.64%		7.59%
						5.74%		6.63%	
					4.93%		5.76%		6.59%
				4.21%		4.98%		5.75%	
			3.56%		4.28%		5.00%		5.72%
		2.98%		3.65%		4.32%		4.99%	
	2.46%		3.09%		3.72%		4.34%		4.96%
2.00%		2.59%		3.17%		3.75%		4.33%	
	2.14%		2.68%		3.23%		3.76%		4.30%
		2.25%		2.75%		3.26%		3.76%	
			2.33%		2.80%		3.27%		3.73%
				2.39%		2.83%		3.26%	
					2.43%		2.84%		3.24%
						2.45%		2.83%	
							2.46%		2.81%
								2.46%	
									2.44%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

(Continued)

EXHIBIT 39–5

Kalotay-Williams-Fabozzi Binomial Lattice; Normal and Inverted Term Structures (*Continued*)

Panel B: Inverted Term Structure and 10% Constant Volatility

									0.38%
								0.70%	
							0.97%		0.33%
						1.21%		0.60%	
					1.41%		0.84%		0.28%
				1.58%		1.05%		0.52%	
			1.72%		1.22%		0.73%		0.25%
		1.83%		1.37%		0.91%		0.45%	
	1.93%		1.49%		1.06%		0.63%		0.21%
2.00%		1.59%		1.19%		0.79%		0.39%	
	1.67%		1.30%		0.92%		0.55%		0.18%
		1.38%		1.03%		0.69%		0.34%	
			1.12%		0.80%		0.48%		0.16%
				0.90%		0.59%		0.30%	
					0.69%		0.41%		0.14%
						0.52%		0.26%	
							0.36%		0.12%
								0.22%	
									0.10%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

smaller over time, illustrating the impact of negative drift under the inverted term structure. Additionally, we notice that the spread from the highest to the lowest rate on the lattice at each time step is noticeably smaller for the inverted term structure scenario than for the normal term structure. This observation is in stark contrast to the Ho-Lee model in which the spread is determined solely by volatility.

Next, we turn to the BDT binomial lattice. Recall that the differential process in this model is lognormal and incorporates endogenous mean-reversion in which the slope of the volatility curve drives mean reversion in the model. Exhibit 39–6 presents the binomial lattice for the normal interest rate tree scenario where the current rate is 2% and the rate increases by 0.15 basis points each period. Panels A, B, and C present three scenarios for a normal term structure across different volatility structures. In Panel A, the volatility structure is decreasing from 20% by 0.5% each period, in Panel B it is increasing from 20% by 0.5% each period, and in Panel C it is constant. When volatility is constant, the model reduces to the KWT model. Note that the rates are all positive and are not extreme as in the normally distributed Ho-Lee model.

The shape of the volatility curve drives the model's mean reversion. This is evident in Panels A, B, and C of Exhibit 39–6 since the only change across the panels is the shape of the volatility structure. Comparing Panel A to Panel C, it is clear that the decreasing volatility structure has the effect of increasing mean-reversion. Note that the upward drift and the spread from high to low rates at each time step are different. The upward drift is checked by the mean reversion when the volatility structure is decreasing and similarly the spread is lower. Comparing panel B to panel C, it is clear that under the positively sloped volatility structure, the upward drift is larger and the spread at each time step is greater.

Exhibit 39–7 presents the BDT interest rate lattices for an inverted term structure where the current short rate is 2% and decreases by 10 basis points each period. The pattern that emerges is similar to the previous exhibit. Comparing panel A to panels B and C, it is clear that the mean-reversion from the decreasing volatility structure has the effect of reducing the spread across rates at each time step.

Turning to the Black-Karasinski model, Exhibit 39–8 presents the interest rate lattice for this model for a flat term structure of rates when volatility is initially 20% but decreases by 0.5% each period. To illustrate the importance of mean reversion in this model, the table contains two panels; Panel A illustrates the lattice with the mean-reversion parameter equal to 0.015 and Panel B illustrates the lattice when the mean-reversion parameter equals 0.005. The figures illustrate that larger mean reversion impacts the rates by narrowing the spread between the rates at each time step. Additionally, it must be noted that in order to fit the model to a binomial lattice the time-step must be allowed to vary for this model. Interpolation is necessary to adjust this tree to equally spaced time steps. The larger mean reversion leads to a decreasing time step. One way to circumvent the uneven time step in this model is to use a trinomial lattice since it allows for an extra degree of freedom.

EXHIBIT 39–6

Black-Derman-Toy Binomial Lattice: Normal Term Structure and Varying Volatility Structures

Panel A: Normal Term Structure and Decreasing Volatility

									10.61%
								9.44%	
							8.28%		8.79%
						7.15%		7.74%	
					6.08%		6.71%		7.29%
				5.08%		5.73%		6.35%	
			4.17%		4.82%		5.44%		6.04%
		3.35%		3.98%		4.59%		5.20%	
	2.62%		3.22%		3.82%		4.41%		5.01%
2.00%		2.56%		3.11%		3.68%		4.26%	
	1.98%		2.49%		3.02%		3.58%		4.15%
		1.95%		2.44%		2.95%		3.50%	
			1.93%		2.39%		2.90%		3.44%
				1.91%		2.37%		2.87%	
					1.90%		2.35%		2.86%
						1.90%		2.35%	
							1.90%		2.37%
								1.93%	
									1.96%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

(Continued)

EXHIBIT 39–6

Black-Derman-Toy Binomial Lattice: Normal Term Structure and Varying Volatility Structures (*Continued*)

Panel B: Normal Term Structure and Increasing Volatility

									23.66%
								17.55%	
							13.16%		16.03%
						9.96%		12.06%	
					7.59%		9.17%		10.86%
				5.81%		7.04%		8.29%	
			4.46%		5.43%		6.39%		7.36%
		3.42%		4.21%		4.97%		5.70%	
	2.62%		3.27%		3.89%		4.46%		4.98%
2.00%		2.55%		3.05%		3.51%		3.92%	
	1.98%		2.40%		2.78%		3.11%		3.38%
		1.89%		2.21%		2.48%		2.69%	
			1.76%		1.99%		2.16%		2.29%
				1.60%		1.75%		1.85%	
					1.42%		1.51%		1.55%
						1.24%		1.27%	
							1.05%		1.05%
								0.87%	
									0.71%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

EXHIBIT 39–6

Black-Derman-Toy Binomial Lattice: Normal Term Structure and Varying Volatility Structures (*Continued*)

Panel C: Normal Term Structure and Constant Volatility

									15.91%
								12.92%	
							10.47%		11.94%
						8.46%		9.71%	
					6.80%		7.87%		8.96%
				5.44%		6.37%		7.29%	
			4.31%		5.12%		5.92%		6.72%
		3.39%		4.09%		4.79%		5.48%	
	2.62%		3.25%		3.86%		4.45%		5.04%
2.00%		2.55%		3.08%		3.60%		4.12%	
	1.98%		2.45%		2.90%		3.35%		3.78%
		1.92%		2.32%		2.71%		3.09%	
			1.84%		2.19%		2.52%		2.84%
				1.75%		2.04%		2.32%	
					1.65%		1.89%		2.13%
						1.54%		1.74%	
							1.42%		1.60%
								1.31%	
									1.20%
Time in Years		0.5	1	1.5	2	2.5	3	3.5	4	4.5

EXHIBIT 39–7

Black-Derman-Toy Binomial Lattice: Inverted Term Structure and Varying Volatility Structures

Panel A: Inverted Term Structure and Decreasing Volatility

									0.30%
								0.73%	
							1.14%		0.30%
						1.48%		0.66%	
					1.75%		0.97%		0.30%
				1.93%		1.23%		0.59%	
			2.04%		1.41%		0.83%		0.30%
		2.08%		1.53%		1.01%		0.53%	
	2.06%		1.59%		1.14%		0.71%		0.29%
2.00%		1.59%		1.21%		0.84%		0.48%	
	1.56%		1.23%		0.92%		0.61%		0.29%
		1.22%		0.96%		0.69%		0.43%	
			0.96%		0.74%		0.52%		0.29%
				0.76%		0.57%		0.38%	
					0.60%		0.44%		0.29%
						0.48%		0.34%	
							0.38%		0.28%
								0.31%	
									0.28%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

(Continued)

EXHIBIT 39–7

Black-Derman-Toy Binomial Lattice: Inverted Term Structure and Varying Volatility Structures

Panel B: Inverted Term Structure and Increasing Volatility

									2.68%
								2.51%	
							2.46%		1.51%
						2.42%		1.58%	
					2.36%		1.63%		0.86%
				2.29%		1.66%		0.99%	
			2.21%		1.66%		1.08%		0.48%
		2.14%		1.64%		1.13%		0.62%	
	2.06%		1.61%		1.16%		0.72%		0.27%
2.00%		1.59%		1.18%		0.78%		0.39%	
	1.56%		1.18%		0.82%		0.47%		0.15%
		1.18%		0.84%		0.53%		0.25%	
			0.86%		0.57%		0.31%		0.09%
				0.61%		0.36%		0.16%	
					0.40%		0.21%		0.05%
						0.25%		0.10%	
							0.14%		0.03%
								0.06%	
									0.02%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

(Continued)

EXHIBIT 39–7

Black-Derman-Toy Binomial Lattice: Inverted Term Structure and Varying Volatility Structures (*Continued*)

Panel C: Inverted Term Structure and Constant Volatility

									0.67%
								1.16%	
							1.52%		0.50%
						1.77%		0.87%	
					1.94%		1.14%		0.38%
				2.03%		1.33%		0.66%	
			2.08%		1.46%		0.86%		0.28%
		2.08%		1.53%		1.00%		0.49%	
	2.05%		1.57%		1.10%		0.65%		0.21%
2.00%		1.57%		1.16%		0.76%		0.37%	
	1.55%		1.18%		0.83%		0.49%		0.16%
		1.18%		0.87%		0.57%		0.28%	
			0.89%		0.62%		0.37%		0.12%
				0.66%		0.43%		0.21%	
					0.47%		0.28%		0.09%
						0.32%		0.16%	
							0.21%		0.07%
								0.12%	
									0.05%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

EXHIBIT 39–8

Black-Karasinski Binomial Lattice: Inverted Term Structure

Panel A: Flat Term Structure, Mean Reversion = 0.015

									3.71%
								3.68%	
							3.59%		3.21%
						3.46%		3.13%	
					3.28%		3.01%		2.78%
				3.06%		2.85%		2.67%	
			2.82%		2.66%		2.52%		2.41%
		2.67%		2.44%		2.35%		2.27%	
	2.22%		2.20%		2.15%		2.11%		2.08%
2.00%		1.98%		1.94%		1.93%		1.93%	
	1.72%		1.72%		1.74%		1.77%		1.80%
		1.47%		1.54%		1.59%		1.65%	
			1.35%		1.41%		1.48%		1.56%
				1.23%		1.31%		1.40%	
					1.14%		1.24%		1.35%
						1.08%		1.19%	
							1.04%		1.17%
								1.02%	
									1.01%
Time in Years	0.50	0.99	1.48	1.96	2.43	2.89	3.35	3.81	4.25

(Continued)

EXHIBIT 39–8

Black-Karasinski Binomial Lattice: Inverted Term Structure (*Continued*)

Panel B: Flat Term Structure, Mean Reversion = 0.005

									4.01%
								3.92%	
							3.78%		3.41%
						3.60%		3.29%	
					3.37%		3.12%		2.91%
				3.12%		2.92%		2.76%	
			2.85%		2.70%		2.58%		2.47%
		2.65%		2.46%		2.38%		2.31%	
	2.24%		2.21%		2.17%		2.13%		2.10%
2.00%		1.97%		1.94%		1.94%		1.94%	
	1.74%		1.72%		1.74%		1.76%		1.79%
		1.46%		1.53%		1.58%		1.62%	
			1.34%		1.39%		1.45%		1.52%
				1.21%		1.28%		1.36%	
					1.11%		1.20%		1.30%
						1.04%		1.14%	
							0.99%		1.10%
								0.96%	
									0.94%
Time in Years	0.50	1.00	1.49	1.99	2.48	2.96	3.45	3.93	4.41

TRINOMIAL LATTICE

Turning to the Hull-White model, Exhibit 39–9 presents the Hull-White trinomial lattice. The trinomial structure is identical the binomial lattice except there are three possible time steps from each node instead of two. Similar to the binomial lattice, the solutions impose restrictions to ensure that the trinomial lattice recombines and that the rates in the tree satisfy the necessary conditions. Exhibit 39–9 presents the Hull-White trinomial lattice when the term structure is flat at 2%, 10% constant volatility, and zero mean reversion. The important properties of the Hull-White process are evident in the lattice: Interest rates become negative for the bottom nodes, the spread between high and low rates at each time step is large, and the rates are distributed normally. Additionally, an upward drift is evident in the middle nodes.

Since the Hull-White model incorporates mean reversion, Exhibit 39–10 presents the Hull-White model with the same term structure and volatility as Exhibit 39–9, but incorporates 5% mean reversion. We expect the mean reversion will have the effect of pulling rates back toward the mean, or that the lattice tree should be "pruned." The mean-reversion property is evident as the spread at each time step is reduced and each rate is pulled back toward the target rate, compared to the tree in Exhibit 39–9.

In summary, the lattice representations of the no-arbitrage interest rate models discussed in this chapter demonstrate the importance of the model assumptions about the short-rate process on the model output. It is of critical importance that users of these models understand the model assumptions and the impact those assumptions have on any results (pricing or risk metrics) based on model outputs.

EXHIBIT 39–9

Hull-White Trinomial Lattice: Flat Term Structure, 10% Volatility, No Mean Reversion

									123.63%
								109.06%	111.38%
							94.77%	96.81%	99.13%
						80.74%	82.52%	84.57%	86.89%
					66.98%	68.50%	70.27%	72.32%	74.64%
				53.48%	54.73%	56.25%	58.03%	60.07%	62.39%
			40.23%	41.23%	42.49%	44.00%	45.78%	47.82%	50.14%
		27.24%	27.99%	28.99%	30.24%	31.75%	33.53%	35.58%	37.90%
	14.50%	14.99%	15.74%	16.74%	17.99%	19.51%	21.28%	23.33%	25.65%
2.00%	2.25%	2.74%	3.49%	4.49%	5.75%	7.26%	9.04%	11.08%	13.40%
	−10.00%	−9.50%	−8.76%	−7.76%	−6.50%	−4.99%	−3.21%	−1.17%	1.15%
		−21.75%	−21.00%	−20.00%	−18.75%	−17.24%	−15.46%	−13.41%	−11.09%
			−33.25%	−32.25%	−31.00%	−29.48%	−27.71%	−25.66%	−23.34%
				−44.50%	−43.24%	−41.73%	−39.95%	−37.91%	−35.59%
					−55.49%	−53.98%	−52.20%	−50.16%	−47.84%
						−66.23%	−64.45%	−62.40%	−60.08%
							−76.70%	−74.65%	−72.33%
								−86.90%	−84.58%
									−96.83%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

EXHIBIT 39–10

Hull-White Trinomial Lattice: Flat Term Structure, 10% Volatility, 5% Mean Reversion

									121.55%
								107.60%	109.30%
							93.78%	95.35%	97.05%
						80.12%	81.54%	83.10%	84.81%
					66.62%	67.88%	69.29%	70.85%	72.56%
				53.30%	54.38%	55.63%	57.04%	58.61%	60.31%
			40.16%	41.05%	42.13%	43.38%	44.79%	46.36%	48.06%
		27.22%	27.91%	28.80%	29.88%	31.13%	32.55%	34.11%	35.82%
	14.50%	14.97%	15.67%	16.56%	17.63%	18.89%	20.30%	21.86%	23.57%
2.00%	2.25%	2.73%	3.42%	4.31%	5.39%	6.64%	8.05%	9.62%	11.32%
	−10.00%	−9.52%	−8.83%	−7.94%	−6.86%	−5.61%	−4.20%	−2.63%	−0.93%
		−21.77%	−21.08%	−20.19%	−19.11%	−17.86%	−16.44%	−14.88%	−13.17%
			−33.32%	−32.43%	−31.36%	−30.10%	−28.69%	−27.13%	−25.42%
				−44.68%	−43.60%	−42.35%	−40.94%	−39.37%	−37.67%
					−55.85%	−54.60%	−53.19%	−51.62%	−49.91%
						−66.85%	−65.43%	−63.87%	−62.16%
							−77.68%	−76.12%	−74.41%
								−88.36%	−86.66%
									−98.90%
Time in Years	0.5	1	1.5	2	2.5	3	3.5	4	4.5

KEY POINTS

- Interest rate models are important tools for practitioners and are useful for pricing fixed income securities, valuing interest-rate contingent claims, and for risk management purposes.
- There exist many interest rate models. One factor models of the short rate make important assumptions about its dynamics through time. Understanding these assumptions and their implications is critical for practitioners.
- Interest rate models specify a stochastic differential equation to capture the dynamics of the models.
- Early models (Ho-Lee and Hull-White) assume the short rate is distributed normally. Interest rates in those models may be negative. Other models (Kalotay-Williams-Fabozzi, Black-Derman-Toy, and Black-Karasinski models) assume the short rate is distributed log-normally, restricting the short rate to be positive.
- Mean-reversion is the tendency for interest rates to tend toward a long-term target rate. Absent mean-reversion, an interest rate model may allow the short rate to grow unbounded.
- The no-arbitrage models incorporate the information in the current term structure and produce identical prices for option-free bonds.
- When pricing bonds with embedded option features, the interest rate model assumptions are critically important and may result in meaningful differences across different models.

PART

FIVE

VALUATION MODELING

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CHAPTER
FORTY

VALUATION OF BONDS WITH EMBEDDED OPTIONS

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

ANDREW KALOTAY, PH.D.
President
Andrew Kalotay Associates

MICHAEL DORIGAN, PH.D.
Director & Senior Quantitative Analyst
PNC Capital Advisors LLC

The complication in building a model to value bonds with embedded options and option-type derivatives is that cash flows will depend on interest rates in the future. Academicians and practitioners have attempted to capture this interest rate uncertainty through various models, often designed as single or multi-factor models. These models attempt to capture the stochastic behavior of rates.

In practice, these elegant mathematical models must be converted to numeric applications. Here we focus on one such model—a single-factor model that assumes a stationary variance or, as it is more often called, volatility. We demonstrate how to move from the yield curve to a valuation lattice. Effectively, the lattice is a representation of the model, capturing the distribution of rates over time. In our illustration we will present the lattice as a binomial tree, the most simple lattice form.

The lattice holds all the information required to perform the valuation of certain option-like interest rate products. First, the lattice is used to generate cash flows over the life of the security. Next, the interest rates on the lattice are used to compute the present value of those cash flows.

There are several interest rate models that have been used in practice to construct an interest rate lattice. These are described in other chapters. In each case, interest rates can realize one of several possible rates when we move from one period to the next. A lattice model where it is assumed that only two rates are possible in the next period given the current rate is called a *binomial model*. A lattice model where it is assumed that interest rates can take on three possible rates

in the next period is called a *trinomial model*. There are even more complex models that assume more than three possible rates in the next period can be realized.

Regardless of the underlying assumptions, each model shares a common restriction. The interest rate tree generated must produce a value for an on-the-run optionless issue that is consistent with the current par yield curve. In effect, the value estimated by the model must be equal to the observed market price for the optionless instrument. Under these conditions, the model is said to be "arbitrage free." A lattice that produces an arbitrage-free valuation is said to be "fair." The lattice is used for valuation only when it has been calibrated to be fair. More on calibration below.

In this chapter we show how to value bonds with embedded options using the lattice methodology. We begin by demonstrating how an interest rate lattice is constructed. Then we use the model to value bonds with an embedded option. The lattice methodology also can be used to value floating-rate securities with option-type derivatives, options on bonds, caps, floors, swaptions, and forward-start swaps.[1]

THE INTEREST RATE LATTICE

Exhibit 40–1 provides an example of a binomial interest rate tree, which consists of a number of "nodes" and "legs." Each leg represents a one-year interval over time. A simplifying assumption of one-year intervals is made to illustrate the key principles. The methodology is the same for smaller time periods. In fact, in practice, the selection of the length of the time period is critical, but we need not be concerned with this nuance here.

The distribution of future interest rates is represented on the tree by the nodes at each point in time. Each node is labeled as N and has a subscript, a combination of L's and H's. The subscripts indicate whether the node is lower or higher on the tree, respectively, relative to the other nodes. Thus node N_{HH} is reached when the one-year rate realized in the first year is the higher of the two rates for that period, then the highest of the rates in the second year.

The root of the tree is N, the only point in time at which we know the interest rate with certainty. The one-year rate today (i.e., at N) is the current one-year spot rate, which we denote by r_0.

We must make an assumption concerning the probability of reaching one rate at a point in time. For ease of illustration, we have assumed that rates at any point in time have the same probability of occurring; in other words, the probability is 50% on each leg.

1. These applications of the lattice methodology are presented in Frank J. Fabozzi, Andrew Kalotay, and Michael Dorigan, "Yield Curves and Valuation Lattices" and "Using the Lattice Model to Value Bonds with Embedded Options, Floaters, Options, and Caps/Floors," Chapters 13 and 14 in Frank J. Fabozzi (ed.), *Interest Rate, Term Structure, and Valuation Modeling* (Hoboken, NJ: Wiley, 2002).

EXHIBIT 40–1

Four-Year Binomial Interest Rate Tree

The interest rate model we will use to construct the binomial tree assumes that the one-year rate evolves over time based on a log-normal random walk with a known (stationary) volatility. Technically, the tree represents a one-factor model. Under the distributional assumption, the relationship between any two adjacent rates at a point in time is calculated via the following equation:

$$r_{1,H} = r_{1,L}e^{2\sigma\sqrt{t}}$$

where σ is the assumed volatility of the one-year rate, t is time in years, and e is the base of the natural logarithm. Since we assume a one-year interval, that is, $t = 1$, we can disregard the calculation of the square root of t in the exponent.

For example, suppose that $r_{1,L}$ is 4.4448% and σ is 10% per year, then

$$r_{1,H} = 4.4448\%(e^{2\times 0.10}) = 5.4289\%$$

In the second year, there are three possible values for the one-year rate. The relationship between $r_{2,LL}$ and the other two one-year rates is as follows:

$$r_{2,HH} = r_{2,LL}\,(e^{4\sigma}) \qquad \text{and} \qquad r_{2,HL} = r_{2,LL}(e^{2\sigma})$$

EXHIBIT 40–2

Four-Year Binomial Interest Rate Tree with One-Year Rates*

*r_t is the lowest one-year rate at each point in time.

Thus, for example, if $r_{2,LL}$ is 4.6958%, and assuming once again that σ is 10%, then

$$r_{2,HH} = 4.6958\%(e^{4\times 0.10}) = 7.0053\%$$

and

$$r_{2,HL} = 4.6958\%(e^{2\times 0.10}) = 5.7354\%$$

This relationship between rates holds for each point in time. Exhibit 40–2 shows the interest rate tree using this new notation.

Determining the Value at a Node

In general, to get a security's value at a node, we follow the fundamental rule for valuation: The value is the present value of the expected cash flows. The appropriate discount rate to use for cash flows one year forward is the one-year rate at the node where we are computing the value. Now there are two present values in this case: the present value of the cash flows in the state where the one-year rate is the higher rate and one where it is the lower-rate state. We have assumed that the probability of

EXHIBIT 40–3

Calculating a Value at a Node

both outcomes is equal. Exhibit 40–3 provides an illustration for a node assuming that the one-year rate is r^* at the node where the valuation is sought and letting

V_H = the bond's value for the higher one-year rate state
V_L = the bond's value for the lower one-year rate state
C = coupon payment

From where do the future values come? Effectively, the value at any node depends on the future cash flows. The future cash flows include (1) the coupon payment one year from now and (2) the bond's value one year from now, both of which may be uncertain. Starting the process from the last year in the tree and working backwards to get the final valuation resolves the uncertainty. At maturity, the instrument's value is known with certainty—par. The final coupon payment can be determined from the coupon rate or from prevailing rates to which it is indexed. Working back through the tree, we realize that the value at each node is calculated quickly. This process of working backward is often referred to as *recursive valuation*.

Using our notation, the cash flow at a node is either

$V_H + C$ for the higher one-year rate
$V_L + C$ for the lower one-year rate

The present value of these two cash flows using the one-year rate at the node, r^*, is

$$\frac{V_H + C}{(1+r^*)} = \text{present value for the higher one-year rate}$$

$$\frac{V_L + C}{(1+r^*)} = \text{present value for the lower one-year rate}$$

Then the value of the bond at the node is found as follows:

$$\text{Value at a node} = \frac{1}{2}\left[\frac{V_H + C}{(1+r^*)} + \frac{V_L + C}{(1+r^*)}\right]$$

CALIBRATING THE LATTICE

We noted earlier the importance of the no-arbitrage condition that governs the construction of the lattice. To ensure that this condition holds, the lattice must be calibrated to the current par yield curve, a process we demonstrate here. Ultimately, the lattice must price optionless par bonds at par.

Assume the on-the-run par yield curve for a hypothetical issuer as it appears in Exhibit 40–4. The current one-year rate is known, 3.50%. Hence the next step is to find the appropriate one-year rates one year forward. As before, we assume that volatility σ is 10% and construct a two-year tree using the two-year bond with a coupon rate of 4.2%, the par rate for a two-year security.

Exhibit 40–5 shows a more detailed binomial tree with the cash flow shown at each node. The root rate for the tree r_0 is simply the current one-year rate, 3.5%. At the beginning of year 2, there are two possible one-year rates, the higher rate and the lower rate. We already know the relationship between the two. A rate of 4.75% at N_L has been chosen arbitrarily as a starting point. An iterative process determines the proper rate (i.e., trial-and-error). The steps are described and illustrated below. Again, the goal is a rate that, when applied in the tree, provides a value of par for the two-year 4.2% bond.

Step 1. Select a value for r_1. Recall that r_1 is the lower one-year rate. In this first trial, we arbitrarily selected a value of 4.75%.

Step 2. Determine the corresponding value for the higher one-year rate. As explained earlier, this rate is related to the lower one-year rate as follows: $r_1 e^{2\sigma}$. Since r_1 is 4.75%, the higher one-year rate is 5.8017% (= 4.75% $e^{2\times 0.10}$). This value is reported in Exhibit 40–5 at node N_H.

EXHIBIT 40–4

Issuer Par Yield Curve

Maturity	Par Rate	Market Price
1 year	3.50%	100
2 years	4.20%	100
3 years	4.70%	100
4 years	5.20%	100

EXHIBIT 40–5

The One-Year Rates for Year 1 Using the Two-Year 4.2% On-the-Run Issue: First Trial

Step 3. Compute the bond value's one year from now. This value is determined as follows:

a. Determine the bond's value two years from now. In our example, this is simple. Since we are using a two-year bond, the bond's value is its maturity value ($100) plus its final coupon payment ($4.2). Thus it is $104.2.

b. Calculate V_H. Cash flows are known. The appropriate discount rate is the higher one-year rate, 5.8017% in our example. The present value is $98.486 (= $104.2/1.058017).

c. Calculate V_L. Again, cash flows are known—the same as those in step 3b. The discount rate assumed for the lower one-year rate is 4.75%. The present value is $99.475 (= $104.2/1.0475).

Step 4. Calculate V.

a. Add the coupon to both V_H and V_L to get the cash flow at N_H and N_L, respectively. In our example we have $102.686 for the higher rate and $103.675 for the lower rate.

b. Calculate V. The one-year rate is 3.50%. (*Note:* At this point in the valuation, r^* is the root rate, 3.50%). Therefore, $99.691 = 1/2($99.214 + $100.169)

Step 5. Compare the value in step 4 to the bond's market value. If the two values are the same, then the r_1 used in this trial is the one we seek. If, instead, the value found in step 4 is not equal to the market value of the bond, this means that the value r_1 in this trial is not the one-year rate that is consistent with the current yield curve. In this case, the five steps are repeated with a different value for r_1.

When r_1 is 4.75%, a value of \$99.691 results in step 4, which is less than the observed market price of \$100. Therefore, 4.75% is too large, and the five steps must be repeated trying a lower rate for r_1.

Let's jump right to the correct rate for r_1 in this example and rework steps 1 through 5. This occurs when r_1 is 4.4448%. The corresponding binomial tree is shown in Exhibit 40–6. The value at the root is equal to the market value of the two-year issue (par).

We can "grow" this tree for one more year by determining r_2. Now we will use the three-year on-the-run issue, the 4.7% coupon bond, to get r_2. The same five steps are used in an iterative process to find the one-year rates in the tree two years from now. Our objective is now to find the value of r_2 that will produce a bond value of \$100. Note that the two rates one year from now of 4.4448% (the lower rate) and 5.4289% (the higher rate) do not change. These are the fair rates for the tree one-year forward.

The problem is illustrated in Exhibit 40–7. The cash flows from the three-year 4.7% bond are in place. All we need to perform a valuation are the rates at the start of year 3. In effect, we need to find r_2 such that the bond prices at par. Again, an arbitrary starting point is selected, and an iterative process produces the correct rate.

The completed version of Exhibit 40–7 is found in Exhibit 40–8. The value of r_2, or equivalently $r_{2,LL}$, that will produce the desired result is 4.6958%. The corresponding rates $r_{2,HL}$ and $r_{2,HH}$ would be 5.7354% and 7.0053%, respectively.

EXHIBIT 40–6

The One-Year Rates for Year 1 Using the Two-Year 4.2% On-the-Run Issue

EXHIBIT 40–7

Information for Deriving the One-Year Rates for Year 2 Using the Three-Year 4.7% On-the-Run Issue

EXHIBIT 40–8

The One-Year Rates for Year 2 Using the Three-Year 4.7% On-the-Run Issue

To verify that these are the correct one-year rates two years from now, work backwards from the four nodes at the right of the tree in Exhibit 40–8. For example, the value in the box at N_{HH} is found by taking the value of \$104.7 at the two nodes to its right and discounting at 7.0053%. The value is \$97.846. Similarly, the value in the box at N_{HL} is found by discounting \$104.70 by 5.7354% and at N_{LL} by discounting at 4.6958%.

USING THE LATTICE FOR VALUATION

To illustrate how to use the lattice for valuation purposes, consider a 6.5% option-free bond with four years remaining to maturity. Since this bond is option-free, it is not necessary to use the lattice model to value it. All that is necessary to obtain an arbitrage-free value for this bond is to discount the cash flows using the spot rates obtained from bootstrapping the yield curve shown in Exhibit 40–4. The spot rates are as follows:

1-year	3.5000%
2-years	4.2147%
3-years	4.7345%
4-years	5.2707%

Discounting the 6.5% four-year option-free bond with a par value of \$100 at the above spot rates would give a bond value of \$104.643.

Exhibit 40–9 contains the fair tree for a four-year valuation. Exhibit 40–10 shows the various values in the discounting process using the lattice in Exhibit 40–9. The root of the tree shows the bond value of \$104.643, the same value found by discounting at the spot rate. This demonstrates that the lattice model is consistent with the valuation of an option-free bond when using spot rates.

FIXED-COUPON BONDS WITH EMBEDDED OPTIONS

The valuation of bonds with embedded options proceeds in the same fashion as in the case of an option-free bond. However, the added complexity of an embedded option requires an adjustment to the cash flows on the tree depending on the structure of the option. A decision on whether to call or put must be made at nodes on the tree where the option is eligible for exercise. Examples for both callable and putable bonds follow.

Valuing a Callable Bond

In the case of a call option, the call will be made when the present value (PV) of the future cash flows is greater than the call price at the node where the decision to exercise is being made. Effectively, the following calculation is made:

$$V_t = \min[\text{call price, PV(future cash flows)}]$$

EXHIBIT 40–9

Binomial Interest Rate Tree for Valuing Up to a Four-Year Bond for Issuer (10% Volatility Assumed)

EXHIBIT 40–10

Valuing an Option-Free Bond with Four Years to Maturity and a Coupon Rate of 6.5% (10% Volatility Assumed)

where V_t represents the PV of future cash flows at the node. This operation is performed at each node where the bond is eligible for call.

For example, consider a 6.5% bond with four years remaining to maturity that is callable in one year at $100. We will value this bond, as well as the other instruments in this chapter, using a binomial tree. Exhibit 40–9 is the binomial interest rate tree that was derived earlier in this chapter and then used to value an option-free bond. In constructing the binomial tree in Exhibit 40–9, it is assumed that interest rate volatility is 10%. This binomial tree will be used throughout this chapter.

Exhibit 40–11 shows that two values are now present at each node of the binomial tree. The discounting process explained earlier is used to calculate the first of the two values at each node. The second value is the value based on whether the issue will be called. Again, the issuer calls the issue if the PV of future cash flows exceeds the call price. This second value is incorporated into the subsequent calculations.

In Exhibits 40–12 and 40–13, certain nodes from Exhibit 40–11 are highlighted. Exhibit 40–12 shows nodes where the issue is not called (based on the simple call rule used in the illustration) in years 2 and 3.[2] The values reported in this case are the same as in the valuation of an option-free bond. Exhibit 40–13 shows some nodes where the issue is called in years 2 and 3. Notice how the methodology changes the cash flows. In year 3, for example, at node N_{HLL} the recursive valuation process produces a PV of 100.315. However, given the call rule, this issue would be called. Therefore, 100 is shown as the second value at the node, and it is this value that is then used as the valuation process continues. Taking the process to its end, the value for this callable bond is 102.899.

The value of the call option is computed as the difference between the value of an optionless bond and the value of a callable bond. In our illustration, the value of the option-free bond is 104.643 (calculated earlier in this chapter). The value of the callable bond is 102.899. Hence the value of the call option is 1.744 (=104.634 – 102.899).

Valuing a Putable Bond

A putable bond is one in which the bondholder has the right to force the issuer to pay off the bond prior to the maturity date. The analysis of the putable bond follows closely that of the callable bond. In the case of the putable, we must establish the rule by which the decision to put is made. The reasoning is similar to that for the callable bond. If the PV of the future cash flows is less than the put price (i.e., par), then the bond will be put. In equation form,

$$V_t = \max[\text{put price, PV(future cash flows)}]$$

Exhibit 40–14 is analogous to Exhibit 40–3. It shows the binomial tree with the values based on whether or not the investor exercises the put option at each node.

2. We assume cash flows occur at the end of the year.

EXHIBIT 40–11

Valuing a Callable Bond with Four Years to Maturity, a Coupon Rate of 6.5%, and Callable after the First Year at 100 (10% Volatility Assumed)

EXHIBIT 40–12

Highlighting Nodes in Years 2 and 3 for a Callable Bond: Nodes Where Call Option Is Not Exercised

EXHIBIT 40–13

Highlighting Nodes in Years 2 and 3 for a Callable Bond: Selected Nodes Where the Call Option Is Exercised

EXHIBIT 40–14

Valuing a Putable Bond with Four Years to Maturity, a Coupon Rate of 6.5%, and Putable after the First Year at 100 (10% Volatility Assumed)

The bond is putable any time after the first year at par. The value of the bond is 105.327. Note that the value is greater than the value of the corresponding option-free bond.

With the two values in hand, we can calculate the value of the put option. Since the value of the putable bond is 105.327 and the value of the corresponding option-free bond is 104.643, the value of the embedded put option purchased by the investor is effectively 0.684.

Suppose that a bond is both putable and callable. The procedure for valuing such a structure is to adjust the value at each node to reflect whether the issue would be put or called. Specifically, at each node there are two decisions about the exercising of an option that must be made. If it is called, the value at the node is replaced by the call price. The valuation procedure then continues using the call price at that node. If the call option is not exercised at a node, it must be determined whether or not the put option will be exercised. If it is exercised, then the put price is substituted at that node and is used in subsequent calculations.

VALUATION OF TWO MORE EXOTIC STRUCTURES

The lattice-based recursive valuation methodology is robust. To further support this claim, we address the valuation of two more exotic structures—the step-up callable note and the range floater.

Valuing a Step-Up Callable Note

Step-up callable notes are callable instruments whose coupon rate is increased (i.e., "stepped up") at designated times. When the coupon rate is increased only once over the security's life, it is said to be a *single step-up callable note*. A *multiple step-up callable note* is a step-up callable note whose coupon is increased more than one time over the life of the security. Valuation using the lattice model is similar to that for valuing a callable bond described earlier except that the cash flows are altered at each node to reflect the coupon characteristics of a step-up note.

Suppose that a four-year step-up callable note pays 4.25% for two years and then 7.5% for two more years. Assume that this note is callable at par at the end of year 2 and year 3. We will use the binomial tree given in Exhibit 40–9 to value this note.

Exhibit 40–15 shows the value of the note if it were not callable. The valuation procedure is the now familiar recursive valuation from Exhibits 40–12 and 40–13. The coupon in the box at each node reflects the step-up terms. The value is 102.082. Exhibit 40–16 shows that the value of the single step-up callable note is 100.031. The value of the embedded call option is equal to the difference in the optionless step-up note value and the step-up callable note value, 2.051.

EXHIBIT 40–15

Valuing a Single Step-Up Noncallable Note with Four Years to Maturity (10% Volatility Assumed)

EXHIBIT 40–16

Valuing a Single Step-Up Callable Note with Four Years to Maturity, Callable in Two Years at 100 (10% Volatility Assumed)

EXHIBIT 40–17

Coupon Schedule (Bands) for a Range Note

	Year 1	Year 2	Year 3
Lower limit	3.00%	4.00%	5.00%
Upper limit	5.00%	6.25%	8.00%

Now we move to another structure where the coupon floats with a reference rate but is restricted. In this next case, a range is set in which the bond pays the reference rate when the rate falls within a specified range, but outside the range no coupon is paid.

Valuing a Range Note

A *range note* is a security that pays the reference rate only if the rate falls within a band. If the reference rate falls outside the band, whether the lower or upper boundary, no coupon is paid. Typically, the band increases over time.

To illustrate, suppose that the reference rate is, again, the one-year rate and the note has three years to maturity. Suppose further that the band (or coupon schedule) is defined as in Exhibit 40–17. Exhibit 40–18 holds our tree and the

EXHIBIT 40–18

Valuation of a Three-Year Range Floater

cash flows expected at the end of each year. Either the one-year reference rate is paid, or nothing. In the case of this three-year note, there is only one state in which no coupon is paid. Using our recursive valuation method, we can work back through the tree to the current value, 98.963.

EXTENSIONS

We next demonstrate how to compute the option-adjusted spread, effective duration, and the convexity for a fixed income instrument with an embedded option.

Option-Adjusted Spread

We have concerned ourselves with valuation to this point. However, financial market transactions determine the actual price for a fixed income instrument, not a series of calculations on an interest rate lattice. If markets are able to provide a meaningful price (usually a function of the liquidity of the market in which the instrument trades), this price can be translated into an alternative measure of value, the option-adjusted spread (OAS).

The OAS for a security is the fixed spread (usually measured in basis points) over the benchmark rates that equates the output from the valuation process with the actual market price of the security. For an optionless security, the calculation of OAS is a relatively simple, iterative process. The process is much more analytically challenging with the added complexity of optionality. And just as the value of the option is volatility-dependent, the OAS for a fixed income security with embedded options or an option-like interest-rate product is volatility-dependent.

Recall our illustration in Exhibit 40–11, where the value of a callable bond was calculated as 102.899. Suppose that we had information from the market that the price is actually 102.218. We need the OAS that equates the value from the lattice with the market price. Since the market price is lower than the valuation, the OAS is a positive spread to the rates in the exhibit, rates that we assume to be benchmark rates.

The solution in this case is 35 basis points, which is incorporated into Exhibit 40–19 that shows the value of the callable bond after adding 35 basis points to each rate. The simple binomial tree provides evidence of the complex calculation required to determine the OAS for a callable bond. In Exhibit 40–11, the bond is called at N_{HLL}. However, once the tree is shifted 35 basis points in Exhibit 40–19, the PV of future cash flows at N_{HLL} falls below the call price to 99.985, so the bond is not called at this node. Hence, as the lattice structure grows in size and complexity, the need for computer analytics becomes obvious.

EXHIBIT 40–19

Demonstration that the Option-Adjusted Spread Is 35 Basis Points for a 6.5% Callable Bond Selling at 102.218 (Assuming 10% Volatility)*

*Each one-year rate is 35 basis points greater than in Exhibit 40–11.

Effective Duration and Effective Convexity

Duration and convexity provide a measure of the interest rate risk inherent in a fixed income security. We rely on the lattice model to calculate the effective duration and effective convexity of a bond with an embedded option and other option-like securities. The formulas for these two risk measures are given below:

$$\text{Effective duration} = \frac{V_- - V_+}{2V_0(\Delta r)}$$

$$\text{Effective convexity} = \frac{V_+ + V_- - 2V_0}{2V_0(\Delta r)^2}$$

where V_- and V_+ are the values derived following a parallel shift in the yield curve down and up, respectively, by a fixed spread. The model adjusts for the changes in the value of the embedded call option that result from the shift in the curve in the calculation of V_- and V_+.

Note that the calculations must account for the OAS of the security. Below we provide the steps for the proper calculation of V_+. The calculation for V_- is analogous.

Step 1. Given the market price of the issue, calculate its OAS.

Step 2. Shift the on-the-run yield curve up by a small number of basis points (Δr).

Step 3. Construct a binomial interest-rate tree based on the new yield curve from step 2.

Step 4. Shift the binomial interest-rate tree by the OAS to obtain an "adjusted tree." That is, the calculation of the effective duration and convexity assumes a constant OAS.

Step 5. Use the adjusted tree in step 4 to determine the value of the bond, V_+.

We can perform this calculation for our four-year callable bond with a coupon rate of 6.5%, callable at par selling at 102.218. We computed the OAS for this issue as 35 basis points. Exhibit 40–20 holds the adjusted tree following a shift in the yield curve up by 25 basis points and then adding 35 basis points (the OAS) across the tree. The adjusted tree is then used to value the bond. The resulting value V_+ is 101.621.

To determine the value of V_-, the same five steps are followed except that in step 2, the on-the-run yield curve is shifted down by a small number of basis points (Δr). It can be demonstrated that for our callable bond, the value for V_- is 102.765.

The results are summarized below:

$$\Delta r = 0.0025$$
$$V_+ = 101.621$$
$$V_- = 102.765$$
$$V_0 = 102.218$$

Therefore,

$$\text{Effective duration} = \frac{102.765 - 101.621}{2(102.218)(0.0025)} = 2.24$$

$$\text{Effective convexity} = \frac{101.621 + 102.765 - 2(102.218)}{2(102.218)(0.0025)^2} = -39.1321$$

Notice that this callable bond exhibits negative convexity.

EXHIBIT 40–20

Determination of V_+ for Calculating Effective Duration and Convexity*

*+25 basis point shift in on-the-run yield curve.

KEY POINTS

- For bonds with embedded options, the expected cash flow will depend on future interest-rate levels, which in turn depend on expected interest-rate volatility.
- An interest rate lattice provides a robust means for the valuation of a number of fixed income securities and derivatives.
- Given the market price of a bond, a lattice model can be used to obtain the option-adjusted spread to a benchmark yield curve based on an assumed interest rate volatility.

- A bond's OAS is the fixed spread (usually measured in basis points) over the benchmark rates that equates the output from the valuation process with the actual market price of the security.
- Effective duration and convexity can be computed for a bond by changing the yield-curve up and down by a given number of basis points and calculating what the new prices would be on the revised interest rate tree. These new prices are then used in the standard duration and convexity formula.

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CHAPTER
FORTY-ONE

VALUATION OF AGENCY MORTGAGE-BACKED SECURITIES

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

SCOTT F. RICHARD, DBA
Practice Professor of Finance
Wharton
University of Pennsylvania

PETER RU
Director, Fixed Income Investment Department
Morgan Stanley Huaxin Fund Management Company Limited

The traditional approach to the valuation of fixed income securities is to calculate yield—the yield-to-maturity, the yield-to-call for a callable bond, and the cash-flow yield for a mortgage-backed security. A superior approach is the option-adjusted spread (OAS) method. Our objective in this chapter is to describe the OAS method as applied to mortgage-backed securities. At the end of the chapter, we apply the method to two agency collateralized mortgage obligation (CMO) deals.

In this chapter we describe the theoretical foundations of this technique, the input and assumptions that go into the development of an OAS model, and the output of an OAS model, which in addition to the OAS value includes the option-adjusted duration and option-adjusted convexity. Because the user of an OAS model is exposed to *modeling risk,* it is necessary to test the sensitivity of these numbers to changes in the assumptions.

Valuation modeling for CMOs is similar to valuation modeling for pass-throughs, although the difficulties are amplified because the issuer has sliced and diced both the prepayment risk and the interest-rate risk into smaller pieces called *tranches*. The sensitivity of the pass-through securities from which the CMO is created to these two risks is not transmitted equally to every tranche. Some of the tranches wind up more sensitive to prepayment risk and interest-rate risk than the collateral, whereas some of them are much less sensitive.

The objective of the money manager is to figure out how the OAS of the collateral or, equivalently, the value of the collateral gets transmitted to the

CMO tranches. More specifically, the objective is to find out where the value goes and where the risk goes so that the money manager can identify the tranches with low risk and high value: the ones he wants to buy. The good news is that this combination usually exists in every deal. The bad news is that in every deal there are usually tranches with low OAS, low value, and high risk.

STATIC VALUATION

Using OAS to value mortgages is a dynamic technique in that many scenarios for future interest rates are analyzed. Static valuation analyzes only a single-interest-rate scenario, usually assuming that the yield-curve remains unchanged. Static valuation results in two measures, average life and static spread, which we review below.

Average Life

The *average life* of a mortgage-backed security is the weighted average time to receipt of principal payments (scheduled payments and projected prepayments). The formula for the average life is

$$\frac{1(\text{principal at time } 1) + \cdots + T(\text{principal at time } T)}{12(\text{total principal received})}$$

where T is the number of months.

In order to calculate average life, an investor must either assume a prepayment rate for the mortgage security being analyzed or use a prepayment model. By calculating the average life at various prepayment rates, the investor can gain some feeling for the stability of the security's cash-flows. For example, a PAC bond's average life will not change within the PAC bands but may shorten significantly if the prepayment rate exceeds the upper band. By examining the average life at prepayment rates greater than the upper band, an investor can judge some of the PAC's risks. With a prepayment model available, the average life of a mortgage security can be calculated by changing the mortgage refinancing rate. As the refinancing rate rises, the prepayment model will slow the prepayment rate and thus cause the bond's average life to extend. Conversely, if the refinancing rate is lowered, the model will cause prepayments to rise and shorten the average life.

Static Spread

One of the standard measures in evaluating any mortgage-backed security is the cash-flow yield, or simply "yield." The yield spread, sometimes called the *nominal spread,* is found by spreading the yield to the average life on the interpolated swap yield-curve. This practice is improper for an amortizing bond even in the absence of interest-rate volatility. Note that since late 1998, structured products are using swaps instead of Treasuries for pricing and hedging purposes. The main reason is that spread to swaps is more stable than to Treasuries.

What should be done instead is to calculate what is called the *static spread*. This is the yield spread in a static scenario (i.e., no volatility of interest rates) of the bond over the entire theoretical swap spot-rate curve, not a single point on the swap yield-curve. The magnitude of the difference between the nominal spread and the static yield depends on the steepness of the yield-curve: The steeper the curve, the greater the difference between the two values. In a relatively flat interest-rate environment, the difference between the nominal spread and the static spread will be small.

There are two ways to compute the static spread. One way is to use today's yield-curve to discount future cash-flows and keep the mortgage refinancing rate fixed at today's mortgage rate. Since the mortgage refinancing rate is fixed, the investor usually can specify a reasonable prepayment rate for the life of the security. Using this prepayment rate, the bond's future cash-flow can be estimated. Use of this approach to calculate the static spread recognizes different prices today of dollars to be delivered at future dates. This results in the proper discounting of cash-flows while keeping the mortgage rate fixed. Effectively, today's prices indicate what the future discount rates will be, but the best estimates of future rates are today's rates.

The second way to calculate the static spread allows the mortgage rate to go up the curve as implied by the forward interest rates. This procedure is sometimes called the *zero-volatility OAS*. In this case, a prepayment model is needed to determine the vector of future prepayment rates implied by the vector of future refinancing rates. A money manager using static spread should determine which approach is used in the calculation.

DYNAMIC VALUATION MODELING

Because CMOs are simply a regrouping of the cash-flows from the underlying pass-through securities, the valuation of CMO tranches follows directly from the valuation of pass-through securities.

Using Simulation to Generate Interest-Rate Paths and Cash-Flows

A technique known as *simulation* is used to value complex securities such as mortgage-backed securities. Simulation is used because the monthly cash-flows are path-dependent. This means that the cash-flows received this month are determined not only by the current and future interest-rate levels but also by the path that interest rates took to get to the current level.

There are typically two sources of path dependency in a CMO tranche's cash-flows. First, collateral prepayments are path-dependent because this month's prepayment rate depends on whether there have been prior opportunities to refinance since the underlying mortgages were issued. Second, the cash-flow to be received this month by a CMO tranche depends on the outstanding balances of the other tranches in the deal. We need the history of prepayments to calculate these balances.

Conceptually, the valuation of pass-through securities using the simulation method is simple. In practice, however, it is very complex. The simulation involves generating a set of cash-flows based on simulated future mortgage refinancing rates, which, in turn, imply simulated prepayment rates.

The typical model that Wall Street firms and commercial vendors use to generate these random interest-rate paths takes as input today's term structure of interest rates and a volatility assumption. The term structure of interest rates is the theoretical spot-rate (or zero-coupon) curve implied by today's swap rates. The volatility assumption determines the dispersion of future interest rates in the simulation. The simulations should be normalized so that the average simulated price of a zero-coupon swap equals today's actual price.

Each OAS model has its own model of the evolution of future interest rates and its own volatility assumptions. Until recently, there have been few significant differences in the interest-rate models of dealer firms and OAS vendors, although their volatility assumptions can be significantly different. Note that the volatility in term structure models is calibrated to the prices of liquid securities that reflect at-the-money options on interest rates, such as at-the-money caps and swaptions, as well as off-the-money swaptions (to capture the volatility skew).

The random paths of interest rates should be generated from an arbitrage-free model of the future term structure of interest rates. By arbitrage-free it is meant that the model replicates today's term structure of interest rates, an input of the model, and that for all future dates there is no possible arbitrage within the model.[1]

The simulation works by generating many scenarios of future interest-rate paths. In each month of the scenario, a monthly interest rate and a mortgage refinancing rate are generated. The monthly interest rates are used to discount the projected cash-flows in the scenario. The mortgage refinancing rate is needed to determine the cash-flow because it represents the opportunity cost the mortgagor is facing at that time.

If the refinancing rates are high relative to the mortgagor's original coupon rate, the mortgagor will have less incentive to refinance or even a disincentive (i.e., the homeowner will avoid moving in order to avoid refinancing). If the refinancing rate is low relative to the mortgagor's original coupon rate, the mortgagor has an incentive to refinance.

Prepayments are projected by feeding the refinancing rate and loan characteristics, such as age, into a prepayment model. Given the projected prepayments, the cash-flow along an interest-rate path can be determined.

To make this more concrete, consider a newly issued mortgage pass-through security with a maturity of 360 months. Exhibit 41–1 shows N simulated interest-rate path scenarios. Each scenario consists of a path of 360 simulated one-month future interest rates. Just how many paths should be generated is explained later.

1. A risk-neutral, arbitrage-free model of Treasury yields means that at all future dates the price of any long-term bond equals the expected value of rolling short-term to maturity. For more details, see Fischer Black, Emmanuel Derman, and William Toy, "A One-Factor Model of Interest Rates and its Application to Treasury Bond Options," *Financial Analyst Journals* (January–February 1990), pp. 33–39.

EXHIBIT 41–1

Simulated Paths of One-Month Future Interest Rates

	Interest-Rate Path Number						
Month	**1**	**2**	**3**	**. . .**	***n***		***N***
1	$f_1(1)$	$f_1(2)$	$f_1(3)$	. . .	$f_1(n)$	. . .	$f_1(N)$
2	$f_2(1)$	$f_2(2)$	$f_2(3)$	. . .	$f_2(n)$	. . .	$f_2(N)$
3	$f_3(1)$	$f_3(2)$	$f_3(3)$	. . .	$f_3(n)$	. . .	$f_3(N)$
t	$f_t(1)$	$f_t(2)$	$f_t(3)$	. . .	$f_t(n)$	. . .	$f_t(N)$
358	$f_{358}(1)$	$f_{358}(2)$	$f_{358}(3)$	. . .	$f_{358}(n)$	. . .	$f_{358}(N)$
359	$f_{359}(1)$	$f_{359}(2)$	$f_{359}(3)$	. . .	$f_{359}(n)$	. . .	$f_{359}(N)$
360	$f_{360}(1)$	$f_{360}(2)$	$f_{360}(3)$	. . .	$f_{360}(n)$	. . .	$f_{360}(N)$

Notation:

$f_t(n)$ = one-month future interest rate for month t on path n

N = total number of interest-rate paths

Exhibit 41–2 shows the paths of simulated mortgage refinancing rate corresponding to the scenarios shown in Exhibit 41–1. Assuming these mortgage refinancing rates, the cash-flow for each scenario path is shown in Exhibit 41–3.

Calculating the Present Value for a Scenario Interest-Rate Path

Given the cash-flow on an interest-rate path, its present value can be calculated. The discount rate for determining the present value is the simulated spot rate for each month on the interest-rate path plus an appropriate spread. The spot

EXHIBIT 41–2

Simulated Paths of Mortgage Refinancing Rates

	Interest-Rate Path Number						
Month	**1**	**2**	**3**	**. . .**	***n***		***N***
1	$r_1(1)$	$r_1(2)$	$r_1(3)$	. . .	$r_1(n)$	. . .	$r_1(N)$
2	$r_2(1)$	$r_2(2)$	$r_2(3)$	. . .	$r_2(n)$	. . .	$r_2(N)$
3	$r_3(1)$	$r_3(2)$	$r_3(3)$	. . .	$r_3(n)$	. . .	$r_3(N)$
t	$r_t(1)$	$r_t(2)$	$r_t(3)$	. . .	$r_t(n)$	. . .	$r_t(N)$
358	$r_{358}(1)$	$r_{358}(2)$	$r_{358}(3)$	. . .	$r_{358}(n)$	. . .	$r_{358}(N)$
359	$r_{359}(1)$	$r_{359}(2)$	$r_{359}(3)$	. . .	$r_{359}(n)$	. . .	$r_{359}(N)$
360	$r_{360}(1)$	$r_{360}(2)$	$r_{360}(3)$	. . .	$r_{360}(n)$	. . .	$r_{360}(N)$

Notation:

$r_t(n)$ = mortgage refinancing rate for month t on path n

N = total number of interest-rate paths

EXHIBIT 41–3

Simulated Cash-Flow on Each of the Interest-Rate Paths

	Interest-Rate Path Number						
Month	**1**	**2**	**3**	**. . .**	***n***		***N***
1	$C_1(2)$	$C_1(2)$	$C_1(3)$	. . .	$C_1(n)$	. . .	$C_1(N)$
2	$C_2(1)$	$C_2(2)$	$C_2(3)$	. . .	$C_2(n)$	. . .	$C_2(N)$
3	$C_3(1)$	$C_3(2)$	$C_3(3)$	. . .	$C_3(n)$	. . .	$C_3(N)$
t	$C_t(1)$	$C_t(2)$	$C_t(3)$	. . .	$C_t(n)$	. . .	$C_t(N)$
358	$C_{358}(1)$	$C_{358}(2)$	$C_{358}(3)$	. . .	$C_{358}(n)$	. . .	$C_{358}(N)$
359	$C_{359}(1)$	$C_{359}(2)$	$C_{359}(3)$	. . .	$C_{359}(n)$	. . .	$C_{359}(N)$
360	$C_{360}(1)$	$C_{360}(2)$	$C_{360}(3)$	. . .	$C_{360}(n)$	. . .	$C_{360}(N)$

Notation:
$C_t(n)$ = cash-flow for month t on path n
N = total number of interest-rate paths

rate on a path can be determined from the simulated future monthly rates. The relationship that holds between the simulated spot rate for month T on path n and the simulated future one-month rates is

$$z_T(n) = \{[1 + f_1(n)][1 + f_2(n)] \cdots [1 + f_T(n)]\}^{1/T} - 1$$

where

$z_T(n)$ = simulated spot rate for month T on path n
$f_j(n)$ = simulated future one-month rate for month j on path n

Consequently, the interest-rate path for the simulated future one-month rates can be converted to the interest-rate path for the simulated monthly spot rates, as shown in Exhibit 41–4. Therefore, the present value of the cash-flow for month T on interest-rate path n discounted at the simulated spot rate for month T plus some spread is

$$\text{PV}[C_T(n)] = \frac{C_T(n)}{[1 + z_T(n) + K]^{1/T}}$$

where

PV$[C_T(n)]$ = present value of cash-flow for month T on path n
$C_T(n)$ = cash-flow for month T on path n
$z_T(n)$ = spot rate for month T on path n
K = spread

The present value for path n is the sum of the present value of the cash-flow for each month on path n. That is,

$$\text{PV}[\text{path}(n)] = \text{PV}[C_1(n)] + \text{PV}[C_2(n)] + \cdots + \text{PV}[C_{360}(n)]$$

where PV[path(n)] is the present value of interest-rate path n.

EXHIBIT 41–4

Simulated Paths of Monthly Spot Rates

	Interest-Rate Path Number						
Month	**1**	**2**	**3**	**. . .**	***n***		***N***
1	$z_1(1)$	$z_1(2)$	$z_1(3)$	. . .	$z_1(n)$	. . .	$z_1(N)$
2	$z_2(1)$	$z_2(2)$	$z_2(3)$	. . .	$z_2(n)$	. . .	$z_2(N)$
3	$z_3(1)$	$z_3(2)$	$z_3(3)$	. . .	$z_3(n)$	. . .	$z_3(N)$
t	$z_t(1)$	$z_t(2)$	$z_t(3)$	. . .	$z_t(n)$	. . .	$z_t(N)$
358	$z_{358}(1)$	$z_{358}(2)$	$z_{358}(3)$	. . .	$z_{358}(n)$	. . .	$z_{358}(N)$
359	$z_{359}(1)$	$z_{359}(2)$	$z_{359}(3)$	. . .	$z_{359}(n)$	. . .	$z_{359}(N)$
360	$z_{360}(1)$	$z_{360}(2)$	$z_{360}(3)$	. . .	$z_{360}(n)$	. . .	$z_{360}(N)$

Notation:
$z_t(n)$ = spot rate for month t on path n
N = total number of interest-rate paths

The option-adjusted spread is the spread K that when added to all the spot rates on all interest-rate paths will make the average present value of the paths equal to the observed market price (plus accrued interest). Mathematically, OAS is the spread K that will satisfy the following condition:

$$\text{Market price} = \frac{\text{PV[path(1)]} + \text{PV[path(2)]} + \cdots + \text{PV[path}(N)]}{N}$$

where N is the number of interest-rate paths.

This procedure for valuing a pass-through is also followed for a CMO tranche. The cash-flow for each month on each interest-rate path is found according to the principal repayment and interest distribution rules of the deal. In order to do this, a CMO structuring model is needed.

Selecting the Number of Interest-Rate Paths

Let's now address the question of the number of scenario paths or repetitions N needed to value a CMO tranche. A typical OAS run will be done for 512 to 1,024 interest-rate paths. The scenarios generated using the simulation method look very realistic and furthermore reproduce today's swap curve. By employing this technique, the money manager is effectively saying that swaps are fairly priced today and that the objective is to determine whether a specific tranche is rich or cheap relative to swaps.

The number of interest-rate paths determines how "good" the estimate is, not relative to the truth but relative to the OAS model used. The more paths, the more average spread tends to settle down. It is a statistical sampling problem.

Most OAS models employ some form of *variance reduction* to cut down on the number of sample paths necessary to get a good statistical sample.[2] Variance reduction techniques allow us to obtain price estimates within a tick. By this we mean that if the OAS model is used to generate more scenarios, price estimates from the model will not change by more than a tick. Thus, for example, if 1,024 paths are used to obtain the estimated price for a tranche, there is little more information to be had from the OAS model by generating more than that number of paths. (For some very sensitive CMO tranches, more paths may be needed to estimate prices within one tick.)

Interpretation of the OAS

The procedure for determining the OAS is straightforward, although time-consuming. The next question, then, is how to interpret the OAS. Basically, the OAS is used to reconcile value with market price. On the left-hand side of the last equation is the market's statement: The price of a mortgage-backed security or mortgage derivative. The average present value over all the paths on the right-hand side of the equation is the model's output, which we refer to as *value*.

What a money manager seeks to do is to buy securities whose value is greater than their price. A valuation model such as the one described earlier allows a money manager to estimate the value of a security, which at this point would be sufficient to determine whether to buy a security. That is, the money manager can say that this bond is 1 point cheap or 2 points cheap, and so on. The model does not stop here, however. Instead, it converts the divergence between price and value into a yield spread measure because most market participants find it more convenient to think about yield spread than about price differences.

The OAS was developed as a measure of the yield spread that can be used to reconcile dollar differences between value and price. But what is it a "spread" over? In describing the preceding model, we can see that the OAS is measuring the average spread over the swap spot-rate curve, not the swap yield-curve. It is an average spread because the OAS is found by averaging over the interest-rate paths for the possible spot-rate curves.

Option Cost

The implied cost of the option embedded in any mortgage-backed security can be obtained by calculating the difference between the OAS at the assumed volatility of interest rates and the static spread. That is,

$$\text{Option cost} = \text{static spread} - \text{option-adjusted spread}$$

2. For a discussion of variance reduction, see Phelim P. Boyle, "Options: A Monte Carlo Approach," *Journal of Financial Economics* 4 (1977), pp. 323–338.

The reason that the option cost is measured in this way is as follows: In an environment of no interest-rate changes, the investor would earn the static spread. When future interest rates are uncertain, the spread is less, however, because of the homeowner's option to prepay; the OAS reflects the spread after adjusting for this option. Therefore, the option cost is the difference between the spread that would be earned in a static interest-rate environment (the static spread) and the spread after adjusting for the homeowner's option.

In general, a tranche's option cost is more stable than its OAS in the face of market movements. This interesting feature is useful in reducing the computational expensive costs of calculating the OAS as the market moves. For small market moves, the OAS of a tranche may be approximated by recalculating the static spread (which is relatively cheap and easy to calculate) and subtracting its option cost.

Other Products of the OAS Models

Other products of the valuation model are option-adjusted duration, option-adjusted convexity, and simulated average life.

Option-Adjusted Duration

In general, duration measures the price sensitivity of a bond to a small change in interest rates. Duration can be interpreted as the approximate percentage change in price for a 100 basis point parallel shift in the yield-curve. For example, if a bond's duration is 4, this means a 100 basis point increase in interest rates will result in a price decrease of approximately 4%. A 50 basis point increase in yields will decrease the price by approximately 2%. The smaller the change in basis points, the better the approximated change in price will be.

The duration for any security can be approximated as follows:

$$\text{Duration} = \frac{P_- - P_+}{2P_0\Delta y}$$

where

P_- = price if yield is decreased (per \$100 of par value) by Δy
P_+ = price if yield is increased (per \$100 of par value) by Δy
P_0 = initial price (per \$100 of par value)
Δy = number of basis points change used to calculate P_- and P_+

The standard measure of duration is modified duration. The limitation of modified duration is that it assumes that if interest rates change, the cash-flow does not change. While modified duration is fine for option-free securities such as Treasury bonds, it is inappropriate for mortgage-backed securities because projected cash-flows change as interest rates and prepayments change. When prices in the duration formula are calculated assuming that the cash-flow changes when interest rates change, the resulting duration is called *effective duration*.

Effective duration can be computed using an OAS model as follows: First, the bond's OAS is found using the current term structure of interest rates. Next, the bond is repriced holding OAS constant but shifting the term structure. Two shifts are used; in one, yields are increased, and in the second, they are decreased. This produces the two prices, P_- and P_+, used in the preceding formula. Effective duration calculated in this way is often referred to as *option-adjusted duration,* or *OAS duration.*

The assumption in using modified or effective duration to project the percentage price change is that all interest rates change by the same number of basis points; that is, there is a parallel shift in the yield-curve. If the term structure does not change by a parallel shift, then effective duration will not correctly predict the change in a bond's price.

Option-Adjusted Convexity

The convexity measure of a security is the approximate change in price that is not explained by duration. *Positive convexity* means that if yields change by a given number of basis points, the percentage increase in price will be greater than the percentage decrease in price. *Negative convexity* means that if yield changes by a given number of basis points, the percentage increase in price will be less than the percentage decrease in price. That is, for a 100 basis point change in yield:

Type of Convexity	Increase in Price	Decrease in Price
Positive convexity	*X*%	Less than *X*%
Negative convexity	*X*%	More than *X*%

Obviously, positive convexity is a desirable property of a bond. A pass-through security can exhibit either positive or negative convexity depending on the prevailing mortgage rate relative to the rate on the underlying mortgage loans. When the prevailing mortgage rate is much higher than the mortgage rate on the underlying mortgage loans, the pass-through usually exhibits positive convexity. It usually exhibits negative convexity when the underlying coupon rate is near or above prevailing mortgage refinancing rates.

The convexity of any bond can be approximated using the formula

$$\frac{P_+ + P_- - (P_0)}{2P_0(\Delta y)^2}$$

When the prices used in this formula assume that the cash-flows do not change when yields change, the resulting convexity is a good approximation of the standard convexity for an option-free bond. When the prices used in the formula are derived by changing the cash-flows (by changing prepayment rates)

when yields change, the resulting convexity is called *effective convexity*. Once again, when an OAS model is used to obtain the prices, the resulting value is referred to as the *option-adjusted convexity,* or *OAS convexity*.

Simulated Average Life

The average life reported in an OAS model is the average of the average lives along the interest-rate paths. That is, for each interest-rate path, there is an average life. The average of these average lives is the average life reported in an OAS model.

Additional information is conveyed by the distribution of the average life. The greater the range and standard deviation of the average life, the more uncertainty there is about the tranche's average life.

ILLUSTRATIONS

We use two deals to show how CMOs can be analyzed using the OAS methodology: a plain-vanilla sequential-pay structure and a PAC/support structure.

Plain-Vanilla Sequential-Pay Structure

As the name suggests, CMO tranches in a sequential-pay structure are amortized in sequence. The sequential-pay structure partitions the underlying mortgage collateral into bonds of varying maturities and durations, but does not allow the optionality of the bonds to be tailored.

The plain-vanilla sequential-pay CMO bond structure in our illustration is FHLMC 3145, Collateral Group 5 analyzed as of June 7, 2007. The focus of our analysis is tranches AB, AC, and AJ. Exhibit 41–5 shows the swap yield spread and volatility curve at the evaluation date.

Panel A of Exhibit 41–6 shows the OAS and the option cost for the collateral and the three tranches in the CMO structure. The OAS for the collateral is 24 basis points. Since the option cost is 32 basis points, the static spread is 56 basis points (24 basis points plus 32 basis points). As can be seen from Panel A of Exhibit 41–5, at the time this analysis was performed, the swap curve was not steep. As we noted earlier, in such a yield-curve environment, the static spread will not differ significantly from the traditionally computed yield spread. Thus, for the three tranches shown in Exhibit 41–6, the static spread is 27 for AB, 36 for B, and 52 for C. Notice that the tranches did not share the OAS equally. The same is true for the option cost. The value tended to go toward the longer bonds, something that occurs in the typical deal. Both the static spread and the option cost increase as the maturity increases. Notice that by purchasing tranches with the higher OAS, the manager is accepting greater interest rate risk as measured by the tranche's effective duration.

Now let's look at modeling risk. Examination of the sensitivity of the tranches to changes in prepayments and interest rate volatility will help us to understand the interaction of the tranches in the structure and who is bearing the risk.

EXHIBIT 41–5

Par Curve and Volatility Curve as of 6/7/2007

a. Swap curve

Years	Swap
0.25	5.35
0.5	5.39
1	5.47
2	5.45
3	5.47
4	5.51
5	5.55
7	5.62
10	5.70
20	5.83
30	5.85

Note: The swap curve is obtained from the Citigroup's proprietary trading group, fitted to key swap rates.

b. Volatility Curve

Option on 6-Month EDF		7.19	
Libor Cap Volatility		Swaptions Volatility	
1-Year	6.58	3M × 10	12.49
2-Year	11.05	1 × 10	12.11
3-Year	12.51	3 × 10	12.74
4-Year	13.16	5 × 10	12.61
5-Year	13.5	7 × 10	12.17
7-Year	13.75	10 × 10	11.57
10-Year	13.67	20 × 10	10.69

We begin with prepayments. Specifically, we keep the same interest-rate paths as those used to get the OAS in the base case (the top panel of Exhibit 41–6), but reduce the prepayment rate on each interest-rate path to 80% of the projected rate.

As can be seen in Panel B of Exhibit 41–6, slowing down prepayments decreases the OAS and price for the collateral. This is so because the collateral is trading below par value. Tranches created by this collateral typically will behave the same way. However, if a tranche was created with a higher coupon, allowing it to trade below above, then it may behave in the opposite fashion. The exhibit reports two results of the sensitivity analysis. First, it indicates the change in the

EXHIBIT 41–6

OAS Analysis of FHLMC 3145 Classes AB, AC, and AJ (as of 6/7/2007)

A. Base case (market-implied interest-rate volatility)

	OAS (bp)	Option Cost (bp)	Effective Duration	Static Spread
Collateral	24	32	5.3	56
AB	12	15	1.9	27
AC	14	22	4.3	36
AJ	20	32	8.4	52

B. Prepayments at 80% and 120% of Prepayment Model

	New OAS		Chg in Price (ticks)		Eff. Dur	
	80%	120%	80%	120%	80%	120%
Collateral	19	30	–10	9	5.8	5.0
AB	12	12	0	0	1.9	1.9
AC	9	17	–7	5	4.5	4.1
AJ	15	26	–14	13	9.0	7.9

C. ± 4% interest-rate volatility

	New OAS		Chg in Price (ticks)		Eff. Dur	
	–4%	+4%	–4%	+4%	–4%	+4%
Collateral	41	19	17	–19	5.6	5.2
AB	12	12	0	0	1.9	1.9
AC	18	10	5	–5	4.3	4.2
AJ	30	8	26	–30	8.6	8.2

D. Diagram of Principal Payment

OAS. Second, it indicates the change in the price, holding the OAS constant at the base case.

To see how a money manager can use the information in Panel B, consider tranche AC. At 80% of the prepayment speed, the OAS for this tranche decreases from 14 basis points to 9 basis points. If the OAS is held constant, the panel indicates that the buyer of tranche AC would lose $0.07 per $100 par value.

Notice that for the tranches AC and AJ reported in Exhibit 41–6, there is a loss from a slowdown in prepayments. This is so because all the sequential tranches in this deal were priced below par. Tranche AB's OAS and price are not impacted by a slowdown in prepayments.

Also shown in Panel B of the exhibit is the second part of our experiments to test the sensitivity of prepayments: The prepayment rate is assumed to be 120% of the base case. The collateral's price increases in this scenario because it is trading below par. This is reflected in the OAS of the collateral, which increases from 24 to 30 basis points.

Now look at the three tranches. Tranche AB's price and OAS did not change. Hence, this tranche is prepayment insensitive from 80% to 120% of the base case. The OAS and price of the other two tranches increased.

Now let's look at the sensitivity to the interest-rate volatility assumption. Two experiments are performed: reducing the volatility assumption to 4% of the base case and increasing it to 4% of the base case. These results are reported in Panel C of Exhibit 41–6. Reducing the volatility increases the dollar price of the collateral by $0.17 and increases the OAS from 24 to 41 basis points in the base case. This $0.17 increase in the price of the collateral is not equally distributed, however, among the three tranches. None of the increase went to tranche AC. Most of the increase in value is realized by the longest tranche, tranche AJ.

The OAS gain for each of the tranches follows more or less the effective durations of those tranches. This makes sense because the longer the duration, the greater the interest rate risk, and when volatility declines, the reward is greater for the accepted risk.

At the higher level of assumed interest-rate volatility, the collateral is adversely affected with the collateral's loss distributed among the tranches in the expected manner: the longer the effective duration, the greater the loss.

Using the OAS methodology, a fair conclusion that can be made about this simple plain-vanilla structure is: What you see is what you get. A money manager willing to extend duration gets paid for that risk in this plain-vanilla structure.

PAC/Support Bond Structure

PAC structures are designed to create a stable set of bonds by directing the prepayment risk of the underlying collateral to other bonds (the supports) in the structure. One set of bonds (the PACs) is assigned a principal redemption schedule, which is given priority over principal payments to the remaining bonds (the supports) in the structure.

Now let's look at how to apply the OAS methodology to a more complicated CMO structure, FHLMC 3104, Collateral Group 1. This $250 million agency CMO deal was issued on January 30, 2006 and analyzed on June 7, 2007 (so the interest-rate environment was that shown in Exhibit 41–5). A summary of the deal is provided in Exhibit 41–7. A diagram of the principal allocation is given in Exhibit 41–8. Shown in parentheses after each tranche's name in Exhibit 41–7 is the type of tranche. There are five planned amortization class (PAC) tranches that are sequential-pay PACs and they have the high structural priority, as shown

EXHIBIT 41–7

Summary of FHLMC 3104, Collateral Group 1

Total issue:	250,000,000	Original settlement date:	2/28/2006
Issue date:	1/30/2006	Days delay:	30
Structure type:	REMIC CMO	Payment frequency:	Monthly; 15th day of month
Issuer class:	Agency		
Dated date:	2/1/2006		

Tranche	Original Balance ($)	Coupon (%)	Stated Maturity	Average Life (yrs)	100% Prepayment Model Expected Maturity
QA (PAC)	71,655,780	5.00	10/15/2025	1.9	3/15/2011
QB (PAC)	25,372,498	5.00	1/15/2029	5.0	11/15/2013
QC (PAC)	25,633,676	5.00	9/15/2031	8.1	4/15/2017
QD (PAC)	31,839,817	5.00	5/15/2034	12.1	1/15/2022
QE (PAC)	24,132,798	5.00	1/15/2036	17.7	11/15/2035
FA (FLT, SUP)	9,074,584	0.84	6/15/2033	1.4	Paid down
SA (INV, SUP)	3,629,834	15.39	6/15/2033	1.4	Paid down
HA (SUP)	10,000,000	5.00	6/15/2033	1.5	Paid down
HB (SUP)	20,525,844	6.00	11/15/2017	2.3	Paid down
HO (PO, SUP)	8,105,169	0.00	1/15/2036	6.4	7/15/2034
HZ (SUP)	20,000,000	6.00	1/15/2036	8.8	7/15/2034

EXHIBIT 41–8

Diagram of Principal Allocation Structure of FHLMC 3104 Collateral Group 1 (as of 6/7/2007)

in Exhibit 41–8, while the other tranches are support bonds that have the low structural priority. Our focus will be on the five PAC tranches and the support tranches HO and HZ. We do not look at the floater and inverse floater support tranches (FA and SA, respectively).

Panel A of Exhibit 41–9 shows the base case OAS and the option cost for the collateral and all the tranches. The collateral OAS is 12 basis points, and the option cost is 28 basis points. The static spread of the collateral is 40 basis points. The 12 basis points of OAS did not get equally distributed among the tranches, as was the case with the plain-vanilla structure. Notice the high OAS for tranche HO the support principal-only tranche: 513 basis points. This tranche's option cost is –83 basis points, suggesting that this tranche, according to the model, is cheap. For the sequential-pay PAC tranches we see that the longer the effective duration, the higher the OAS.

The next two panels in Exhibit 41–9 show the sensitivity of the OAS and the price (holding OAS constant at the base case) to changes in the prepayment speed (80% and 120% of the base case) and to changes in volatility (±4% of the base case). With respect to sensitivity to prepayments, the short-term PAC tranche QA and support bond HZ are insensitive for the prepayment range tested. For all of the other tranches, the OAS and price decrease with a decrease in prepayments. The opposite holds for an increase in prepayments.

The sensitivity of the collateral and the tranches to changes in volatility are shown in Panel C of Exhibit 41–9. The shorter-term PAC tranche (QA) is insensitive to changes in volatility. However, unlike with prepayments, support tranche HZ is sensitive to interest-rate volatility. For all of the tranches except tranche HO, OAS and price increase with a decline in volatility and decrease with an increase in volatility.

EXHIBIT 41–9

OAS Analysis of FHLMC 3104 Collateral Group 1 (as of 6/7/2007)

A. Base case (market-implied interest-rate volatility)

	OAS (bp)	Option Cost (bp)	Effective Duration	Static Spread
Collateral	12	28	6.2	40
QA (PAC)	26	15	1.7	41
QB (PAC)	47	18	4.3	65
QC (PAC)	54	24	6.3	78
QD (PAC)	57	25	8.3	82
QE (PAC)	60	24	10.5	84
HO (SUP PO)	513	–83	6.0	430
HZ (SUP)	55	40	5.1	95

B. Prepayments at 80% and 120% of prepayment Model

	New OAS		Chg in Price (ticks)		Eff. Dur	
	80%	120%	80%	120%	80%	120%
Collateral	6	20	–13	12	6.6	5.9
QA (PAC)	26	26	0	0	1.7	1.7
QB (PAC)	41	53	–9	7	4.4	4.1
QC (PAC)	43	64	–21	17	6.7	6.0
QD (PAC)	48	66	–23	19	8.8	7.9
QE (PAC)	55	65	–14	12	11.0	10.1
HO (SUP PO)	480	555	–22	27	5.2	6.6
HZ (SUP)	55	56	0	2	5.3	5.0

C. ±4% interest-rate volatility

	New OAS		Chg in Price (ticks)		Eff. Dur	
	–4%	+4%	–4%	+4%	–4%	+4%
Collateral	13	–7	16	–19	6.4	6.0
QA (PAC)	26	26	0	0	1.7	1.7
QB (PAC)	50	45	3	–3	4.3	4.2
QC (PAC)	60	46	11	–14	6.5	6.2
QD (PAC)	65	47	18	–23	8.7	8.1
QE (PAC)	67	50	18	–26	10.9	10.2
HO (SUP PO)	473	552	–27	25	5.9	6.1
HZ (SUP)	70	37	26	–28	5.4	4.9

KEY POINTS

- Mortgage-backed securities are complex instruments. Traditional measures of valuation such as cash-flow yield and relative valuations such as yield spread or static spread are inadequate because of the prepayment option given to homeowners.
- The OAS valuation model is a sophisticated analytical tool available to assess value.
- The results of an OAS model should be stress-tested for modeling risk: alternative prepayment and interest rate volatility assumptions.
- OAS analysis helps the investors understand where the risks are in a CMO deal and to identify tranches that based on the model are fairly priced and those are possibly cheap or rich.
- Compared with a sophisticated analytical tool such as OAS analysis, traditional static analysis can lead to very different conclusions about the relative value of the tranches in a deal.

CHAPTER
FORTY-TWO

CONVERTIBLE SECURITIES: THEIR STRUCTURES, VALUATION, AND TRADING

MIHIR BHATTACHARYA, PH.D.
Managing Director
UBS Financial Services

Convertible debentures and convertible preferred shares, or more generally equity-linked securities, span the space from common stock on the one hand to nonconvertible (straight) debt on the other. While the majority of newly issued convertible securities combine a balance of the common stock and straight debt attributes, some are close proxies for common stock and others skewed toward straight debt. Some new issues may have maturity of as short as three years, as in the case of convertible notes and mandatorily convertible securities, while traditional convertible preferred shares are perpetual; that is, the issuer is not ever required to repay the par or the principal amount of the security. The vast majority, though, have maturity dates ranging from 5 to 30 years, with 5 to 10 years being the most common. Over time, a convertible security that may have started out as very close to straight debt may become very much like common stock due to price appreciation in the common stock into which it is convertible, called the *underlying stock*. The reverse is also true as the price of the underlying common stock declines.

Convertible securities have evolved significantly along with the market's sophistication in analytics, trading, and attention to risk. This chapter will examine the products that comprise the asset class, its evolution, motivations for their issuance and purchase, and their structural aspects. A substantial part of the chapter will focus on valuing these securities, colloquially known as *convertibles* or *converts*. Passing reference will be made to convertible markets in the other regions, namely, Europe, Japan, and non-Japan Asia.

The essential features of convertible products, and notable exceptions thereto, are as follows:

- A convertible security may be converted, generally at any time until its maturity date, into the underlying common stock. Exceptions: some converts may have an initial nonconversion period of 6 to 12 months, sometimes longer. Some may have a *Contingent Conversion* clause

whereby the conversion right of the investor only commences upon the underlying stock price exceeding a threshold price, usually ranging from 25% to 50% above the then effective conversion price, for a prespecified number of days.[1]

- The vast majority of convertibles are convertible into the shares of the issuer. The rest are convertible into shares of another publicly traded entity. These latter securities are called *exchangeables*.
- The conversion right rests with the investor. Exceptions: in mandatorily convertible securities, investors are not given a conversion option; they receive the applicable shares mandatorily at maturity. Some nonmandatorily convertibles may have a knock-in automatic conversion subject to the underlying stock price exceeding a threshold price for a prespecified number of days.
- Almost all converts have a redemption feature that allows the issuer to redeem them prior to maturity. Exceptions: some traditional convertibles and most mandatorily convertibles are nonredeemable.
- Even if convertible at any time, investors are likely to exercise the conversion right only in response to a redemption notice by the issuer—also known as the *issuer redemption* or *issuer call,* or simply, the *call.* In other words, virtually all conversions occur only when forced by the issuer. Exceptions: (a) when the underlying stock pays a high dividend and is also illiquid, e.g., Real Estate Investment Trust Stocks; (b) in the presence of material market friction such as future restrictions on conversion or it is costly to borrow the underlying stock to sell it short as a hedge; and (c) when the underlying stock price is above the *critical stock price,* discussed in further detail below.
- Upon conversion, the issuer will usually satisfy its obligation by transferring to the investor the specified number of shares of the underlying stock per convertible. This is called a *physical settle.* Exception: Sometimes the issuer may have the right, specified in the prospectus for the convertible, to satisfy its obligation by paying the investor the cash value of the underlying securities. This is known as the *cash settle option.* Depending on the liquidity of the underlying stock, a cash-settled convert may fetch a slightly lower price than would a physical settled convert due to the cost incurred by arbitrage and hedge fund investors in covering their stock short position. With some

1. Investors are unlikely to exercise their conversion option prematurely, as doing so would extinguish the time value of the conversion option embedded in the security. Despite this, if the convertible security structure allows the issuer the option to settle the conversion in cash, in full, or in part, the total liability of the convertible issue is deemed a short-term liability. The initial nonconversion period avoids this undesired detriment to the issuer's current assets to current liability ratio.

exceptions for deep-out-of-the-money convertibles, hedge funds short the underlying stock against a long position in the convert. In some instances, conversion is specified into a combination of the underlying stock and cash, or a specified combination of stocks or a choice among specified multiple stocks. The last case is called a *rainbow conversion option,* wherein the investor has the option of converting into that stock among the choices provided that results in the highest value upon conversion.

- A convertible's current yield or yield to maturity or yield to first put usually exceeds the dividend yield of the underlying stock.
- The price of a convertible is at least equal to the value of the shares into which it is convertible, that is, its *conversion value*. In other words, a convertible should trade at a non-negative premium to its conversion value. Exceptions may occur under the following conditions: (a) when there are restrictions on the investors' conversion right; (b) when the underlying stock is illiquid and the cost of borrowing the stock is high; (c) in anticipation of forced conversion leading to a loss of the accrued coupon—this feature is colloquially known as the *screw clause*—a currently redeemable, deep in-the-money, convertible may trade at a discount to its conversion value; and (d) in the case of cash settled convertible, which may cause additional transaction costs for arbitrage and hedge fund investors.
- Convertible debentures are most commonly issued as subordinated debentures, although senior subordinated and senior unsubordinated debentures are increasingly more frequent. Unsubordinated convertible debentures are generally the rule in Europe. When issued as either subordinated convertible debenture or convertible preferred, they are accompanied with relatively fewer restrictive covenants.
- Convertibles have a prespecified maturity. Exceptions include: (a) A handful of mandatorily convertibles whose maturities may be extended by a year at the option of the issuer; and (b) the "PHONES" convertible product (described below), in which maturity may be extended by as long as 30 years.
- Convertibles have a prespecified number of shares per convertible, i.e., a fixed *conversion ratio*. Exceptions: (a) The number of shares received upon conversion of a mandatorily convertible security is not fixed, but is a function of the underlying share price on the settlement date. However, the number of shares to be received is bounded by prespecified maximum and minimum limits; and (b) some Japanese and non-Japan Asian converts have a *reset* or *refix* clause whereby the conversion ratio is adjusted upwards, and the conversion price adjusted downward if the underlying stock price does not exceed prespecified trigger prices.

Evolving sophistication of convertible issuers, investment bankers, and investors has changed the convertible market in several key ways. Higher interest rate volatility has highlighted *duration risk* and *convexity* inherent in any security with a fixed income component, including converts. The increased volatility of corporate spreads (over U.S. Treasury or LIBOR or other interest rate benchmarks) resulting from concerns about corporate defaults as well as defaults by countries—the *sovereign defaults*—has heightened investor sensitivity to default risk. The consequent emergence and importance of *credit default swap* (CDS) as an instrument for risk transference for corporate and sovereign issues can hardly be overemphasized.[2] The volatility in corporate spreads, in the context of converts, raises concern regarding the reliability of a convert's estimated *fixed income floor* or *bond value*. As a result, to arrive at a better estimate of the bond floor and hedge against the default probability of a convert, CDS pricing level applicable for the issue and its trading have very quickly become integral parts of convertible valuation and arbitrage.

Convertibles have equity and interest rate options, and occasionally, currency options, embedded in them. The value of these options is a function of, among others: (a) Equity volatility; (b) interest-rate volatility; (c) spread volatility; (d) default probability; and (e) recovery value in the event of default. Except in some simple situations in which options embedded in a convertible are separable and therefore can be valued using simple models in an additive mode, in the vast majority of cases the options interact with each other and are not separable. Investors should, therefore, be aware of the inherent danger of attempting to value the embedded options as if they were separable options.

The balance of this chapter describes the evolution in the convertible product including details of their various structures, their pay-off diagrams, reasons for investing in them. This is followed by the basic characteristics of convertible securities at their various stages, their valuation parameters, and valuation models. We close by discussing aspects of trading these securities.

2. A CDS transfers the default risk of the underlying *reference debt security* from a holder of the reference debt who buys the CDS to the CDS seller. The buyer makes a stipulated series of quarterly or semiannual premium payments to the CDS seller as consideration. These payments continue until the maturity of the CDS unless terminated earlier upon the occurrence of the default event. The CDS seller, usually a financial institution that wants to assume the credit exposure, agrees to pay a stipulated percent of the notional amount of the reference debt in the event of default and upon receipt of a *deliverable security* from the CDS buyer. Naked CDS purchases, i.e., without also holding or acquiring the underlying deliverable reference security is a directional credit bet that the credit of the reference security and/or its issuer will decline or default. Various sovereign governments in the Euro-zone and elsewhere have, with dubious merit, blamed credit shorts via CDS, either covered or naked, for the financial pressures on their economies and have even banned such trading for a period of time.

EVOLUTION IN THE CONVERTIBLE MARKETS

While most of the issues in the convertible market continue to be noninvestment grade rating or are unrated, it is no longer true that only firms of marginal credit quality and/or firms unable to access public debt markets raise funds by issuing convertibles. This asset class has evolved into a sizable and mature one wherein issuers have raised large amounts, exceeding $1 billion each, some even through overnight transactions with very little marketing effort.[3] To understand this evolution and its future direction, it will be useful to segment this asset class into its distinct distribution channels.

Convertible Market Segments

The principal segment comprises of the publicly issued convertibles that includes those issued either as registered under the Securities Act of 1933 ("SEC registered") or under Rule 144A institutional private placement ("144A issue"). Gross proceeds at issue in this segment are of least $50 million each. Smaller size issues—generally from "small cap" and "micro cap" issuers—may not attract institutional buying interest and as a result tend to be illiquid with wide bid/offer spreads.[4] The present chapter will, therefore, focus on the publicly traded convertibles, though the economic and valuation logic apply to other convertibles as well.

Another segment of the convertible market consists of highly structured and individually negotiated transactions, wherein the issuer and a single investor or handful of investors draw up the terms and conditions of the investment and the structure of the convertible security purchased. This "private investment" is not available to investors at large. The specific one-off nonmarket features and covenants of privately placed issues may include: (a) a relatively high conversion premium in exchange for a high coupon or preferred dividend; (b) an extended period of nonconversion; (c) conversion into restricted stock which cannot immediately be monetized upon conversion; (d) a resetting of the conversion premium and/or coupon or preferred dividend based on balance sheet/income statement/cash-flow target ratios for

3. An example of a large issue is KfW Bank's Aaa rated €5.0 billion (US$5.66 billion) 0.75% exchangeable debt maturing on 8/8/2008, issued in July 2003. Microsoft Corporation's $1.25 billion 0% capped call maturing on 6/15/13, issued in June 2010, was also rated Aaa. China Petro Chemical's step-up coupon convertible bond for Yuan 23 billion (US$3.5 billion) priced on February 2011 is another example, although the issue is unrated.

4. Although convertible bonds may be listed on the New York Stock Exchange (NYSE) or the American Stock Exchange (AMEX), they are most frequently traded in the Over-The-Counter (OTC) markets. As a result, the price levels reported in the press may not be representative of the current market price indications. SEC registered convertible preferreds usually trade on the NYSE and AMEX. 144A convertible preferreds trade on the OTC market until they are registered or are *seasoned,* at which time they are listed and trade on the NYSE or AMEX.

specific time periods[5]; (e) debt covenant restrictions; (f) seniority in the event of bankruptcy, merger, or acquisition; and (g) provisions for voting and control issues. Typical investors are leveraged buyout funds, private equity funds, hedge funds and, occasionally, mutual funds. These buyers provide strategic capital infusion to distressed firms, firms needing added capital to restructure or grow through acquisitions, and firms not otherwise ready for, or unwilling to pursue, public market transactions. This set of investors tends to have medium or long holding period horizons, and have bullish projections about the future stock market performance of the firm and/or hedge themselves. Consequently, the lack of secondary market liquidity of the privately placed structured convertible is less of a concern.

Convertible Products Range

Convertible products[6] may be divided into three categories, based on their seniority in the balance sheet and the tax treatment of the preferred dividend. These categories are (1) convertible debt products; (2) convertible preferred products of the mandatory and the nonmandatory types; (3) hybrid products which are preferred shares from a financial reporting perspective, but are structured so as to be tax deductible, and thus to reduce the net cost to the issuer; and (4) structured public convertibles.

Convertible Debt Products

Convertible Debt Products' interest payment obligation can be in the form of cash coupons or interest accrual or both or neither. The "neither" case occurs when the value of the equity option embedded in the convertible offsets the value of coupon payments of an otherwise identical nonconvertible debt of the same issuer. Not surprisingly, the zero coupon nonaccreting structures are more common in low interest rate environments. Coupon payments and accrued interest are tax deductible and the issuer is accorded no equity credit from the rating agencies.[7] The products in this category include:

5. In the "post-Internet bubble crash," the reset feature of such securities has been criticized and often referred to as "death spiral" or "toxic." However, at the time of issuance issuers often either did not realize the extreme dilutive impact of this feature, specifically the continuing pressure on the stock price due to shorting by the investors to hedge their exposure to the stock, or did not consider it material, given their then expectations of stock price growth. Such toxic converts have fallen out of favor.
6. For the balance of this chapter, unless otherwise noted, we will use the term *convertible* for exchangeables as well. As may be expected, exchangeables are used to monetize stakes that an entity, be it a firm or an individual, owns in the shares of another publicly traded common stock.
7. Equity credit from rating agencies is outside the scope of this chapter. Suffice it to say that rating agencies have repeatedly indicated that with the exception of common shares, which (by definition) are accorded 100% equity credit, they do not adhere to a formulaic approach to assigning ratings for securities or corporate issuers. Nonetheless, one of the rating agencies has indicated the general range of equity credit that may be expected for a list of financial instruments. See Libby Bruch, "Integration of Rating Scales and Re-evaluation of Equity Credit," *Standard & Poor's CreditWeek,* February 24, 1999, pp. 9–11.

- *Traditional Convertible Debt:* Typical maturities are five, seven, or 10 years, with a 15% to 40% conversion premium, and a nonredemption period (*hard noncall*) of three years or longer. The bond is issued at par, matures at par, and has a fixed conversion ratio[8] and hence a fixed conversion price during its life. Basic variations include a higher conversion premium with a higher associated coupon, or a stock price trigger based conditional redemption (also known as a *provisional call* or a *soft call protection*).[9] The combination of an initial period of hard noncall followed by a soft call is often used to trade off against a lower coupon and/or a higher conversion premium. As a rule, the greater the volatility of the underlying stock and the higher its growth expectations, the greater the variation from the basic structure.[10] Reset or refix clauses are included when the outlooks for the firm or for the firm's primary economic domicile country, or both, are unfavorable. The conversion price is revised downward if some stock price triggers are not met. The reset clause lowers the risk to the investor and transfers it to the issuer.[11]
- *Zero-Coupon Convertible Debt:* Also known as LYON,[12] this product is a zero coupon, putable, redeemable, convertible debenture with 15 to 30 years maturity; with one day puts at accreted value at 5, 10, 15 years

8. Conversion ratios for all converts are adjusted for stock splits and special situations, such as special dividends or distributions, as specified in the prospectus for each convert. They may also be adjusted for increase of regular dividends beyond a prespecified dividend payment rate per share threshold.
9. A "two-year hard plus one year 130% soft" means that the convert is not redeemable in the first two years from issue date. It is conditionally redeemable in the third year only if the stock price is at least 30% above the conversion price for at least twenty out of thirty consecutive trading days; after the third year, the convert is redeemable unconditionally. Provisional triggers usually range from 120% to 150%.
10. For example, Amazon.com issued a $1.25 billion, 10-year maturity convertible debt with a coupon of 4.75%, and conversion premium of 27%. Amazon.com is a very volatile stock with strong name recognition as a market leader in the internet retail sector. It was able to issue the convert after a one-day marketing and increase the issue size from an initially announced $500 million to a finally executed $1.25 billion based on investor demand. The structure provided no hard call protection. Instead, it had a three-year "150% provisional redemption with investment *premium makewhole.*" This means that if the 150% trigger condition were satisfied during the first three years, then the issuer may force conversion. However, the issuer would then simultaneously have to pay the investor a cash amount of $212.60 [= $1,000.00 less ($1,000.00 divided by 1.27)] per bond. The net effect upon conversion is as if the investor purchased Amazon.com common stock on the date of issue of the convert. A more common variation currently is the *coupon makewhole* as distinct from the premium makewhole. In this variation, if redeemed during the makewhole period, the issuer pays the arithmetic dollar difference between the stipulated coupon stream until the noncall date minus coupons already paid prior to the redemption date.
11. The reset structure was developed in Japan during the 1990s when its economic growth was anemic at best. There is an element of the "death spiral" element here. However, with a downward reset limit feature usually included in the structure, say, conversion price declining to no less than 50% of the initial conversion price, a total death spiral is avoided.
12. Liquid Yield Option Note is a service mark of Bank of America Merrill Lynch.

from the settlement date following new issuance; and with a hard noncall until the first put date. Thereafter, the issue is unconditionally redeemable at any time at the accreted value. The debenture is issued at a discount to par, calculated at the semiannually compounded yield to maturity of the security. For example, a 5% yield to maturity, 20-year LYON will be issued at a price of 37.243% of par, which is the present value of $100 discounted at 2.5% for 40 periods. The initial conversion premium ranges in most cases from 15% to 40%. The conversion ratio established at issue remains constant during the life of the security. As a result, since the bond value is accreting toward par while the conversion ratio is fixed, the conversion price rises continuously.[13] Attractive features of this security from the perspective of the issuer include:

- Conservation of cash and the option to deploy it at the (presumably higher) internal rate of return of the issuer;
- Tax deduction on the accrued interest;
- Upon conversion, the per bond equity addition to the balance sheet is comprised of the initial issue price plus the accrued interest amount;
- Upon conversion, there is no re-capture (by the Treasury) of the accrued tax deduction;
- The LYON and its zero coupon variation of the CoCo structure (discussed later) are, all else being equal, the most debtlike of all equity-linked securities with the highest effective conversion price;
- This structure signals to the market that the issuer is unwilling to sell equity at the spot price at issue but only at the high effective conversion price.

The trade-offs to investors for the rising conversion price include the higher option value in the five years of hard noncall; a higher accretion rate; and the option to put the security back to the issuer at accreted value at the stated intervals.[14] Among the typical variations in the structure are higher conversion premiums for highly rated issuers and/or high volatility–high expected growth stocks, sometimes in conjunction with a first put in year 3 with a corresponding hard noncall also for 3 years.

13. Continuing with the numerical illustration, assuming that the stock price of the underlying share to be $45.00 per share, and the initial conversion premium of 25%, the initial conversion price is = $45.00 × 1.25 = $56.25 per share. The conversion ratio per bond accreting at 5% and 20 year maturity will be the issue price divided by the initial conversion price = (372.43/56.25) = 6.621 shares. In five years, the bond will accrete to $476.74, which is the issue price compounded at 2.5% for 10 semiannual periods. The effective conversion price will then be = (476.74/6.621 shares) = $72.00 per share. In options terminology, these bonds have strike prices increasing with time.
14. The puts are sequential European puts, also known as *Bermudan puts*; they can be either *hard puts* or *soft puts*. In the former, upon exercise of the put, the investor is paid the put amount in cash. In the latter, it can be satisfied in cash or shares equal to the value of the put amount, or combination, at the option of the issuer. Earlier versions had an equal value of a new straight debt security as a third alternative; this alternative has been dropped due to ambiguities regarding the valuation of the new debt security.

Other variations include longer first put date, often in year 7, as well as nonsymmetric put and call dates with the first call date occurring before the first put date.

- *Original Issue Discount Convertible Debt:* This structure (called the *OID convert*) combines aspects of the preceding two structures in that a small part of the yield to maturity is paid in the form of cash coupon, and the balance accretes. As is to be expected, all else being equal, the yield to maturity in this structure straddles those of the preceding two structures. The conversion price is also rising but at a rate lower than that for the zero coupon structure. Maturity for this product is usually five to seven years with a typical hard noncall protection of three years and is typically not putable prior to maturity although there is no reason why it cannot be structured with, say, a put in year 3 and final maturity in year 5 or 7.
- *Premium Redemption Convertible Debt:* This is simply another variation of the OID convert. The only difference between this variation and the OID is that the latter is issued at below par and accretes to par at maturity, while the Premium Redemption Convertible is issued at par and accretes in exactly the same manner to a number above par and hence the name. This structure occurs more in Europe and Asia, where regulations may require the issuance of bonds at par.
- *Step-Up Convertible Debt:* This product follows a *pay-in-kind* or *PIK* structure common in the non-investment-grade debt market, wherein the security pays no coupon for a period of up to five years. The coupon then steps up to a higher level cash coupon than what it would have been if it were current coupon paying from the start. Adapted for the convertible market, this security pays a low cash coupon for the first three years, which is also the hard noncall period. The coupon then steps up for the balance of the life of the convert that ranges from another four to seven years. The effective conversion price rises continuously until the last low-coupon payment date, and stays constant at its higher level thereafter until maturity. As might be expected, the absolute levels of the coupons in step-up convertibles are much lower than those in the high-yield market due to the inclusion of the conversion option. Interest is expensed at the rate of the yield to maturity, which is higher than the cash coupon during the low coupon period, but lower than the cash coupon rate in the later period. The incentive for the issuer to redeem this security prior to the higher coupon kicking in is therefore very strong. A flip-side variation of the structure, particularly in low interest rate environments, is the step-down convertible wherein after an initial cash coupon period the coupon drops to a lower level or to zero with or without accretion.

Contingent Convertible Bonds

In most convertibles the investor has an American option to convert into the underlying stock. As a result, Generally Accepted Accounting Principles (GAAP) require that the denominator in the earnings per share (eps) calculation add the new number

of shares to be issued upon conversion of this convertible to the existing number of shares outstanding. The increase in the number of shares in the denominator—and hence eps dilution—occurs immediately upon the settlement of the newly issued convertible transaction and is based on the conservative assumption of immediate conversion by the investor. In this nicknamed *CoCo convertible,* the conversion option granted investors is not immediate but contingent upon the stock price exceeding a prespecified hurdle, i.e., the investor's option to convert "knocks in." By adopting this twist, first introduced in 1999, the issuer did not have to recognize immediate eps dilution but could defer it to the knock-in date. Under those rules, the CoCo structure grew to dominate U.S. convertible new issuance. The majority of the issues were investment grade, and the transactions generally very large, as the non-immediate dilution feature was particularly attractive to issuers.

However, that was before the Financial Accounting Standards Board's Staff Position APB 14-1 in May 2008 and adopted shortly thereafter. It established that prospectively as well as retroactively, all convertible debt would be treated under the "bifurcation concept," i.e., viewed as a combination of straight debt plus an equity component. Consequently, regardless of the CoCo structure, eps dilution would be recognized immediately upon issuance of the convertible security. As a result, the issuance of CoCo convertibles has declined materially from its peak. CoCos now may, at the option of the issuer, settle in shares, i.e., physical shares settlement, or a combination wherein the par value may be paid in cash and the in-the-money component paid in shares, called *net share settlement,* or both components paid in cash. Clearly, the latter two alternatives are aimed at reducing the number of shares delivered upon conversion.[15,16,17]

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15. Assume that at settlement the stock is at $45, the conversion ratio for the bond is 32. Then the intrinsic value of the bond is 45 × 32 = $1,440. Under the net share settlement, the investor receives $1,000 cash toward the par value and 440/45 = 9.7778 shares.
16. A brief note regarding the bifurcation principle: Under the *debt method,* a $1,000 par convertible would be viewed as, say, $850 of discounted debt that will accrete to $1,000 at maturity, and the $150 equity component to be accounted as equity. The interest expense would be increasing over time to maturity and is computed as the accreted bond liability times the straight, nonconvertible debt rate applicable to the bond at the time of issuance of the convertible security. Note that under the old method the debt expense would have been par times the cash coupon of the convertible which would have been lower that the nonconvertible bond rate. The increased interest expense flows through to the earnings calculation. Upon conversion, the eps is the more dilutive of (a) the debt method above, or (b) the fully diluted "equity method" in which all the shares underlying the bond are included in the denominator, not just the shares paid out in the net share settlement method.
17. Lately, following the financial turmoil of 2007/2008, the term "CoCo bonds" has been applied in a totally different context. These CoCo bonds, issued by banks and financial institutions, may be converted into equity at the option of the issuer banks if/when their business losses cause their core capital ratios to decline below regulator-mandated levels. The bond investors, in effect, have sold an embedded credit put to the issuing financial institutions and, therefore, have no say if and when this variety of CoCo bonds will be converted into equity to the detriment of the investor. Very unlike the CoCo bonds discussed here it is more like a *reverse convertible,* wherein, once again, there is an embedded put sold by the investor to the issuer. Not surprisingly, neither of these issuer putable securities is traded on the convertible desk.

- *Contingent Payable Bonds:* As one might surmise from the name, these *CoPay* bonds knock-in contingent payment by the issuer to the investor subject to the stock price exceeding a pre-established threshold. The Co-Pay feature generally helps defer voluntary conversion by the investor thereby allowing the issuer to continue claiming interest deduction on a typical long-dated structure since the bifurcation method also applies here. Conditioned on a credible probability of the contingent payment, the issuer can deduct interest expense at the long term straight debt rate matching the maturity of the security. The magnitude of the tax benefits of this structure varies depending on whether the security is ultimately converted or not, but in either case it potentially generates significant tax benefits to the issuer. The Co-Pay structure may also be embedded inside CoCo or any of the accreting structures.
- *Negative Yield Convertible Debt:* Yield on the benchmark 10-year Yen denominated Japanese government debt has hovered below 1% for several years and was at 0.54% as of 3/10/11 for five-year Japanese government bonds (JGBs). Dividend yields on Japanese equity are traditionally very low. Under this scenario, consider a yen denominated, zero coupon, low conversion premium, unsubordinated convertible debt with an effective maturity of five years issued with hard noncall also of five years. Its theoretical value would most likely be a few points above par. To make it equitable to both issuer and investor, such a convert might be issued at 1% to 3% above par, yet it matures at par thereby resulting in a negative yield to maturity security. Not surprisingly, this structure will be more frequently used in a low interest-rate environment and particularly so when combined with high volatility in the underlying stock.

Increasingly, convertibles debentures have been issued as senior unsubordinated debt, pari passu with senior existing or future nonconvertible debt of the issuer. This feature has long been common in convertible bonds issued out of Europe and is particularly suited for CoCo/CoPay structures. The collateral benefits accruing from of this structure are the increased liquidity due to it facilitating capital structure arbitrage trading as well as credit hedging via CDSs in addition to a higher tax deduction rate.

Convertible Preferred Products

Convertible preferred products are senior only to the issuer's common stock. The preferred dividend is not tax deductible, and hence is a costly source of funding on an eps basis. Convertible preferreds are mostly issued, therefore, when the firm needs equity credit from the rating agencies, or when it is unable or unwilling to issue debt due to leverage covenants imposed on them by other classes of senior securities, or when the firm does not pay taxes due to accumulated losses or a combination of these reasons. These products are viewed as "permanent" or long-term financing and provide the issuer with the option to skip payment of preferred

dividends without triggering default. Hence they are generally accorded up to 50% equity credit from the rating agencies.[18,19] Withholding taxes and the low bond floor equivalent resulting from the perpetual maturity are the primary reasons why these structures are not commonly issued in Europe. Withholding tax on preferred dividends applicable to non-U.S. investors deters them from investing in U.S. preferreds too. The products in this category may be further subdivided into those that redeem at par if not converted, that is, without impairment to the original investment, and those that convert mandatorily into a formula number of common shares at maturity. In the latter case, investors may lose part of their initial investment if the stock price falls below that on the date of issue.

Nonmandatorily convertible preferred shares include:

- *Perpetual Maturity Convertible Preferred Shares:* This is the preferred share counterpart of the Traditional Convertible Debt described above in that it has a fixed conversion price, it is a very easy structure to understand, and has been a staple of the convertible market for several decades. The main differences are its perpetual maturity and lower seniority. Consequently, the dividend on the convertible preferred will be higher than the coupon on an otherwise identical convertible debt. The higher rate on the preferred results from the fact that both the corresponding benchmark interest rate and the credit-spread corresponding to this longer maturity are higher, and the two together form the base rate.[20] The dividend rate on the convertible preferred is determined by adjusting downward from this higher base rate for the embedded equity option.[21,22]

18. While skipping preferred dividends does not result in default, it does tend to severely depress the stock price. Restrictions on common dividend payments, board seats to preferred shareholders and other remedies may be imposed on the firm until the arrears in preferred dividends are paid. Consequently, the option to skip preferred dividends, although embedded in the structure, is resorted to only when the firm is in financial distress.
19. Issuance of traditional preferred shares, in most cases, is viewed as helping prevent a ratings downgrade but not necessarily help in a ratings upgrade. Since mandatorily convertible securities, by structure, are certain to convert into common shares within three years and at most in five years, they are viewed more akin to common shares, and therefore may be accorded up to 85% equity credit. This applies to all flavors of mandatorily convertible securities—preferred, exchangeable debt, or hybrid tax deductible preferred.
20. When the 30-year Treasury bond was the longest dated liquid benchmark, preferred were priced off of its yield to maturity. However, since 2001 when the Treasury halted regular issuance of the 30-year bonds—although it has been brought back with limited frequency and liquidity since 2006—the 10-year U.S. tenor is the most liquid long-dated U.S. Treasury security, converts are priced off of this benchmark. The CDSs are also typically 5-year tenor and occasionally longer.
21. This logic applies to all converts.
22. A variation of this security allows the issuer the option to exchange the convertible preferred for an otherwise identical convertible subordinated debenture of maturity 10 years from the original date of issue. Issuer will usually exercise this option when it returns to tax-paying status.

- *Dated Convertible Preferred:* Again a convertible adaptation from the high-yield market, this product has a maturity of 10 to 12 years, although 30-year dated convertibles have also been issued. Typically, it matches or is outside the maturity of high-yield debt which is usually 10 and sometimes 12 years. If not converted, a dated convertible preferred must be redeemed at par at maturity. In all other aspects it is similar to the perpetual maturity convertible preferred. Rating agencies are less likely to accord any equity credit due to this product's debtlike redemption at maturity feature and is almost always used by noninvestment grade issuers faced with covenant restriction limits.
- *Step-Up Convertible Preferred:* This product is analogous to the step-up convertible debt, but with perpetual maturity.

Mandatorily convertible preferred shares in essence transfer the downside risk of the stock to the investor in exchange for a higher preferred dividend. This category of converts includes:

- *Capped Common:* Also known as PERCS,[23] the capped common is essentially a combination of purchasing a common share and writing an out-of-the-money call to the issuer. Investors have no conversion option at any time during the life of the security, which is typically three years and sometimes shorter. The issuer, however, may redeem this convertible at any time provided the preferred dividend due until the maturity date is paid in its entirety. The premium for the call option that the investor is short is packaged in the form of quarterly preferred dividends. This packaging of a common options strategy, known as the *buy-write* strategy, allows convertible funds to invest in them. Were these three-year convertible securities unbundled, the charter of convertible funds which may disallow pure play option positions would generally prohibit such investment. The investor in the capped common realizes all of the stock price appreciation from the spot price at issue up to the cap or strike price level; anything beyond the cap price is retained by the issuer. On the other hand, the investor loses part of her principal to the extent that the stock price at maturity is lower than the price at issue. In a rising equity market, the issuer has almost always exercised the call option and this product has under-performed the common stock from an investor perspective. Consequently, its popularity has declined considerably. Rating agencies may generally be expected to accord equity credit of up to 85%.

23. The Preferred Equity Redemption Cumulative Stock (PERCS) is a service mark of Morgan Stanley.

- *Modified Capped Common:* A variation on the above, the modified capped common may be viewed as a PERC with some downside protection to the investor, in the form of an embedded put the investor purchases from the issuer. Microsoft Corporation was the first to use this structure in 1996; it offered $1 billion of this security with a cap of 28% on the upside, but without any downside risk to the investor; that is, with no hit to the principal. The embedded put purchased by the investor for this three-year maturity security was an at-the-money European put on what was then a high volatility stock, and hence was very expensive. The net option premium paid to the investor in the form of preferred dividend was accordingly low.[24]
- *Mandatorily Convertible Preferred:* This structure, invented in 1993, and its hybrid version, the *Trust Mandatory Preferred* (described below) have been so frequently used to raise funds in the convertible market that it has spawned a host of acronyms.[25] Typically, it is issued at the same price as the underlying stock price; matures in three to five years, most frequently three-year maturity. It has a conversion premium in the 20% to 22% range, but may be higher in low interest rate regimes. It is easiest to view this security (popularly known as a *mandatory*) as a traditional convertible with a three-year maturity that is share settled, packaged with an embedded at-the-money put purchased by the issuer from the investor. The number of shares received by the investor at maturity depends on the share price on the maturity date.[26] This security's popularity has stemmed from the high equity credit from rating agencies, the transfer of risk to the investor in the event of a decline in the share price, and the traditional convertible features on the upside. Because the issue is settled in shares, the question of credit risk of the issuer with respect to payment of par is irrelevant. Only the credit risk with respect to the payment of the preferred dividends remains. Consequently, the structure is relatively insensitive to the creditworthiness of the issuer. The typical high preferred dividend rate of the mandatory being attractive to the buyers is another reason for its popularity.

24. Microsoft Corp. Series A 2.75 % Convertible Preferred issued on 12/17/96 maturing on 12/15/99; cap at 28%.
25. The service marked acronyms, followed in parenthesis by their respective investment banks, include: DECS (Citigroup), PRIDES (Bank of America Merrill Lynch), ACES (Goldman Sachs), PEPS (Morgan Stanley) and SAILS (Credit Suisse First Boston).
26. Assuming a spot stock price of $100 a share, the mandatory will also be issued at $100. If the conversion premium is 20%, the minimum conversion ratio is the issue price divided by the conversion price = $100.00/120.00 = 0.8333 shares per mandatory. If the stock price at maturity is at or above $120 the investor receives 0.8333 shares. If the stock price is at $100 or below, he receives one share that is the maximum number of shares per preferred. So, in the event that the stock price is $65 at maturity, the investor has a hit to the principal of $35 per share. If the stock price is between $100 and $120, the investor receives between 0.8333 and 1.0 shares so as to be worth the initial investment of $100. Sometimes for the sake of standardization, the par amount is set to $50 or $1,000; the conversion ratio is calculated in exactly the same way.

- A variation on the preceding structure, the *modified mandatory convertible preferred* provides the investor with downside protection for the first 10% to 25% from the spot price, in exchange for a lower preferred dividend. In effect, the net put component of the package purchased by the issuer is 10% to 25% out-of-the-money. Hence the put premium is lower, and this is translated as a lower preferred dividend. The maximum number of shares is 1.111 for a 10% out-of-the-money put case, rather than the one share in the at-the-money put case of the traditional mandatory. The equity credit accorded is identical.

Mandatorily and modified mandatorily exchangeable securities (wherein the underlying stock is different from the issuer's common stock) can be issued as debt securities whereas a mandatorily convertible security issued on the issuer's own stock is deemed as a forward sale of the common and hence is not tax deductible. Specialized structures, the specific details of which are outside the scope of this chapter, are crafted in compliance with the applicable tax code in order to achieve effective tax deductibility. The next subsection briefly outlines these hybrid products.

Hybrid Convertible Products

This category consists of structures which are treated as preferred shares for financial reporting purposes, but their distributions are tax deductible. The development of hybrid convertible preferreds closely followed the invention of the MIPS, QUIPS and TOPRS[27] in the fixed-rate nonconvertible preferred market. The essential structure in this category is as follows: a Trust[28] issues convertible preferred shares to investors and simultaneously uses the proceeds to purchase convertible subordinated debt from the issuer. The convertible subordinated debt will be the sole asset of the Trust. The coupon from the issuer to the Trust exactly mirrors the preferred dividend paid by the Trust. Upon conversion by the investors, the Trust in turn converts the convertible debentures and passes through the shares to the investors.

- *Trust nonmandatory preferred:* The maturity of this product ranges from 15 to 30 years and equals the life of the Trust; its cash distributions and maturity mirrors that of the convertible debenture purchased by the Trust from the issuer. Investors are generally not sensitive to the structural difference between these securities and the traditional perpetual convertible preferred. Rating agency equity credit may be equal to that of the traditional perpetual convertible preferred, although recent discussions might lead this product to be viewed as being closer to debt.

27. Monthly Income Preferred Shares (MIPS) and Quarterly Income Preferred Shares (QUIPS) are service marks of Goldman Sachs. Trust Originated Preferred Securities (TOPRS) is a service mark of Bank of America Merrill Lynch and is more descriptive of the structure.
28. The Trust qualifies as a closed end fund under the Investment Company Act of 1940.

- *Trust mandatory preferred and modified mandatory preferred:* This product is similar to its non-tax-deductible counterpart, except for the complexities involved with the Trust and the forward purchase contract between the investor and the issuer which is required to ensure mandatory conversion at the end of the life of the Trust, typically three years. Variations among the trust mandatory preferred relate to the structure and conditions regarding the forward purchase contract. Trust structure is also employed when the entity selling the shares is not an SEC registrant, but rather an individual or an investment or venture capital partnership. If the creditworthiness of the corporate issuer is less than acceptable, or the seller is not an SEC registrant, preferred dividends due the investors over the life of the security are escrowed in the Trust in the form of Treasury strips with maturities matching the scheduled preferred dividend payment dates. On the date of issue, proceeds from the sale of the Trust mandatory preferred to the investors, less the cost of the Treasury strips and Trust administration costs are forwarded to the issuer. The underlying shares are simultaneously escrowed in the Trust so as to create a bankruptcy remote Trust with an implied AAA credit rating.

Zero Premium Exchangeable Debt

This product acronym "PHONES"[29] is a 30-year zero conversion premium security issued at the same price as the underlying share into which it is exchangeable. It is redeemable by the issuer at any time, and convertible by the investor at any time, though there may be an initial nonconversion period. However, if the security were to be converted by the investor in the initial 30-year maturity period, the conversion ratio will be 0.95 implying a 5% penalty for voluntary conversion. The security is extendible for a further 30 years, subject to certain minimal conditions, at which time the conversion ratio becomes one share. The investor receives a pass-through of the dividend paid by the underlying share plus a fixed interest component. Any increase in the dividend paid by the share is deemed return of principal and deducted from the residual "par value" which is initially equal to the original issue price. Investors are liable for taxes on income deemed as received at the issuer's subordinated straight debt rate, which considerably exceeds the interest paid by the issuer. In exchange, the investor's basis for the share will rise with time. Zero premium exchangeable debt, at its most basic level, is a tax advantaged way for the issuer to monetize its holding of the underlying shares without actually transferring ownership of the shares. It thus potentially allows the issuer to defer the capital gains tax for as long as 60 years while enjoying a much larger interest deduction than cash coupon paid (6% imputed rate versus 1.75% actual cash coupon rate in one instance). Given the substantial tax advantage it provides

29. Participating Hybrid Option Note Exchangeable Securities (PHONES) is a service mark of Bank of America Merrill Lynch. Another investment bank calls it "ZONES."

the issuer it is attractive for the issuer. However, due to its material tax liability for a taxable investment entity, this product is most likely to appeal to tax sheltered investment vehicles of the equity income type, tax sheltered index funds, and off-shore hedge funds. Many investors do not consider this security to be a convertible, as it lacks any meaningful convexity and their popularity has fallen off.

Structured Public Convertibles

A recent innovation to reduce earnings per share dilution relating to the issuance of a convertible entails combining it with an equity derivative overlay transaction. The most common among these is the "call spread overlay." Consider a convertible issued with a 25% conversion premium. With part of the proceeds from the sale of this convertible the issuer buys from an investment bank an off-setting 25% out-of-the-money call matching exactly the conversion option embedded in the convertible in its maturity, number of shares and redemption features. Further, the issuer sells a 50% out-of-the-money call with identical features. In so doing, the issuer has reduced the potential dilution impact of the convertible through this net 50% out-of-the-money call. In addition, the net cost of the call spread can be deducted for tax purposes. Furthermore, the investment bank, as the seller of the call spread, has to hedge itself—in the 25% to 50% out-of-the-money range—by buying the underlying shares, thereby benefitting the stock. At maturity settlement for the investor in the convertible is as usual and can be in shares or cash or combination. If the stock exceeds the 50% threshold, the settlement with the investment bank is in net shares.

Exhibit 42–1 provides a schematic of the terminal payoff diagrams for the major convertible securities. Similar payoff diagrams can be drawn for the other convertible products.

Since the upheaval in the convertible market in 2005, and even more dramatically in 2007–2008, issuers and investors have moved noticeably to the simpler product structures. Traditional convertible bonds, mandatories, and convertible preferred shares have been chosen over some of the more complicated structures described above.

Investing in Convertible Securities

The most frequently cited reason to invest in convertibles is that convertibles provide upside participation with downside protection. While generally true, it does not fully apply to mandatory securities in which the investor retains the downside risk of the stock. Since convertibles span the space between equities and straight debt, the risk profile of each convertible product contains elements of both. Investors will choose from the subset of convertible offerings that match their target risk-reward profile and/or their assessments of the future levels of the underlying stock price, interest rate and credit-spread levels, volatility parameters, as well as market technicals such as supply/demand and liquidity. These are discussed in detail in the following.

EXHIBIT 42–1

Equity-Linked Payoff Diagram

Institutional investors in convertible securities can be broadly classified into *outright* investors and hedgers. Outright investors include the dedicated convertible funds, equity income funds, insurance companies, and fixed income funds seeking to participate in the potential upside in the equity. Convertible mutual funds, money managers who manage third party funds such as those from pension funds with specific allocation for convertibles as an asset class, as well as in-house managed funds earmarked for convertibles are also included in this category. The main hedge funds participants include those focused on convertible arbitrage, equity volatility arbitrage, and capital structure arbitrage. The common investment objective of the outright investors is to obtain equity exposure with portfolio volatility lower than that of common stocks. They are active money managers and are often measured by holding period returns compared to benchmark indexes such as the Standard & Poor's 500 Index, or the Russell 2000 Index of small stocks, or a risk adjusted benchmark. A subset of managers is measured by the Sharpe ratio.[30] An aspect of the charter of outright convertible funds is that they may not be allowed to hold the common shares received upon conversion nor permitted to hedge their convertible positions. That flexibility is left to the convertible arbitrage funds.

30. Sharpe ratio is defined as the excess return of the portfolio divided by the risk of the portfolio as measured by the standard deviation of its returns. Portfolio excess return is the realized return of the portfolio minus the return from the riskless asset. It attempts to measure the excess return per unit of risk undertaken by the portfolio manager. The measure can be applied to portfolios or to asset classes. The higher the Sharpe ratio, the better is the performance of the portfolio manager or the asset class.

The assets under management dedicated to convertibles, particularly by hedge funds, in the past decade has dramatically altered not only the size of this asset class, but also the way convertibles structured, marketed, evaluated, and traded. Convertible hedge funds went from being a significant part of convertible market to being the most dominant segment leading up to 2007 when they were variously rumored to be more than 80% of the funds invested in U.S. and global convertible markets. Further, due to their high portfolio turnover, they accounted for the majority of the liquidity provided. The financial illiquidity of 2007–2008 hit dedicated convertible arbitrage funds very hard forcing many to shut down while multistrategy hedge funds drastically reduced their allocation to the strategy. As they ceased to be the buyers to drive the new issue pricing, outright buyers with a longer holding period horizon have seen new issue pricing move in their direction and now account for a larger segment for the asset class than before the illiquidity event.

Outright investors will seldom buy a convert unless they like the fundamentals, or the *equity story,* of the underlying stock. Ideal attributes of an issuer, from outright investors' perspective, include

- A strong management team with a well articulated business model
- Presence in a growing sector of the economy
- The firm being in the growth phase of its business cycle
- Strong or improving credit with the ability to undertake the fixed liability without jeopardizing its credit rating
- Credit-spread established by an actively traded nonconvertible bond by the issuer or indications of credit default swap or asset swap levels
- High volatility stock
- Little or no dividend on the common stock
- Liquid secondary market for the convertible and the underlying stock

Additional items considered by hedge funds, who are essentially relative value investors, include:

- Cost to borrow the stock
- Richness or cheapness of the implied volatility of the options embedded in the convertible versus those of comparable listed equity options and the historical volatility of the underlying stock. This forms the basis of volatility trading.
- Implied equity volatility of credit default swaps and *equity default swaps*. Together with implied volatility of comparable equity options.
- Credit-spreads for all levels of seniority of obligations of the underlying stock, including the convertible with a view to *capital structure arbitrage*. The idea is to arbitrage (a) credit-spread mispricings, (b) differential implied probabilities of corporate default, or (c) recovery rate in the event of default embedded in the pricing of these obligations.

Thus, evaluating a convertible encompasses, among others, fundamental equity research, analysis of interest rates, credit-spreads, capital structure, associated equity and debt derivatives as instruments of trade expression or hedging, market technicals, liquidity of the security itself as well as the restriction on, and costs of, shorting the underlying stock. To understand the arena where this increasingly sophisticated analysis is deployed, we discuss convertible new issues next.

Convertible New Issues

Publicly issued convertible new issue product in the United States has had its ups and downs as it grew steadily in size from $12 billion in 1992 to over $106 billion in 2001 before the collapse of the dot.com boom and did not recover to the $100 billion level until 2007. And, not surprisingly, it dropped off again following the global illiquidity crunch that followed, ending with a paltry new supply of $39 billion in 2010. Taking the maturing issues into consideration, there was indeed a net contraction of the market during these years. Globally, the new issuance peaks and valleys roughly mirrored the United States' pattern with total issuance of $180 billion in 2003, $198 billion in 2007, and ending with $101 billion in 2010. While geographically continuing to be the most liquid of the convertible markets with the largest new issue calendar, the United States' proportion of the global new issues has fluctuated from as high as 61% in the challenged market conditions of 2008 to as low as 38% in both 2009 and 2010, but accounted for more than half of global issuance for most years in the last two decades. European issuance, on the other hand, has been steady at mid-teen to mid-twenties percent, with a spike to 37% in 2009. Japanese issuance in the current century ranges in the mid-single-digits to a rare spike of 16% in 2004—due to a few large transactions including one by Toshiba Corp for Yen 100 billion (US$923 million)—and considerably below the levels of issuance commensurate with its prior decades of growth. However, as might be expected, the portion of non-Japan Asia new issuance—at 25% in 2010—is considerably higher in keeping with their very high rates of growth compared to those of the developed regions comprising the United States, Western Europe, and Japan.

What determines the amount and type of convertible financing selected by issuers? One key factor, surely, is the economic cycle, along with the equity and bond market environments. As might be expected, in the low interest environments, issuers will clearly prefer to build up their capital base/extend maturities/restructure their balance sheets by issuing straight debt rather than dilute their earnings by issuing equity or equity-linked securities. Banks and financial companies, particularly, and others that bore a major brunt of the downturn were the exceptions with mandatories being the structures of choice for them. Hence the structure of convertible financing has a cyclical element to it with tax and accounting rules as factors being not far behind. Governmental financial inputs to stabilize global economies and the resultant or concurrent low interest rate environment are

expected to curtail convertible new issuance until the economies are in stronger recovery stages. History provides an indication of the choice of structures.[31]

Despite the lull in convertible new issues since the 2007–2008 financial crisis years, 15 converts were issued in the United States with proceeds exceeding $1 billion each, from 2009 on to the first quarter of 2011. Select examples are: (a) 4.75% mandatory maturing on December 1, 2013, issued by General Motors on November 18, 2010, as it emerged from bankruptcy; (b) Citigroup's 7.5% mandatory maturing on December 15, 2012 and issued on December 6, 2009 for $3.5 billion to add equity to its capital base; (c) Intel Corp.'s 3.25% convertible bond maturing on August 1, 2039 and issued on July 21, 2009 for $2.0 billion; and (d) MetLife Inc.'s $3.0 billion mandatory issued on March 3, 2011 and maturing on September 11, 2013, carries a preferred dividend of 5.0%. Depending on market conditions, the average size of a U.S. convertible issue has ranged from a low of $160 million to a very respectable and liquid $550 million. European issues are roughly comparable in size, although with larger variations from year to year, while non-Japan Asia issues are gradually increasing in size to an average of $225 million in 2010. While Japanese issues are predominantly Yen denominated and European issues in Euro, even in these countries US$ denominated issuance is not uncommon and is the currency of choice in most non-Japan Asian issuance.

When US 144A transactions started being issued with increasing frequency, they were not kindly received, as many tended to be overnight issues as opposed to being registered and fully marketed over a few days or weeks of road shows.[32] That is, the issues are announced after the trading day is over, orders solicited that same night or early the next morning, and the transaction completed before trading starts that morning. Over time, the ire over 144A issuance has tempered as investors have come to accept their inevitability. The demand for the product is largely unaffected while issuers do not need to provide investors a number of days, as is done in registered offerings, to study the details of the company's finances

31. As the economic conditions recovered in 1995 and peaked in mid 1998, the tax-deductible mandatory convertible and the tax-deductible nonmandatory convertible preferred increased in importance. Issuance of traditional convertible debt declined substantially in 1998 and came to a virtual halt following the Russian government bond default in mid-1998 and the Asian/emerging market contagion then in full swing. Convertible financing in the first half of 1999 was off significantly from that of the previous year, due to fears of rising interest rates but spurted in the last quarter of 1999 amid a recovery and start of the boom cycle. Convertible debt as a percent of total issuance jumped up to more than 80% in 2000 and 2001. With the burst of the Internet bubble, preferred share structures returned in favor at 42% of total gross proceeds in 2002. However, 2003 saw the resumption of the dominance of convertible debt issues, particularly the zero coupon/part coupon/CoCo structures, as interest rates continued to be extremely low in real terms. The CoCo bubble was burst by the FASB change cited earlier.

32. As an alternative to a US SEC registered offering which can be sold to any investor, including individual investors, 144A issues can be publicized, sold, or resold only to the larger institutional investors and Qualified Institutional Buyers (QIBs). This avenue, available to SEC registrant firms who are current with respect to filing financial reports with the SEC or those that agree to make the financial reports available to investors, allows new issue or secondary transactions to be executed without having to undergo the time-consuming registration process.

and/or the transactions prospectus thanks to a large extent to hedge funds, institutional buyers and QIB's as they can quickly respond to the new issue offer.

Although the total issuance volume in this asset class pales in comparison to both investment grade and high-yield issuance in the United States, they are still healthy. And in countries and regions in which the straight debt market is not as developed, convertibles are the vehicles of choice as the economies graduate from bank financing. That said, we next discuss convertible valuation.

BASIC CHARACTERISTICS OF CONVERTIBLE SECURITIES

The simplest convertible security, namely a traditional convertible bond, can be viewed from a fixed income investor's perspective as a combination of an otherwise identical nonconvertible bond plus a call option to exchange the bond for the underlying shares. From the equity oriented investor's viewpoint, it may be viewed as a combination of a long position in the underlying shares, a put option to exchange the underlying shares for an otherwise identical nonconvertible bond, and a swap to receive coupons of the convertible bond in exchange for dividends on the underlying shares. This is an immediate implication of the European version of the put-call parity theorem.[33] The introduction of redemption features and other embedded options in the more varied convertible structures discussed above may complicate, but does not invalidate, the basic equivalence concept.

Value Diagram and Descriptive Measures

Exhibit 42–2 value diagram shows the roles of debt and equity components in valuing a convertible security. The horizontal axis is the value of the underlying shares and equals the stock price times the conversion ratio. This value is called the convertible's *parity value,* or simply *parity*. The line ODQ also represents parity. ACDB is the value of the corresponding straight debt, and ACVS represents the value of the convertible bond. Because a convertible bond provides the investor with rights beyond those provided by an otherwise identical nonconvertible bond, in that it can be converted into the underlying shares, its value should equal or exceed the larger of the corresponding debt or parity. Accordingly, in the value diagram, ACVS is equal to or above the segment OD, where bond value exceeds parity, and is equal to or above DQ, where parity exceeds bond value.[34]

33. See John Cox and Mark Rubinstein, *Option Markets*. Englewood Cliffs, NJ: Prentice-Hall (1985) pp. 41–43.

34. The value of a convertible in a two-factor valuation model would be represented by a three-dimensional surface with the value of the convertible on the y-axis, stock price—the first factor—on the x-axis, and interest rates—the second factor—on the z-axis. The simpler two-dimensional representation above is, therefore, a section of the pricing surface parallel to the x, y plane, at a given level of interest rate plus credit-spread, and assumes a constant volatility level. On the other hand, the volatility surface of a convertible can be graphically represented if the interest rate plus credit-spread were to be held constant, while volatility, represented on the z-axis, is assumed to change with changing stock price levels.

EXHIBIT 42–2

Convertible Value Diagram

Three measures of premium are commonly used in convertible parlance. They are the conversion premium, the points premium, and the investment premium. The vertical distance between ACVS denoting the value of the convertible bond, and the bond floor (or investment value) line ACDB, represents the convertible bond value in excess of its investment value. This is expressed as the *investment premium,* defined as

$$\text{Investment Premium} = [(\text{Convertible Price} / \text{Investment Value}) - 1] \times 100 \quad (42.1)$$

The vertical distance between the convertible bond value ACVS and parity ODQ represents *premium over parity*. This may be stated in *points premium,* defined as the dollar value of the convertible bond minus the dollar value of parity, expressed as a percent of par. For example, if the bond price were $1047.50 and parity were $920, then points premium would be 12.75 points. Alternately, the premium may be stated as the *conversion premium,* defined as

$$\text{Conversion Premium} = [(\text{Convertible Price/Parity}) - 1] \times 100 \quad (42.2)$$

The conversion premium is 13.86% in the illustration above. Conversion premium, or simply, the *premium,* is an important and commonly used measure. Together with the investment premium and the notion of the *delta* of the convertible (defined below), the conversion premium helps characterize the change in the value of the convertible with a changing underlying share price.

The ratio of the change in the value of the convertible to the change in the value of the underlying shares, or parity, is called the convertible's *parity delta.* As does the equity call option delta, the parity delta ranges from zero to 1.0, and is the per share delta of the convertible. Therefore, it is also called the *delta,* or the *neutral hedge ratio;* the per share basis is the unstated assumption. At zero delta the convertible behaves like straight debt, and at 1.0 it behaves like common stock. Therefore, the delta of the convert may be viewed as the correlation of the change in the price of the convert to the price change in the underlying share. A 65% delta means that for small moves in the underlying share price of, say, \$0.10, the change in parity = the change in the price per share times the number of shares per convertible = \$0.10 × 6.621 = \$0.6621. The expected change in the value of the convertible bond then is = the change in parity times the hedge ratio = \$0.6621 × 0.65 = \$0.4304, or 0.0434 bond points. If an investor of the convert wanted to hedge the equity risk, she would in theory have to sell short.

Conversion ratio × delta = 6.621 × 0.65 = 4.3037 shares per bond
to establish a *delta neutral position.*

The neutral hedge ratio is the tangent to, and the slope of, the convertible bond valuation curve at a particular stock price. For infinitesimal moves up or down in the stock price from this initial level, a hedged portfolio consisting of long the convert and short the shares, as illustrated above, will result in neither a loss nor gain. For noninfinitesimal stock price change upwards, the gain arising from the long position in the convert will be lesser than the loss incurred due to the short position in the shares as the conversion premium declines.[35] In the event of a large move up, the ex-ante neutral hedged position turns out to be ex-post underhedged, and hence the loss. The reverse is true in a large down move in share price. In this case, decline in the convert price, all else being the same, will be lower than the gain on the short position in the shares as the conversion premium increases or "blows out". Viewed ex-post, the position was over-hedged. The main point to note is that a traditional convert is long an embedded equity call option and thus is a positive gamma security with respect to the underlying stock. On the other hand, like all callable fixed income instruments, it is also negatively convex with respect to interest rates.

35. Gamma is the second derivative of the convertible value with respect to parity, and is the rate of change of delta with respect to the share price is an important element in convertible trading. In times of high volatility such as what the markets have witnessed in recent years, gamma of each position, and its aggregation to the level of each trader's position and to the level of the firm, is an important risk measure of the entity's profit/loss potential. A positive gamma is always desirable and negative gamma "a Giffen good."

Stages of a Convertible Security

The price response of a convertible to a change in parity can be conceptually segmented into four stages or regions. These approximate regions are delineated in Exhibit 42–2. They are:

Balanced Converts

Several factors determine the conversion premium of a convert. Among the more important of these is the price response of a convert to changes in the underlying stock price and interest rates. Convertibles with conversion premium of 15% to 40%, and investment premium of 15% to 25%, respond materially to both. Their deltas range from roughly 55% to 75%.[36] Hence converts with these attributes, either upon issuance or subsequently as a result of stock price movements, are called *balanced convertibles*. Their upside/downside participation and risk/return tradeoff characteristics appeal to outright convertible funds and equity funds seeking a lower risk alternative or add-on position to common stock from an issuer with attractive equity fundamentals. All else being equal, lower the premium, more attractive the convertible from a buyer's perspective.

Equity Substitute Converts

The more the underlying stock price exceeds the fixed conversion price of a traditional convert, or, in the case of an accreting convert, the then effective conversion price, the deeper in-the-money is the convert. When such a convert's premium is about 15% or less, while its investment premium is higher than 40% it is referred to as being *equity like,* or as an *equity substitute*. It will respond sharply to changes in parity, and to a lesser extent to changes in the interest rates or interest spreads, and its delta is usually above 80% to 85%. Clearly, this movement is due to the investor put option to exchange the convert for its redemption price being now deep-out-of-the-money. While share price is the prime determinant of the value of a convert in this phase, it cannot be emphasized enough that other factors, such as remaining call protection and stock price volatility, also materially affect its value. The shorter (longer) the remaining call protection, the lower (higher) the conversion premium an investor would be willing to pay. Outright convert funds tend to sell the security at this stage in favor of other balanced converts while equity income funds tend to buy in this stage. Hedge funds' trading role increases along with stock price fluctuations, in what is known as *gamma trading*. With positive convexity feature of the convertible prominent at this stage, portfolio leverage and small net capital requirement due to the high delta, this stage of the convertible constitutes a potentially lucrative trading opportunity for hedge funds.

36. All else being the same, higher (lower) the credit-spread, lower (higher) the conversion premium. High bond floor makes the convert respond more to interest rates and less to equity.

Busted Converts

If the share price were to decline such that the conversion option were deep-out-of-the-money, and correspondingly, the put option deep-in-the-money, the conversion premium would increase while the investment premium would decline. The conversion premium in this stage is usually larger than 50% and may be as high as 200% or even higher, but investment premium is less than 15%. As the conversion option is worth very little, the convertible bond value approaches that of an otherwise equivalent nonconvertible bond. Its price falls to a level determined by the relevant yield measures. For traditional converts, those measures are the current yield and the yield to maturity. For the accreting converts they are the yield to put and/or yield to maturity. Outright convert funds exit their positions in these converts, to be replaced by fixed income funds seeking equity participation and hedge funds with credit analysis expertise. Credit risk may be offset by buying CDSs if they are available. In the absence of CDS on the particular issuer, proxy credit hedging methods include purchasing CDS of a similar credit in the same industry sector, shorting straight bonds of the issuer particularly if they are pari passu in seniority at a duration based hedge ratio, or buying equity puts or over-hedging by shorting more shares than suggested by the bond's equity delta. Some funds, though, may choose to retain exposure to the credit if their fundamental credit analysis or analytical models conclude that the risk/reward ratio is compelling, the yield give-up in exchange for the deep-out-of-the-money conversion option is relatively minor and, sometimes may even be negative, due to market inefficiencies in this region. However, fixed income funds that traditionally invest in senior or senior-subordinated bonds may not be reluctant to buy subordinated convertibles, nor do they generally buy busted convertible preferreds.

Distressed Converts

These converts may be considered a subset of the busted converts with the distinction that the stock price has fallen so far as to materially increase the probability of default. The ratings may be lowered either explicitly by the rating agencies or implicitly by the market as reflected in a substantial widening of its credit-spread or materially increased CDS premiums. Unlike the other stages in which the bond floor holds up reasonably well (see Exhibit 42–2) here the bond floor falls rapidly with the stock price. At this stage, the fixed income funds exit and *distress funds* or *vulture funds,* are the primary investors. These funds specialize in assessing the default probability and recovery rate estimation in the event of default. Both the conversion premium and the investment premium are very small to negligible in this stage. Interestingly, the gamma with respect to the stock price is extremely high as small changes in the low stock price may change the delta very significantly. Distressed funds may be long or short the convertibles based on the relative values of other senior or pari passu debt used as hedging instruments as well as depending on the availability and relative attractiveness of establishing deep-out-of-the-money protective put hedges.

Before leaving this section, some caveats are in order. First, the stages discussed do not have discrete boundaries. For instance, newly issued converts in Europe may have high conversion premiums but a low investment premium, and a delta in the region of 55% to 70%. This is due to the very high implied ratings of the investment grade converts resulting in a high bond floor. Second, convertible securities are not static, in that their price response changes and they may become more equity-like or debtlike with the attendant changes in the risk/return profile. Consequently, analytical tools for fundamental equity research as well as those for valuing fixed income securities and derivatives would be needed to select and manage a portfolio of convertible securities. Third, while the conversion premium is often used as a readily available measure to determine the current stage of the convertible, that is, whether it is a busted convert or in-the-money or something else, the more appropriate measure is the investment premium. For example, an in-the-money convert with extended period of remaining call protection, on a volatile, low dividend paying underlying stock can trade at substantial conversion premium. However, higher (lower) the investment premium, unambiguously more (less) in-the-money is the convert.

APPROACHES TO VALUATION OF CONVERTIBLES

In this segment, we discuss the traditional valuation method as well as the analytical—and more mathematically intensive modeling—approaches. The latter are increasingly more standard though it is not uncommon for investors to use both these approaches, to varying degrees to supplement each other.

Traditional Valuation Method

This approach is based on the premise that buying a convertible is the equivalent of buying common stock at a premium with the premium recouped over time from the difference between the higher income from the convertible coupon and the lower dividend on the underlying stock.[37] *Payback period* or break-even period is the principal metric employed in assessing the relative attractiveness of the convert versus the common stock. The shorter the payback period, the more attractive the convertible, especially if the payback period is shorter than the call protection period. As we shall see, the concept of payback period is flawed, yet this concept continues to be used by some equity-oriented investors as an adjunct to their fundamental analysis of the underlying stock. Unfortunately, this measure is not applicable to some of the newer structures, and may even prove misleading. Even within the traditional structures, most convertible new issues in the past decade would fail the payback period test. We will use the following example to explain the traditional valuation method.

37. Note the difference between this approach and the contingent claims approach, which views the convert as a combination of equity, a put option to exchange into straight debt, and the swap to receive coupons of the convertible for dividends on the underlying shares.

Consider a convertible bond issued at a par of $1,000 by PQR Corp. with 2.625% annual coupon and a five-year maturity that can be converted into 16.1421 shares of PQR common stock. Due to the appreciation of the stock price since its issue and the elapse of time—it now has about four years remaining to maturity—the bond currently trades at 121 (bond points, in percent of the par amount) and the common stock at $65.06. The common stock dividend has been, and is still, zero.

If an investor purchased one PQR convertible at 121 instead of buying the common shares equal to the conversion ratio of the note, she paid a premium of $159.75 (= $1,000 × 121 percent – $65.06 × 16.1421), or 15.975 bond points. However, this premium would be compensated for by the cash-flow differential between the convertible bond and the underlying shares:

$$\begin{aligned}&\text{Annual cash-flow differential}\\&= \text{Par amount} \times \text{coupon rate} - \text{Parity} \times \text{dividend yield}\\&= \$1{,}000 \times 2.625\% - \$1{,}050.25 \times 0\%\\&= \$26.25\end{aligned}$$

This implies that each year, the bond investor receives $26.25 more income than she would from dividends on the PQR common shares. Thus the payback period is:

$$\begin{aligned}&= \text{Premium paid/Annual cash-flow differential}\\&= \$159.75 / 26.25\\&= 6.09 \text{ years.}\end{aligned}$$

Simple derivation leads to the following formula for computing the cash-flow payback:[38]

$$\text{Cash-flow payback period} = [\text{Conversion Premium}/(1+ \text{Conversion Premium})]/ [\text{Current yield} - \{\text{Dividend yield}/(1+ \text{Conversion Premium})\}] \qquad (42.3)$$

where current yield refers to the current yield of the convertible. For the convertible the conversion premium was 15.211% and the current yield is 2.625% /121 = 2.169%, and the dividend yield on the common was zero. Using these inputs, Equation (42.3) results in the same payback period of 6.09 years. All inputs for the computation should be in decimals.

An alternate method of calculating payback period, though less defensible, is more commonly used. It is called the *dollar-for-dollar* payback. Under this method, the implicit question asked is, "If I were to invest the same dollar amount in buying the common shares as I would in buying the convertible, what would be the payback period of the premium?"

38. For convertibles with changing coupons or dividends, such as step-up convertibles, this formula does not apply. The payback period can be calculated by directly using the definition.

In the above example, if the same dollar amount were invested in PQR stock, one could buy $1,210/$65.06 = 18.5982 shares. The annual cash-flow differential would still be the same as before, as would the payback period under this method, on account of the fact that PQR pays no dividends. However, if the stock paid a significant dividend, the latter method would result in a longer payback period. The formula for this latter method can be derived as:

$$\text{Dollar-for-dollar payback} = [\text{Conversion Premium}/(1+\text{Conversion Premium})]/[\text{Current yield} - \text{Dividend yield}] \quad (42.4)$$

The denominator of Equation (42.4) is called the *yield advantage*. Note that the payback period of over six years is longer than the remaining maturity of the PQR convertible bond, which is about four years. Is this a valuation anomaly, or is the valuation approach lacking?

While the definitions of paybacks can be refined by using dividend growth rates and discounting the cash-flow streams, the basic flaw in the traditional valuation approach lies in its failure to consider the optionality embedded in the convert, i.e., in its assuming conversion into common stock with absolute certainty. In the case of the traditional convertible, bond investors have the right, but not the obligation, to convert should the stock price not exceed the conversion price, in which event they would receive par at maturity. And the meaning of payback period becomes even more problematic for accreting securities. For example, investors in zero-coupon convertible bonds do not receive current cash income. Thus, the convertible's income advantage would be zero or negative, and it's payback period could not be calculated. One may be tempted to substitute the yield to maturity or yield to the next put for the current yield. However, this again implicitly assumes a conversion probability of 100%, and excludes the possibility of default by the issuer.

Analytical Valuation Models

Virtually all valuation models for convertible securities currently in use by market professionals follow the economic framework of contingent claims analysis pioneered by Fischer Black, Myron Scholes, and Robert Merton.[39] The models differ from each other in the number of *stochastic variables* used in their construction.[40] The simpler one-factor model assumes that the stock price, or more correctly, the stock return, is the only underlying stochastic variable. All other items that impact on the value of a convertible are descriptors and variables.

39. See Fischer Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy*, May-June 1973, pp. 637–659; and Robert C. Merton, "Theory of Rational Option Pricing," *Bell Journal of Economics and Management Science*, Spring 1973, pp. 141–183.

40. A variable whose value changes over time in a nondeterministic or an uncertain way is said to follow a stochastic process.

The more complex two-factor models assume both stock returns and interest rates to be stochastic and are discussed below.

Descriptors and Variables That Affect Convertible Valuation

Descriptors are the attributes of a security that are known with certainty, such as its stated maturity, coupon, and call and put schedules. Variables are inputs that can be estimated, albeit with estimation error. Examples include future dividends and the costs involved in hedging the security. Descriptors that affect the value of a convertible security include:

- *Spot price of the underlying security:* The higher the stock price, the more the conversion option is likely to be in-the-money (or less out-of-the-money), and hence the higher the value of the convert.
- *The dividend yield of the underlying common stock:* The higher the dividend yield of the underlying stock, the lower the value of the convert as it results in a lesser yield advantage thereby reducing the attractiveness of the convert as an alternative to the common stock. Looked at another way, a higher dividend restrains the stock price appreciation and the convert's potential to go in-the-money. The same logic holds for the dividend growth rate. Most new issue converts have a dividend protection clause that compensates the investor in cash or decrease in the conversion price if the dividend payout on the common stock exceeds a prespecified level.
- *Coupon or preferred dividend:* The higher the distributions from the convert, the higher the yield advantage and hence the higher the value of the convert.
- *Issuer redemption:* A longer noncall period increases the value of the convert in two ways. First, the investor enjoys the yield advantage for a longer period. Second, absent a voluntary conversion by the investor, the minimum maturity of the conversion option equals the convert's first redemption date; hence the longer the conversion option, the higher the value of the convert. A hard noncall is worth more to the investor than a soft call of the same maturity.
- *Maturity:* Consider two converts identical in all respects except their maturity dates. The longer maturity convert will have the lower value. This may seem contradictory because we know that the longer the maturity of a call option, the higher will be its value. But while longer maturity does increase the value of the conversion option, it is swamped by the decrease in the value of the bond floor caused by discounting the cash-flow stream at a higher rate over a longer period. For deep-in-the-money converts, the direct impact of increasing rates is smaller because conversion value of the convert acts as the lower bound. However, if rate

increase impacts the stock price adversely, which is plausible, then the second order impact of rates on deep-in-the-money can also be negative.

- *Investor put:* Redemption at maturity is the equivalent of an investor put at maturity. A convert with a put prior to maturity will be worth more than one without. The earlier the put date, all else being equal, the higher the convert's value; also, the higher the put redemption level, also called the *put price,* the higher the convert's value.
- *Liquidity:* The more illiquid the convert, the lower the value of the convert as even moderate size trades are likely to materially change convert prices, causing sellers to realize less than they otherwise would and buyers to pay more. As seen during the 2007–2008 period, market illiquidity caused convert prices to fall quite dramatically as hedge funds needed to sell positions to meet client redemptions. Not surprisingly, the most liquid converts were the easiest to sell, although at discounted prices. Even though market volatility increased, the *implied volatility* of the convertible securities fell. In other words, the pricing curve of convertible in Exhibit 42–2 declined. Conversion premiums did "not open" or increase with declining stock prices—as would be expected under normal market conditions—during this period of illiquidity. Thus even positions held by better financially better situated funds and outright funds experienced mark-to-market looses. The notion of "illiquidity premium" became more relevant.
- *Borrow costs*: Increase in the cost to borrow stock effectively has the same impact as an increase in the dividend of the underlying stock. When the convert is illiquid and/or the stock borrow cost excessive, the convert may trade below parity, leading investors to voluntarily exercise their conversion option, which normally they would not. Outright investors are also affected as increased hedging costs to investment banks' trading desks are likely to result in wider bid/offers, smaller transaction sizes or accepting the outright investors' sell order on a "work the order," which entails the investor holding the position until another buyer is found and having to bear market exposure until the position is sold.
- *Country risk:* As with other non-domestic securities, country risk assessment needs to be balanced against economic growth potential in general, and that of the underlying stock in particular. Not surprisingly, therefore, there is generally less exposure to non-U.S. converts in most U.S.-based outright portfolios. International funds, specific regional funds, and hedge funds account for the bulk of the investment pool for non-U.S. converts as they they may have a wider array of securities to hedge currency risk as well as at least a part of the country risk. As a general rule, converts originating from countries with perceived higher country risk typically are issued at lower premiums, or equivalently, their equity volatility is not fully priced. On the other hand, converts from large

multinational firms, especially from the G-10 countries, are well received when the implied corporate credit rating is high and the country risk low.

Candidate stochastic variables used to model the value of a convert include:

- *Stock returns:* This is the most basic explanatory variable, and is part of all convertible valuation models. A single factor model assumes stock returns to be the sole stochastic variable and posits a behavior of stock returns and variance.[41] Not surprisingly, since volatility plays a crucial role in valuation of options, it does so too in the valuation of convertibles. Some models use a flat volatility as an input for all time and stock price levels, whereas the more sophisticated ones use a term structure of volatility, and yet others may also incorporate *option volatility skew* wherein the volatility estimate depends on the extent the option is away from the at-the-money strike at each stock price as the stock price evolves over time.
- *Interest rates:* Valuation models for bond options have interest rates as the main stochastic variable. Since the price dynamics of a convertible are also influenced to a considerable degree by the straight bond component and its convexities, it stands to reason that two-factor convertible models include interest rates as the second factor. Its volatility, called the *yield volatility,* is an estimated parameter, analogous to stock return volatility in the single factor model.

  As stated, higher interest rates reduce the value of the bond floor of a convert by discounting the convert's cash flows at the higher rate. The impact of interest rates on the embedded options is more complex. An increase (decrease) in the interest rate increases (decreases) the value of the conversion option, and the reverse for the option to put the convert, if there is an investor pre-maturity put feature. From the issuer's perspective, if the convert is out-of-the-money, higher (lower) interest rates will reduce (increase) the value of the issuer's call option, as it would entail financing the redemption value by new debt at a higher (lower) rate. In the case of in-the-money converts, which should in most cases be called as soon as possible, the issuer's incentive for a conversion-forcing call will increase with rising interest rates.
- *Credit-spread:* The lower the credit quality of the issuer, the higher the probability of default, and hence the higher the credit-spread. For example, a Baa3/BBB- rated issuer may have a credit-spread of 210 basis points for a five-year maturity subordinated debt. If the rating were a notch lower at Ba1/BB+, the spread could widen by a further

41. The common assumption is that the process governing stock price returns is a geometric Weiner process. Stock returns over time Δt are normally distributed with mean $\mu\Delta t$ and variance $\sigma^2\Delta t$, where μ and σ^2 are the instantaneous mean and variance of the stock price returns, respectively.

50 to 150 basis points or even wider.[42] Thus spreads impact on converts in the same direction as do interest rates. Credit-spread is increasingly viewed as a stochastic variable in its own right and its volatility is tracked very closely.[43] Development of liquid CDSs on individual corporate issues, standardization of swap languages, and liquidly traded index CDSs as well as asset swaps allow investors to hedge credit risk for a majority of investment grade issues and many non-investment grade issues. Credit-linked products are an exciting growth area for convertible investment and arbitrage trading as also in relative value capital structure and equity volatility trading.

- *Exchange rates:* Consider a US$ denominated bond—both par and coupon are US$ denominated—exchangeable into shares of a UK pound (GBP) denominated underlying stock. In addition to the equity risk associated with the investor's conversion option into the underlying ordinary shares, a U.S.-based investor is exposed to exchange rate risk because the shares are denominated in a different currency. With the number of shares per bond fixed, any increase in the value of the GBP against the US$ would benefit the investor, and any decline reduce the value of her position. Thus the investor thus has an embedded call on GBP, or equivalently, an embedded put on US$, in the convert.

Since exchange rates are stochastic, they could potentially be an additional factor in the valuation of a convert. Exchange rate volatility would have to be estimated.

Analytical Valuation Models and Factor Choices

Stand-alone analytical models to evaluate convertibles have developed far beyond the initial bond plus separable warrant approach and almost invariably draw on the contingent claims approach pioneered by Black, Scholes, and Merton. Early among them were those by Brennan and Schwartz[44] and Ingersoll.[45] The general approach is to develop a partial differential equation (pde) that applies to corporate securities and is based on the stochastic process or processes driving the return process for the underlying asset. Then boundary constraints relevant to the

42. The spreads could be even wider as the security, in this example, has crossed the threshold from being an investment-grade security to a non-investment-grade one.
43. The widening of credit-spreads globally, despite falling Treasury rates, during the Asian and Russian debt crises of the latter half of 1998 and the more recent global financial market illiquidity in 2007–2008 have further enhanced portfolio managers' sensitivity to credit-spreads.
44. Michael J. Brennan and Eduardo S. Schwartz, "Analyzing Convertible Bonds," *Journal of Financial and Quantitative Analysis* (1980) pp 907–929.
45. Jonathan E. Ingersoll, Jr., "A Contingent-Claims Valuation of Convertible Securities," *Journal of Financial Economics* (1977) pp. 289–322.

particular corporate security being valued, in this case the convertible, are applied to the pde. They include that the value of the convertible:

1. Be no less than its conversion value at any time except under the non-conversion period
2. Be the higher of par or the conversion value at maturity
3. Be no less than its "bond floor" or its recovery value upon default, whichever is lower
4. Be less than or equal to its redemption price during the redemption period for out-of-the-money convertibles
5. If putable, be higher than or equal to the put price discounted to the valuation date

Despite the appealing notion of viewing the convertible as a bond plus an added and separable option component—a view prescribed for accounting purposes by FASB—convertible bonds are more complicated as the options are often nonseparable except in the simple case of convertibles nonredeemable and nonconvertible until maturity, i.e., the issuer and investor options are all of the European type. Also distinguishing convertibles from a bond plus warrant is that an American-style conversion adds an interest rate option in favor of the convertible investor whereby the investor can turn in the convertible bond to satisfy the exercise price, even if the bond component is worth less than the exercise price, which usually equals the bond's par value. This *usable bond feature* of the convert is absent in a bond plus warrant. In the event of exercise prior to maturity, the warrant exercise price is payable in cash and equals the par value, never anything less.

Clearly, convertibles are complex securities. In the presence of the boundary constraints mentioned above, its pde does not lead to a closed form solution and instead requires computationally intensive numerical methods. Implicit finite-difference method and explicit finite-difference method are the commonly used finite difference approaches.[46] A special case of the explicit finite-difference method is the binomial method, by far the most widely used approach for derivative valuations. The computational load increases exponentially with each additional stochastic variable included in the valuation model. In the language of the binomial tree approach, the binomial tree becomes "very bushy" very quickly. Consequently, even in nonconvertible bond option modeling in which the interest rates for short maturity and long maturity are two eminently logical stochastic variables, most practitioners employ a single factor model for the short rate and assume the evolution of the long rate in relation to the short rate. The inclusion or exclusion of a stochastic variable, therefore, involves a tradeoff between theoretical elegance and/or incremental gain in accuracy on the one hand, and com-

46. There are Taylor series approximations for partial derivatives in partial differential equations. While the implicit finite-difference has better stability properties than does the explicit finite-difference approach, it is computationally more time consuming; explicit finite-difference method is more flexible and more easily understood.

putational costs and complexity on the other. Almost invariably, when input estimation errors are likely to swamp the computational precision achieved through the inclusion of an additional stochastic variable, investors spend more effort in improving the input estimates and opting for a simpler model.

Needless to say, the theoretical value of a security will be a function of the particular pde chosen, In the case of convertible valuation, a single factor model with the underlying stock return as the stochastic factor is most commonly used in practice due to the frequency and accurate recording of trading in common stock. In these cases, the interest rate and credit-spreads are assumed to be input parameters. Many models make adjustments—either heuristic or market-calibration based—to compensate for the attributes of stochastic interest rate lost in a single factor model. That said, two-factor models, with interest rates as the second factor, are gaining in popularity.

Virtually all models sacrifice the candidates for a third and/or fourth factor in favor of computational ease. For example, to avoid considering each of these as a separate stochastic variable, resulting in exponentially increasing computational expense and are excessively time-consuming (to the point of making them impractical), credit-spreads may be bundled together with interest rates, and the two together are assumed to follow a stochastic process. Analogously, the impact of exchange rates on a convertible with two currencies is similarly addressed by creating a synthetic price series comprising the underlying stock price, say denominated in GBP, multiplied by the exchange rate of dollars per GBP each day, and estimating the volatility of the price series thus generated in US$. As a proxy for the term structure of volatility of stock price returns, volatility is estimated by applying subjective corrections to historical and implied volatilities, and the estimate is assumed to be constant over the life of the security; in other words, a flat volatility is assumed. That said, use of volatility surfaces is not uncommon in assessing volatility arbitrage opportunities across related securities.

The theoretical elegance of a single valuation model that is based on the value of the firm as the underlying asset thereby resulting in a consistent paradigm to value all corporate securities—bonds, stocks, options and all other derivatives being special cases—is widely recognized. Despite that, separate and individual valuation models for each of the securities and assets of the capital structure continue to be the norm despite often inherent inconsistencies in their underlying assumptions. Chief among them is that the value of a firm is not a traded asset. Consequently, price observations are rarely, if ever, available, and their distributional properties cannot be empirically established. The complexities of the individual securities, and their correlations with each other, necessitate assumptions that are not always palatable. Nonetheless, progress has been made in modeling corporate securities as options on the value of the firm and some of these are available commercially.[47]

47. CreditGrades and Moody's KMV are two such models. One might arguably say that during the financial crisis of 2007–2008 these models did not fare well; the primary reason being that the estimates of future correlations based on historical estimates did not hold as realized correlations far exceeded estimated correlations.

Space considerations do not permit us to describe the details of the construction of the binomial tree and the backward induction.[48] Additionally, there are several "off-the-shelf" convertible valuation models available in the market. Not surprisingly, therefore, most trading desks subscribe to one or more of these models[49] and focus their attention on estimating the input parameters to these models. There is the unstated assumption that the technology of the model construction among the market competitors results in valuation outcomes within acceptable bounds of each other, given a common set of input parameter values.

Exhibit 42–3 displays the front page of one of such commercially available models, KYNEX convertible model.

EXHIBIT 42–3

A Convertible Analytics Model: Sample Page

48. Interested readers are referred to Kevin B. Connolly, *Pricing Convertible Bonds*. Hoboken, NJ: John Wiley & Sons (1998).

49. These models may also be available as part of a subscription service, such as Bloomberg, or available gratis from brokerage houses as client service provided with the expectation of trade execution through them.

Rates, Credit-Spreads, and Volatility Revisited

Since traders and portfolio managers are generally not the developers of the models, the nuances of the models need to be understood. This segment highlights issues, adaptations, and/or variations with respect to interest rates, credit-spreads, and volatility estimates deployed in the model development as they materially affect the value of the convert and the resulting trading/hedging recommendations.

Interest Rate

The interest rate input for each node of the binomial tree, used to solve the pde, is obtained from the derived zero coupon yield-curve from on-the-run Treasury securities or the LIBOR curve, with the latter being more frequently used as the benchmark rate. Some models may use a flat term structure. A flat credit-spread is also commonly used, though a term structure of credit-spreads based on CDS curves may be used to arrive at the credit-spreads, although there may not be as many data points to create the CDS curve.

Several models use a single interest rate adding together the (LIBOR) benchmark rate as well as the spread. This makes the resulting models more analytically tractable and the results conform to the put-call parity theorem. However, there is a problem. Consider a convertible that is separable into a bond and a warrant. Using a single interest rate, equal to the Treasury plus the applicable spread in valuing this convertible implies that both the bond component and the warrant component are discounted at the same rate. Warrants and options, however, when traded separately, do not use the credit-spread in their valuations because the risk neutral valuation approach of derivatives is independent of the default risk of the underlying stock. When the single rate is used, it tends to overvalue the embedded net conversion option. To achieve consistency with the option markets, the benchmark rate alone is used for the optionality and the benchmark rate plus the spread for the coupons and par. In practice, the short equity position in a hedged portfolio earns the short term riskless rate and not the benchmark rate plus the spread rate used to discount the cash flows of the convertible. Note that the put-call parity attribute is then lost.

A further modification of the two interest rates is to use a hedge ratio weighted mix of the benchmark rate and the benchmark rate plus the credit-spread. If the convert is deep-out-of-the-money, the probability of conversion is very low and the convert behaves like straight debt; its delta equals zero. Hence all cash flows associated with the convert are discounted at the benchmark rate plus the credit-spread. At the other extreme, when the convert is deep-in-the-money, the probability of conversion is very high and the convert behaves like a common stock; its delta equals 1. With a 100% hedge, the probability of loss vanishes and the portfolio should earn the benchmark rate. At intermediate points, the weighted average rate, weighted by the delta at the node, is employed.

Credit-Spread

The ideal input to the model is an *option-adjusted spread* applicable to the security. However, this information is seldom available. Due to the rapid and still growing importance and liquidity of CDSs, they have become the prime

input proxy source for credit-spread estimation. In addition to variations mentioned above, some models allow users to parameterize the credit-spread as a function of the stock price level. The logic is that as stock price rises (falls), its debt to equity ratio falls (rises), and hence the credit-spread should decline (increase) correspondingly. However, the speed and process of the corporate credit-spread adjustment to the stock price change is yet unknown and may evolve at different paces for different securities and times. Hence this adaptation, although elegant, is to be used with caution and largely for risk scenario assessments.

Stock Volatility

In any contingent claim model, an estimate of the future volatility likely to occur during the life of the contingent claim security is the required input. Volatility estimation is even more critical for the very long dated options embedded in converts. Among the sources to estimate this parameter are:

1. Historical volatility for periods ranging from 1 month to 12 months, and their trend.
2. The implied volatility trends for listed options and *LEAP*s and index options with maturities longer than 9 months. Particular attention is paid to the *implied volatility skew*.
3. The implied volatility of existing converts from the same issuer.
4. The implied volatility of converts in the sector.
5. Volatility implied in the pricing of CDS of the issuer (or close proxies) matching the first put date or maturity of the convertible.

A downward adjustment is warranted to the resulting estimate if the common stock and/or convert are not likely to be liquid; very high volatility estimates, above 40%, are usually capped in anticipation of volatility mean reversion.[50]

Applying the Valuation Model

The most common application of the valuation models, not surprisingly, is to estimate the theoretical worth of a security at any point in time. If the theoretical value is, say, 104.5, and the security is trading at par, it is said to be 4.5% cheap. Other equivalent ways to view this cheapness or richness is through the implied

50. A more elaborate method for estimating volatility is the generalized autoregressive conditional heteroskedasticity (GARCH) approach, which gives progressively increasing weight to more recent observations of volatility. The weighting scheme is defined by an estimated decay parameter, analogous to the mean reversion parameter in interest rate models. See Tim Bollerslev, "Generalized Autoregressive Conditional Heteroskedasticity," *Journal of Econometrics,* 1986, pp. 307–327.

volatility or the implied credit-spread or the implied option adjusted spread. This cheapness/richness estimate depends, of course, on the inputs and the particular valuation model employed. A valuation model will need to be calibrated periodically against market prices of liquid converts to catalog its biases. After this initial calibration, most practitioners are more concerned with the consistency of the model than with its absolute accuracy. The trading task is made easier when the model also provides scenario analyses—for varying input parameters of holding period horizon, rates, spread, volatility, changing richness/cheapness from current situations—and also built in portfolio management, risk analytics, and trade execution systems. Most analytical trading models provide for these features, including the one cited above.

Theoretical rich/cheap analysis is but one of the inputs to determine whether a convertible is a buy or a sell candidate. Additionally, its relative attractiveness compared with other available opportunities, its risk/expected return profile and its contribution to the portfolio as a whole also need to be considered. We discuss some of analytical items among these next.

Partial Derivatives

The partial derivatives commonly used in monitoring equity and bond derivative risk/reward profiles are also applicable here. Briefly, in addition to the hedge ratio or delta, the other partial derivatives, collectively called the *greeks,* one needs to pay attention to are:

- *Theta:* The time decay of the value of the options embedded in the convertible, especially for its short maturity options, such as during the *redemption notice period*[51] or close to the mandatory conversion date or maturity.
- *Vega:* High volatility underlying shares, such as those in the Internet, technology, and telecommunication sectors carry the risk of volatility collapse, more specifically, collapse of implied volatility. Illiquidity driven implied volatility collapse devastates the premium and the value of convertibles. This has occurred episodically such as during 1994, the Asian, Russian, and emerging market crises of 1998, in 2005 in the U.S. and, most painfully globally, in 2007–2008. Vega estimates for a position or portfolio's potential profit/loss exposure to sudden large moves are common in risk reports. Most non-directional hedge funds hedge their Vega exposure.
- *Gamma:* This measure of convexity or rate of change of delta is a very closely watched second derivative and deserves elaboration. A negative

51. The redemption notice period is the prespecified number of days, usually, 15 to 30 days, following the redemption notice by the issuer, during which period the holder needs to exercise the conversion option, failing which the holder is deemed to have opted for the redemption amount.

gamma position resulting from short option positions such as writing a put or writing a call, or shorting a convertible, can quickly cause significant losses in the event of large up moves in the underlying. A long position in a deep-in-the-money convertible that is delta hedged by a short stock position, on the other hand, is a positive convexity position due to its equivalence to a long put position. However, a long convertible bond, unless credit hedged by long CDS position, is equivalent to a short credit convexity or credit gamma as the investor is exposed to the credit risk of the bond. The concepts of credit duration or credit delta, credit gamma, and credit volatility are now integral parts of the risk metrics that guide convertible trading and capital structure arbitrage.

- *Rho:* This measures the change in the value of the convert due to a small change in the interest rate and credit-spread. As the volatility of interest rates or *yield volatility* has increased, traders and investors need to be aware of the interest rate duration and negative convexity embedded in the convertible and deliberate decisions need to be made about retaining or hedging away these risks via interest rate futures or options. *Credit-spread delta,* or simply, *credit delta* is an important trading and risk metric to monitor and separate interest rate risk from the credit risk of the position.
- *Cross partials:* These are second order, although important, risk elements. We discussed the impact of a change in stock price on the credit-spread of the bond; the other is on equity volatility skew. Estimating these is still an art with no easy solutions.

Implied Default Probability and Implied Recovery Rates

An investor can hedge the credit risk of a convertible (or straight bond) via an appropriate long CDSs position with the bond as the reference security. Asset swaps, on the other hand, are used to hedge both the rate risk of the coupon payments as well as the credit risk of the bond. Implied in the pricing of the CDSs and asset swaps are estimates of default probability and asset recovery rates in the event of default.

Implied Volatility and Implied Credit-Spread

From the investor's relative value analysis perspective, higher (lower) the implied volatility of the convert compared to the historical volatility of the underlying stock, richer (cheaper) is the security. Similarly for credit-spread implied by convertibles are compared with those of comparable converts and straight bonds.

While metrics regarding implied volatility, credit-spread, default probability and recovery rates are useful, some caution is in order regarding their interpretations. First, estimates of "the implieds" are conditioned on the validity of all

inputs into the model and the valuation model itself and are not to be thought of as "absolute estimates." Furthermore, there is an element of circularity in sequentially estimating them using the same set of inputs. Second, it is well known that the value of a convertible is most sensitive to volatility when the convert is near the money, and to credit-spread when deep-out-of-the-money; it is less sensitive to either when deep-in-the-money. Misleading implied volatility estimates/conclusions may result if one is not mindful of, or control for, the skews or maturities of the embedded options.

EXERCISING THE EMBEDDED OPTIONS

In this section, we discuss the decisions facing investors and issuers with respect to the options embedded in the convert. Clearly, there are some game-theoretic aspects to the anticipatory or responsive actions taken by the two parties.

Investors' Options

Conversion Option

With the conversion privilege terminating at the expiration of the redemption notice period, the question is when during this period should the investor tender the bond for conversion, assuming that it is in-the-money. Following the redemption notice, if the stock price falls below the effective per share redemption price,[52] the investor can choose to receive the redemption price. Thus, the redemption notice triggers a knock-in put, with maturity equal to the number of days in the redemption notice period. Due to the embedded long American conversion call option, under normal circumstances premature exercise is suboptimal when the underlying stock does not pay any common dividend. For dividend paying underlying stock, premature exercise of an American call is warranted when the present value of the dividend stream during the life of the call exceeds the present value of interest likely to be earned on the exercise price. This roughly implies that voluntary conversion of a convertible is rational when the dividend yield on the common exceeds the current yield on the convert, and the yield advantage becomes negative.[53] These situations seldom arise.

Therefore, by deferring the decision to exercise either option until the moment before the expiration of the redemption period it will be evident whether

52. Effective conversion price is defined as the redemption price divided by the conversion ratio. For example, if the bond is redeemable at 103.5 and the conversion ratio is 14.865 shares, the effective conversion price is \$1035/14.865 shares = \$69.627 per share, although the conversion price is \$1000/14.865 shares = 67.272 per share. In the case of accreting securities, it is the accreted price divided by the conversion ratio.

53. We say "roughly" because some converts on high dividend yielding stocks have been issued with negative yield advantage. Investors correctly view them as equity with very valuable puts, and hence, as very defensive securities.

the conversion option is worth more or the redemption option and choose accordingly. Investors who elect to sell their convert during the redemption notice period can find ready buyers among convertible arbitrage funds who will usually pay some value for the remaining optionality, less their transaction cost. Occasionally, voluntary conversion may occur when the stock borrow cost is very large, and thus has the same effect as a negative yield advantage. The voting right of a common share will rarely be the reason to voluntarily terminate the life of the convert and receive the shares.

Finally, absent a redemption notice, premature conversion may be rational if the underlying price exceeds the *critical stock price*. That price level of a dividend-paying stock at which the yield advantage for the convert is negative, and the value of the put option exactly equals the absolute value (of the now negative value) of the swap to receive the coupon in place of dividends, is called the critical stock price. At this point, conversion premium is zero, making the investor indifferent between holding the convert or receiving common stock upon conversion. Higher the dividend yield, lower the critical stock price. For most stocks, this point is approximately at 175% of the conversion price.[54]

Put Option

Exercise of a putable convert is rational if the estimated value of the convert immediately following the next put date is lower than the put price. Some issuers want to know the scenarios under which the convert will be put to them, and this can be an important consideration in their choice of financing instrument. With a view to defer put exercise, an issuer may, voluntarily and unilaterally, insert an additional put, at an appropriate price, immediately following the next put in the existing put schedule of the convert. This is called a *put extension sweetener*.

Change of Control Put Option

Most converts include an investor put at par, or slightly above par, in the event that a specified percent, usually 51%, of the shares of the underlying stock is acquired by another entity. The put price is payable in cash and has the deterrent effect of a poison pill, particularly if the convert is out-of-the-money. For those trading above the put price, the put exercise results in the loss of the conversion premium in excess of the put price, and the convert is terminated. Quite often, the acquirer's common stock will replace the target firm's common shares according to a specified exchange ratio. This will preserve the conversion option and some, or all, of the conversion premium. The decision rule for investors, as always, is to choose the value-maximizing alternative. Depending on the circumstances, value maximization may or may not entail exercising the change of control put and especially so if the convertible structure includes a *takeover protection clause* that makes the investor whole in the event of a change of control event.

54. This may explain why following a hard noncall period, a year of provisional call protection at 175% or higher is roughly worth equal to another year of hard call protection.

Issuer's Options

The optimal issuer action is to minimize the gain of the convert investor and maximize the benefit to the shareholder. Conceptually, in the absence of the redemption notice period, the optimal redemption moment is exactly when parity equals the redemption price. Since the redemption notice period does exist, the optimal decision, and its timing, becomes a function of the issuer's intent and of whether the convert is in-the-money and by how much. If the issuer is indifferent to whether the issue converts or is redeemed for cash, then the issuer's optimal decision will be to redeem at the earliest opportunity. This situation occurs when the convert constitutes an insignificant component of a large firm's balance sheet and/or refinancing is readily available at lower net costs. The most common issuer options are:

- *Conversion forcing redemption:* The benefits to the shareholder of forcing conversion include saving the interest expense, lower leverage, and an increase in debt capacity due to the additional equity in the balance sheet resulting from the conversion. If the after tax cost of the coupon on the convertible is lower than the dividend yield, or in the case of accreting converts, if the after tax cash flow is positive to the issuer, the issuer may choose to defer redemption. Given the redemption notice period, the issuer needs to allow for a margin of safety such that the probability of the stock's falling below the effective conversion price is at an acceptable level. The greater the risk aversion of the issuer to the adverse effects of nonconversion, the higher will be the cushion, and results in what is known as the *call delay*. The negative impact of a failed attempt at forcing conversion may be severe; and in smaller firms it may lead to financial distress. At the very least, the issuer will have to refinance the redemption value with cash or debt and thereby cause the capital structure to be different than intended. Alternately, the issuer may have to pay—a usually unwilling—investment bank to write a put guaranteeing conversion. Such puts are difficult to hedge and banks are therefore reluctant to sell them. Even if they do so as a favor to the client, these puts are expensive due to the large gamma and event risk. Greater the call delay, higher the value of the convert. Call delays have declined over time and are currently in the 15% to 30% region today, and are a function of the volatility of the underlying stock, the length of the redemption notice period, and the issuer's risk aversion.[55]

55. Specifically, it is equal to $\sigma\sqrt{t}$, where σ is the stock's volatility estimate for the period, and t is the length in years of the redemption notice period. As a numerical illustration, if t is one month, the short term volatility estimate is 0.30 per annum, and absent any jumps, the stock is expected to move $0.30 \times \sqrt{(1/12)} = 0.866$, that is, ±8.66% in one month with a probability of 68%. The two standard deviation, or equivalently, a 95% confidence interval implies a call delay of $2 \times 8.66 = 17.32\%$ above the effective conversion price, assuming a log-normal return distribution for the stock price.

- *Debt refinancing redemption:* If the issuer does not want conversion to occur, the logic of the call delay also applies here, except that now the stock price has to be below the effective redemption price so as to provide the desired cushion. The issuer's reasons for redeeming the convert for debt may include reduction in equity dilution, refinancing at a lower rate and/or extending maturity. The cost of debt of matching seniority and maturity is the appropriate benchmark from a cost of capital perspective.
- *Put extension sweetener and co-pays:* As discussed, in situations in which it is economically optimal for investors to exercise a put option but the issuer does not want the put exercised, put extension sweeteners are used. In addition knock-in payments may also be used.
- *Issuer buybacks:* Often illiquid or deep-out-of-the-money convertibles or convertibles with heavy carry costs (dividends and cost of stock borrow) are presented to the issuer by hedge funds interested in selling the bonds back to the issuer in exchange for a sweetener to where the bonds may be trading or are marked. By buying these bonds back in one-off transactions and mindful not to trigger a "creeping tender" violation of SEC regulations, the issuer can lower his debt/equity ratio as well as recognize a gain for buying the bond back under par. Typically, the sweetener can range from half a bond point to three bond points above the estimated value or mark of the convertible and is paid in either cash or equivalent increased number of shares as agreed upon by the two parties.

LOOKING FORWARD

Despite the growth trajectory of the convertible asset class there have been hiccups along the way making many investors uncomfortable with its complexity and periods of illiquidity. Analytical and structural diversity as well as its market efficiency have been aided by a leading, if not a dominant role from time to time, by hedge funds and institutional investors. With hedge funds being the most active traders in convertible secondary markets, it is easy to view them as the marginal trader that drives pricing. What then are the risk/return and funds flow implications on the convertible asset class of hedge funds and of the development of risk mitigating products such as asset swaps and credit default swaps?

Hedge Funds

Issuers generally dislike, but are gradually getting used to, this class of investors as they are seen to exert downward pressure on the stock when they buy the convert and short the stock. And the number of shares shorted increase as the stock price increases. However, the point often overlooked is that hedge funds also support the stock were it to decline. In this event, they would buy back the stock to

reduce their hedge ratio and arrive at a lower neutral hedge position. The structured convertible, described above, is a strong case in point. Thus hedge funds contribute to volatility stabilization of the underlying share. Imagine a situation in which shorting the stock were not permitted, as was periodically enacted in different countries during the 2007–2008 crisis period. With these sudden proscriptions of short-sales, there was an immediate drop and severe disruption in the markets, broadly and even deeper for convert products. The liquidity providing role of hedge funds was immediately reversed and they became liquidity seekers who needed to raise cash in light of fund redemptions by their own fund investors. Only when the short-sale restrictions were removed and liquidity returned to the market did convertibles rebound in 2009 and new issuance began to take off as issues again accessed this asset class.

Empirical research documents a 2% to 3% decline in the underlying shares upon conversion of a convertible security, and this decline typically reverses itself in the following two to four weeks. This may largely be due to the short positions in the underlying by hedge funds against their positions in deep-in-the-money converts. In effect, the associated hedging is equivalent to preconverting over time so that the single day rush to the exits that would have otherwise occurred does not occur. Furthermore, over the recent years, the fund flows into hedge funds have helped issuers sell new issues via overnight transactions, thereby eliminating the market exposure that otherwise would have to be borne by the issuer due to the time-consuming customary road shows for a new issue transaction.

Asset Swaps

In a convertible security asset swap transaction a fixed income fund or a financial institution takes on the interest rate and credit risks embedded in the convert while the convertible holder, typically a bank trading desk or hedge fund, retains the equity optionality. Most common are the callable asset swaps on the underlying convert with a back-to-back redemption wherein if the issuer redeems the convert the trading desk may redeem the convert from the asset swap buyer. Until then the cash flows of the convert are passed through to the asset swap counterparty while the convert holder retains the equity optionality. This separation of the fixed income risk from the equity optionality of the convert makes the market more efficient by segmenting the elements of risk and trading in them by participants specializing in assuming and valuing these risks. It also helps provide liquidity to the busted converts, subject to credit quality constraints, and to new issue investment grade converts, which may be larger as a result. As the growth of the CDS product continues, however, asset swaps as applied to convertibles is expected to continue to decline.

Credit Default Swaps

The development of CDSs has helped bring ever closer corporate debt and equity liabilities trading via the "bridge products" such as convertibles. Capital structure

arbitrage is one such outcome. Already, in several leading investment banks, credit derivative desks are either integrated with, or are physically located in proximity of, convertible trading desks. Equity derivative desks are also similarly situated. Integrated approaches to valuing corporate liabilities is an exciting development phase and should result in creation of newer derivative products with the aim of isolating in even finer granularity the embedded risks in the securities and allowing a portfolio manager to make deliberate choices of retaining or hedging away some of these risks thereby resulting in more efficient and liquid markets.

Growth Markets and Distressed Markets

As discussed earlier, convertible issuance and asset class growth is most conducive when accompanied by growing economies and sectors. It is not surprising, therefore, to evidence more convertible issuance, albeit from a small base, from the more rapidly growing global economies of Asia and elsewhere while the U.S., the developed Western-European economies, and Japan remain the mainstays—despite their slower economic growth—due to their developed financial markets. But, in time, this balance too is expected to change. The versatility, range and usefulness of the convertible product was demonstrated that on the one hand when it was used to stabilize the balance sheet of distressed companies, as in the case of Citicorp mandatory at the depth of its crisis period, and on the other as growth stage financing for SanDisk in 2010. This flexibility too is expected to continue and develop further.

KEY POINTS

- Convertibles are fairly complex securities with several interwoven embedded options.
- They span the space between equity and debt securities. As a result, innovative flexible structures have evolved to address issuer and investor needs and also to address regulatory, accounting, and tax considerations. This flexibility will continue to ensure its presence as an important security in the corporate capital structure.
- To understand their nuances, tradeoffs and values, traditional methods of evaluation, in conjunction with the contingent claim valuation approach, need to be employed.
- In practice, both approaches are employed together with the fundamental equity and credit analysis of the underlying equity and debt for trading, hedging, portfolio and risk management of these equity-linked securities.
- Convertibles issuance is more attractive in high interest rate environments or when other modes of financing, such as bank financing, debt, or equity are either difficult or undesirable.

- While a majority of the convertible issues are noninvestment grade or unrated, they still constitute a meaningful avenue for capital raising by investment grade issuers and are capable of financing multibillion-dollar issues without extra effort.
- Convertibles are a much smaller asset class than equities and debt and their issuance volumes and trading are quite sensitive to market liquidity. And yet, when severe balance sheet repair is needed, the convertible market remains an attractive avenue to explore.

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PART

SIX

CREDIT RISK

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CHAPTER
FORTY-THREE

CREDIT ANALYSIS FOR CORPORATE BONDS

MARTIN FRIDSON, CFA
Global Credit Strategist
BNP Paribas Asset Management

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

ADAM B. COHEN, J.D.
Founder
Covenant Review

The purpose of this chapter is to provide a framework for the credit analysis of corporate bonds. Although there are numerous types of corporate bonds outstanding, three major issuing segments can be differentiated: industrials, utilities, and finance companies. This chapter will deal primarily with industrials in its general description of bond analysis and then discuss utility and finance issues. Special factors that must be considered in the credit analysis of high-yield corporate issues are addressed. At the end of this chapter, credit scoring models for identifying potential issuers that may default are described.

APPROACHES TO CREDIT ANALYSIS

Traditionally, credit analysis for corporate bonds has focused almost exclusively on the default risk of the bond—the chance that the bondholder will not receive the scheduled interest payments or principal at maturity. This one-dimensional analysis concerned itself primarily with the calculation of a series of ratios historically associated with fixed income investment. These ratios typically would include fixed charge coverage, leverage, and funds flow/total debt. Such an approach was deemed appropriate when interest rates were stable and investors purchased bonds with the purpose of holding them to maturity. Under those conditions, fluctuations in the market value of the bonds owing to interest-rate changes were minimal, and fluctuations owing to credit changes of the bond

Parts of this chapter are based on the chapter by Jane Tripp Howe that appeared in previous editions of this handbook.

issuer were mitigated by the fact that the investor had no intention of selling the bond before maturity. During the past four decades, however, the purpose of buying bonds has changed dramatically. Investors still purchase bonds for security and thereby forgo the higher expected return of other assets such as common stock. Increasingly, however, investors buy bonds to trade them actively with the purpose of making a profit on changes in interest rates or in absolute or relative credit quality. The second dimension of corporate bond credit analysis addresses the latter purpose of buying a bond. What is the likelihood of a change in credit quality that will affect the price of the bond? This second dimension deals primarily with ratios and profitability trends, such as return on equity, operating margins, and asset turnover, generally associated with common stock analysis. Both dimensions should be applied in corporate bond analysis because they address the same issue—default or credit risk–from complementary perspectives. Only by using both dimensions of credit analysis will the analyst address the dual purpose of bondholding: security of interest and principal payments and stability or reduction in credit risk during the life of the bond.

Another outgrowth of the shift from buy-and-hold strategies to active bond management is a premium on prompt responses to news that affects a company's ability to generate cash flow to cover its interest charges. A sudden leap or plunge in stock price may reflect significant new information about a company's future profitability that the bond market does not yet reflect. By taking a clue from the equity market, an astute investor may get a jump on competitors in catching an upswing or avoiding a downswing in the issuer's bonds.

Beyond this sort of reactive approach, bond investors can use equity-based information to conduct systematic and potentially profitable analysis. The idea that stock analysis and bond analysis are intertwined has been advanced by the development of options analysis.[1] Underlying this line of reasoning is the basic insight that all of a company's liabilities derive their value from the same set of cash flows. This suggests that the intrinsic value of the equity must be consistent with the intrinsic value of the debt. (Note that the equity value referred to here is economic value, rather than the accounting value represented on the balance sheet by shareholders' equity.)

The ability to derive analytical benefits from these insights springs from the expectation that the company's owners will cease paying interest, that is, default on their debt, if the value of their equity drops to zero. This rational response is analogous to homeowners whose mortgages exceed the value of their houses "mailing the keys to the bank" instead of continuing to make interest payments. It follows that the bigger the equity cushion beneath bondholders, the more remote is the probability of default.

Exhibit 43–1 supports the argument that a large equity cushion, as measured by the company's valuation in the stock market, implies a small likelihood of default. The table ranks 22 U.S. investment-grade chemical companies by the ratio of market value of equity to total liabilities (MV/TL). A relationship between

1. Credit risk models, discussed in Chapter 45, are referred to as "structural models," "asset-value models," and "firm-value models."

EXHIBIT 43–1

Stock-Based Credit Comparison of Investment-Grade Chemical Companies

Name	Mkt Val/TL	Rating
Mosaic Co.	8.54	BBB-
Sigma-Aldrich Corporation	7.86	A
Monsanto Co.	4.81	A+
Ecolab Inc.	3.88	A
Albemarle Corp.	3.26	BBB
Praxair Inc.	3.25	A
The Sherwin-Williams Company	3.19	A
FMC Corp.	2.81	BBB+
Lubrizol Corporation	2.59	BBB+
Westlake Chemical Corp.	2.48	BBB–
Air Products & Chemicals Inc.	2.45	A
International Flavors & Fragrances Inc.	2.37	BBB
HB Fuller Co.	1.97	BBB
Airgas Inc.	1.94	BBB
Cabot Corp.	1.55	BBB+
Eastman Chemical Co.	1.52	BBB
The Valspar Corporation	1.50	BBB
RPM International Inc.	1.48	BBB–
EI DuPont de Nemours & Co.	1.47	A
Cytec Industries Inc.	1.31	BBB
PPG Industries Inc.	1.31	BBB+
The Dow Chemical Company	0.87	BBB–

Constructed from data obtained from Capital IQ.

the equity valuations and the corresponding bond ratings is apparent. The top half of the rankings includes six of the seven companies (86%) rated within the single-A category. The bottom half includes 10 of the 14 companies (71%) that are rated within the triple-B category.

The alignment is by no means perfect, however. Most strikingly, Mosaic has the highest MV/TL ratio in the group (8.54×) and the lowest rating (BBB–), whereas DuPont ranks 19th in MV/TL, yet has the second highest rating (A). Anomalies of this sort may help to identify a bond that is misrated, perhaps because the rating agencies have not yet fully responded to changes that the equity market has incorporated into the company's share price. Indeed, Mosaic rose from BB to BBB–at Standard & Poor's between October 2004 and

June 2008. That left the rating one step lower than Moody's equivalent Baa2, which Mosaic reached in August 2009 following a long climb from B1 in November 2006. Perhaps the rating agencies were being more deliberate than the equity market in recognizing a genuine reduction in default risk at the company.

Drawing a definitive conclusion, however, requires more than a simple comparison of a company's credit rating and stock valuation. Other factors could explain the ratings disparity between Mosaic and DuPont. For one thing, potash and phosphate producer Mosaic has a much less diversified product line than DuPont, and its earnings are highly sensitive to volatile commodity prices. In addition, Mosaic's stock price shot up dramatically in 2010 after an attempted takeover of Potash Corp. by BHP Billiton focused investors' attention on the value of potash reserves. This effect could have proved temporary. A long-run view of default risk might favor DuPont, despite the near-term restraint on its earnings imposed by a slow economic recovery in 2010.

More generally, the probability of default is a function not only of the equity cushion's size, but also its volatility. A company with a comparatively small equity cushion may receive a fairly high rating if its stock price is exceptionally stable. An extremely steady share price makes the company's equity value very unlikely to fall to zero and trigger a default.

A final caveat on the interpretation of equity valuations in the context of credit analysis is that under certain circumstances an increase in the equity cushion can indicate *increased* risk of default. The ultimate effect of a leveraged buyout (LBO) is that a substantial portion of the equity in the company's capital structure is replaced by debt, resulting in substantially heightened credit risk. For example, SunGard Data Systems fell from BBB+ to B+ at Standard & Poor's in connection with its 2005 LBO. To effect the transaction, however, the LBO sponsor must pay a premium to prevailing market value to acquire the stock from the existing shareholders. Sometimes, word of the pending LBO leaks into the market before the deal is announced, pushing the share price higher. That results in a short-run increase in the equity cushion, but analysts who leap to the conclusion that credit risk is declining will receive a rude surprise when the true cause of the price appreciation comes to light.

INDUSTRY CONSIDERATIONS

The first step in analyzing a bond is to gain some familiarity with the industry. Only within the context of an industry is a company analysis valid. For example, a company growing at 15% annually may appear attractive. However, if the industry is growing at 50% annually, the company is competitively weak. Industry considerations can be numerous. An understanding of the nine variables discussed in this section, however, should give the general fixed income analyst a sufficient framework for properly interpreting a company's prospects:

- Economic cyclicality
- Growth prospects

- Research and development expenses
- Competition
- Sources of supply
- Degree of regulation
- Labor
- Accounting
- Event risk

In some industries, for instance, an analysis of labor costs must consider technological advances that have made it feasible to outsource certain functions to lower-wage countries. Examples include handling of customer inquiries, analysis of diagnostic results, and financial statement analysis. Also, cross-border differences in accounting standards complicate credit quality comparisons of industry peers domiciled in different countries.

Economic Cyclicality

The economic cyclicality of an industry is the first variable an analyst should consider in reviewing an industry. Does the industry closely follow gross domestic product (GDP) growth, as does the retailing industry, or is it recession-resistant but slow-growing, like the regulated electric utility industry? The growth in earnings per share (EPS) of a company should be measured against the growth trend of its industry. Major deviations from the industry trend should be the focus of further analysis. Some industries may be somewhat dependent on general economic growth but be more sensitive to demographic changes. For example, the aging of the U.S. population should cause demand for health care to grow faster than the economy as a whole. Analysts must bear in mind, however, that efforts by government and employers to control health care costs may limit revenue growth. Other industries, such as banking, are sensitive to interest rates. When interest rates are rising, the earnings of banks with a high federal funds exposure underperform the market because their loan rates lag behind increases in the cost of money. Conversely, as interest rates fall, banking earnings outperform the market because the lag in interest change works in the banks' favor.

In general, however, the earnings of few industries correlate perfectly with one economic statistic. Not only are industries sensitive to many economic variables, but often various segments within a company or an industry move countercyclically or at least with different lags in relation to the general economy. For example, the housing industry can be divided between new construction and remodeling and repair. New construction historically has led GDP growth, but repair and remodeling have exhibited less sensitivity to general trends. Therefore, in analyzing a company in the construction industry, the performance of each of its segments must be compared with the performance of the subindustry.

Growth Prospects

A second industry variable related to economic cyclicality is the growth prospects for an industry. Is the growth of the industry projected to increase and be maintained at a high level, such as in the nursing home industry, or is growth expected to decline, as in the defense industry? Each growth scenario has implications for a company. In the case of a fast-growth industry, how much capacity is needed to meet demand, and how will this capacity be financed? In the case of slow-growth industries, is there a movement toward diversification or a consolidation within the industry, such as in the railroad industry? A company operating within a fast-growing industry often has a better potential for credit improvement than does a company whose industry's growth prospects are below average. However, barriers to entry and the sustainability of growth must be considered along with growth prospects for an industry. If an industry is growing rapidly, many new participants may enter the business, causing oversupply of product, declining margins, and possible bankruptcies.

The growth prospects of an industry also should be considered in a global context, particularly if a company has international exposure. Frequently, the growth prospects of an industry vary by country. For example, the soft drinks industry is declining in the United States but continues to achieve high growth in many emerging market countries.

Research and Development Expenses

The broad assessment of growth prospects is tempered by the third variable—the research and development (R&D) expenditures required to maintain or expand market position. Products with high-tech components can become dated and obsolete quickly. Therefore, although a company may be well situated in an industry, if it does not have the financial resources to maintain a technological lead or at least expend a sufficient amount of money to keep technologically current, its position is likely to deteriorate in the long run. In the short run, however, a company with R&D expenditures consistently below industry averages may produce above-average results because of expanded margins.

Evaluation of research and development is further complicated by the direction of technology. Successful companies not only must spend an adequate amount of resources on development, but they also must be correct in their assessment of the direction of the industry. Deployment of significant amounts of capital may not prevent a decline in credit quality if the capital is misdirected. For example, computer companies that persisted in devoting a high percentage of their capital expenditures to the mainframe component of their business suffered declines in credit quality as the mainframe business declined. In industries such as software and telecommunications, new technologies emerge frequently, and not all achieve market viability. A company that ties its product plans to the wrong technology loses competitive ground in addition to being unable to recover a substantial investment in R&D.

Competition

Competition is based on a variety of factors, with their relative importance varying by industry. Price is almost always a major competitive consideration, but product quality also affects the customers' decisions. For many consumer products it is difficult to measure product quality by objective standards. Brand name recognition and celebrity endorsements consequently shape perceptions of product quality. Companies also compete by striving to achieve advantages in distribution and by cultivating long-term relationships with customers.

Some companies are able to maintain strong competitive positions over extended periods through patents and trademarks. The flip side is that the expiration of a patent can lead to a major revenue loss. This is particularly pertinent for a pharmaceutical maker that will have to begin competing with generic drug producers once patent protection expires on a highly successful product. Another danger signal is heavy concentration of revenues at a small number of customers. In such a situation, a decision by a major customer to switch to another provider could deal a severe blow.

Increasingly, all forms of competition are waged on an international basis and are affected by fluctuations in relative currency values. Companies that fare well are those that compete successfully on a global basis and concentrate on the regions with the highest potential for growth. Consumers are largely indifferent to the country of origin of a product as long as the product is of high quality and reasonably priced. This fact is exemplified by the significant increase in the manufacture of automobiles and automobile parts in Mexico that are shipped to the United States.

Competition within an industry relates directly to the market structure of an industry and has implications for pricing flexibility. An unregulated monopoly is in an enviable position in that it can price its goods at a level that will maximize profits. Most industries encounter some free-market forces and must price their goods in relation to supply and demand, as well as the price charged for similar goods. In an oligopoly, a pricing leader is not uncommon. A concern arises when a small company is in an industry that is moving toward oligopoly. In this environment, the small company's costs of production may be higher than those of the industry leaders, and yet it may have to conform to the pricing of the industry leaders. In the extreme, a price war could force the smaller companies out of business. This situation has occurred in the automobile industry over many decades, first on a national and later on a global basis. Many U.S. producers either failed or merged with larger competitors as the field narrowed to the Big Three—General Motors, Ford Motor Company, and Chrysler. In addition to getting squeezed on costs and pricing, smaller automakers faced a disadvantage in producing fewer models, making them more sensitive to changes in consumer tastes than the industry leaders. Similarly, concentration in one region of the world became a handicap as the industry globalized. Recessions usually vary in severity from country to country, so global producers could reduce their vulnerability to economic downturns by spreading their sales across continents.

A concern also arises when there is overcapacity in the industry. Often overcapacity is accompanied by price wars. Generally, price wars result in an industry-wide financial deterioration as battles for market share are accompanied by declining profits or losses.

Sources of Supply

The market structure of an industry and its competitive forces have a direct impact on the fifth industry variable—sources of supply of major production components. A company that is not self-sufficient in its factors of production but is sufficiently powerful in its industry to pass along increased costs is in an enviable position.

Degree of Regulation

In a regulated monopoly such as electric power generation, pricing is determined by a government body. The intention is to prevent companies from extracting excess profits, yet to provide a fair rate of return on capital. That policy tends to promote stable earnings regardless of economic conditions. State regulatory commissions vary, however, in their responsiveness to requests for rate relief to offset increased costs.

Non-monopoly industries face regulation in such areas as labor practices, financial reporting, product safety, and environmental impact. The costs of complying with these regulations are often substantial and the ability to pass the costs on to customers varies by industry. Compliance with regulations that are stricter than in other countries may disadvantage companies relative to foreign-based competitors. Violating regulations can result in costly fines as well as reputational damage that may result in lost business.

Labor

The seventh industry factor requiring analysis is the labor situation. Is the industry heavily unionized? If so, what has been the historical incidence of strikes? What level of flexibility does management have to reduce the labor force? When do the current contracts expire, and what is the likelihood of timely settlements? The labor situation is also important in nonunionized companies, particularly those whose labor situation is tight. What has been the turnover of professionals and management in the firm? What is the probability of a firm's employees, such as highly skilled engineers, being hired by competing firms? What is the likelihood of union activity in nonunionized companies? Are the states in which unionization is a possibility right-to-work states and therefore more difficult to unionize? How much of a cost advantage do the nonunionized companies have over the unionized companies?

The more labor-intensive an industry, the more significance the labor situation assumes. This fact is evidenced by the domestic automobile industry, in

which overcapacity and high unionization have contributed to high fixed costs and cyclic record operating losses.

Occasionally, analysts concentrate on the per-hour wages of the labor force. Such an emphasis is misleading. An evaluation of the labor force should concentrate on work rules because work rules are more important in the overall efficiency of an organization than the wage rates. This is an important factor in the profitability of some automobile supply companies.

Accounting

One more industry factor to be considered is accounting. Does the industry have special accounting practices, such as those in the insurance industry or the electric utility industry? If so, an analyst should become familiar with industry practices before proceeding with a company analysis. Also important is whether a company is liberal or conservative in applying accounting rules. The norm of an industry should be ascertained and the analyst should analyze comparable figures.

Particular attention should be paid to companies that use an accounting system other than U.S. generally accepted accounting principles (GAAP). Reported results should be reconciled with those which would have been reported under U.S. GAAP. In addition, changes in GAAP should be scrutinized.

Care also should be taken when dealing with historical data. Frequently, companies adjust prior years' results to accommodate discontinued operations and changes in accounting. These adjustments can mask unfavorable trends. For example, companies that regularly dispose of underperforming segments and then highlight the more profitable continuing operations may be trying to hide poor management. To appreciate all trends fully, both the unadjusted and the adjusted results should be analyzed.

Accounting practices also demand attention when mergers and acquisitions occur. How much of pro-forma synergies are attributable to savings that are not yet realized but are allowed in pro-forma results? How much goodwill is generated by the combination? Are any contracts written up because the acquiring company believes that it can improve the historical performance of the company it acquired? A conscientious analyst will be aware of these accounting entries and determine whether they reflect a pro forma reality or, a too-optimistic assessment of future performance.

Event Risk

The final industry factor to consider is event risk. This term refers to a major discontinuity in a company's financial performance. It includes transactions that radically alter a company's capital structure, such as leveraged buyouts and takeovers that are heavily financed with debt. Event risk also comprises shocks such as natural disasters, environmental catastrophes, nationalizations, terrorist attacks, and revelations of accounting fraud.

Shocks can have severe credit impact, up to and including bankruptcy. As an example, during the course of June 2010 Moody's Investors Service lowered BP's credit rating all the way from Aa1 to A2. The two-stage downgrade reflected potential costs of containment, cleanup, litigation, and fines arising from the company's massive oil spill in the Gulf of Mexico. Shocks are unforeseeable by their nature, but to some extent it is possible to assess a company's probability of experiencing a shock.

FINANCIAL ANALYSIS

Having achieved an understanding of an industry, the analyst is ready to proceed with a financial analysis. The financial analysis should be conducted in three phases. The first phase consists of traditional ratio analysis for bonds. The second phase, generally associated with common stock research, consists of analyzing the components of a company's return on equity. The final phase considers such nonfinancial factors as management and foreign exposure and includes an analysis of the indenture.

Traditional Ratio Analysis

There are numerous ratios that can be calculated in applying traditional ratio analysis to bonds. Of these, the following eight will be discussed in this section:

- Pretax interest coverage
- Leverage
- Cash flow
- Net assets
- Intangibles
- Unfunded pension liabilities
- Age and condition of plant
- Working capital

These selected ratios are the ones with the widest degree of applicability. In analyzing a particular industry, however, other ratios assume significance and should be considered.

Pretax Interest Coverage

Generally, the first ratio calculated in credit analysis is pretax interest coverage. This ratio measures the number of times interest charges are covered on a pretax basis. Pretax interest coverage is calculated by dividing pretax income plus interest charges by total interest charges. The higher the coverage figure, the safer is the credit. If interest coverage is less than 1×, the company must borrow or use cash flow or proceeds from the sale of assets to meet its interest payments.

Generally, published coverage figures are pretax as opposed to after-tax because interest payments are a pretax expense. Although the pretax interest coverage ratio is useful, its utility is a function of the company's other fixed obligations. For example, if a company has other significant fixed obligations, such as rents or leases, a more appropriate coverage figure would include these other fixed obligations. An example of this is the retail industry, in which companies typically have significant lease obligations. A calculation of simple pretax interest coverage would be misleading in this case because fixed obligations other than interest are significant.

The analyst also should be aware of any contingent liabilities such as a company's guaranteeing another company's debt. Although the company being analyzed may never have to pay interest or principal on the guaranteed debt, the existence of the guarantee diminishes the quality of the pretax coverage. In addition, the quality of the guaranteed debt must be considered.

Once pretax interest coverage and fixed-charge coverage are calculated, it is necessary to analyze the ratios' absolute levels and the numbers relative to those of the industry. For example, pretax interest coverage for an electric utility of 3.0× is consistent with an A rating, whereas the same coverage for a drug company would indicate a lower rating.

Exhibit 43–2 shows the various key pretax interest coverage ratios reported by Standard & Poor's and how they are computed by that rating agency. The exhibit defines each measure used in a ratio and the formula.

Leverage

A second important ratio is leverage, which can be defined in several ways. The most common definition of *leverage* is long-term debt as a percent of total capitalization. The higher the level of debt, the higher is the percentage of operating income that must be used to meet fixed obligations. If a company is highly leveraged, the analyst also should look at its margin of safety. The *margin of safety* is defined as the percentage by which operating income could decline and still be sufficient to allow the company to meet its fixed obligations.

The traditional method of calculating leverage uses the company's capital structure as stated in the most recent balance sheet. A helpful supplement to the traditional ratio is the *market-adjusted debt ratio*. It uses debt as reported, but substitutes for stated shareholders' equity the market value of all outstanding shares.

One drawback to the traditional, book-value-based leverage ratio is that the accounting rules generally require physical assets to be recorded at historical cost. They may be written down to reflect impairment, but not written up to reflect increases in their economic value, unless they become involved in an acquisition. Furthermore, the accounting rules require immediate expensing, rather than capitalizing, of many outlays that create substantial long-run value. Examples include research and development, the creation of brand names, and the buildup of an effective sales organization. Consequently, the traditional ratio may overstate leverage by understating the economic value of the company's equity.

EXHIBIT 43–2

S&P Glossary of Terms and Formula for Key Ratios

Glossary

Pretax income from continuing operations: Net income from continuing operations before (1) special items, (2) minority interest, (3) gains or reacquisition of debt, plus income taxes.

Eight times rents: Gross rents paid multiplied by capitalization factor of eight.

Equity: Shareholders' equity (including preferred stock) plus minority interest.

Free operating cash flow: Funds from operations minus capital expenditures and minus (plus) the increase (decrease) in working capital (excluding changes in cash, marketable securities, and short-term debt).

Funds from operations (or funds flow): Net income from continuing operations plus depreciation, amortization, deferred income taxes, and other noncash items.

Gross interest: Gross interest incurred before subtracting (1) capitalized interest, (2) interest income.

Gross rents: Gross operating rents paid before sublease income.

Interest expense: Interest incurred minus capitalized interest.

Long-term debt: As reported, including capitalized lease obligations on the balance sheet.

Operating income: Sales minus cost of goods manufactured (before depreciation and amortization), selling, general and administrative, and research and development costs.

Total debt: Long-term debt plus current maturities, commercial paper, and other short-term borrowings.

Formulas for Key Ratios

$$\text{Pretax interest coverage} = \frac{\text{Pretax income from continuing operations} + \text{Interest expense}}{\text{Gross interest (before subtracting capitalized interest and interest income)}}$$

$$\text{Pretax interest coverage including rents} = \frac{\text{Pretax income from continuing operations} + \text{Interest expense} + \text{Gross rents}}{\text{Gross interest} + \text{Gross rents}}$$

$$\text{EBITDA interest coverage} = \frac{\text{Pretax income from continuing operations} + \text{Interest expense} + \text{Depreciation and amortization}}{\text{Gross interest}}$$

$$\text{Funds from operations (or funds flow) as a \% of total debt} = \frac{\text{Funds from operations}}{\text{Total debt}} \times 100$$

$$\text{Free operating cash flow as a \% of total debt} = \frac{\text{Free operating cash flow}}{\text{Total debt}} \times 100$$

(Continued)

EXHIBIT 43–2

S&P Glossary of Terms and Formula for Key Ratios (*Continued*)

Pretax return on permanent capital

$$= \frac{\text{Pretax income from continuing operations} + \text{Interest expense}}{\text{Sum of (1) the average of the beginning of year and end of year current maturities, long-term debt, noncurrent deferred taxes, minority interest, and shareholders' equity and (2) average short-term borrowings during year per footnotes to financial statements}} \times 100$$

$$\text{Operating income as a \% of sales} = \frac{\text{Operating income}}{\text{Sales}} \times 100$$

$$\text{Long-term debt as a \% of capitalization} = \frac{\text{Long-term debt}}{\text{Long-term debt} + \text{Equity}} \times 100$$

$$\text{Total debt as a \% of capitalization} + \text{short-term debt} = \frac{\text{Total debt}}{\text{Total debt} + \text{Equity}} \times 100$$

Total debt + 8 times rents as a % of capitalization + short-term debt + 8 times rents

$$= \frac{\text{Total debt} + 8 \text{ times gross rentals paid}}{\text{Total debt} + \text{Equity} + 8 \text{ times gross rentals paid}} \times 100$$

Source: "Adjusted Key U.S. Industrial Financial Ratios," *Standard & Poor's Credit Week*, September 20, 2000, pp. 39–44.

The market-adjusted version is a useful corrective, because under normal conditions, the stock market will reflect a disparity—whether positive or negative—between the book value and economic value of a company's assets. Analysts should bear in mind, however, that share prices can be highly volatile. As gauged by the company's stock market value, leverage may look considerably higher a month from now than today, with the change mainly reflecting a general drop in share prices rather than a fundamental decline in the company's earnings prospects.

Finance companies traditionally have been among the most highly leveraged companies. Debt-to-equity ratios of 10:1 are not unusual for *captive finance companies* that finance the sales of, and have debt guarantees from, parent companies engaged in manufacturing or retailing. For noncaptive companies, ratios of 5:1 to 7:1 are typical nowadays. Investors tolerate finance companies' high leverage because of the generally liquid nature of their assets. Loans, receivables, and other financial instruments ordinarily can be sold without substantial loss of face value if necessary to repay maturing debt. In contrast, industrial companies typically include large amounts of plant and equipment that cannot be disposed of so quickly. Therefore, book-value-based leverage of 5:1 or more would cause an industrial company to be viewed as highly speculative.

In addition to considering the absolute and relative levels of leverage of a company, the analyst should evaluate the debt itself. How much of the debt has a fixed-rate, and how much has a floating rate? A company with a high component of debt tied to the prime rate may find its margins being squeezed as interest rates rise if there is no compensating increase in the price of the firm's goods. Such a debt structure may be beneficial during certain phases of the interest-rate cycle, but it precludes a precise estimate of what interest charges for the year will be. In general, a company with a small percentage of floating-rate debt is preferable to a similarly leveraged company with a high percentage of floating-rate debt.

The maturity structure of the debt also should be evaluated. What is the percentage of debt that is coming due within the next five years? As this debt is refinanced, how will the company's embedded cost of debt be changed?

The existence of material operating leases can understate the leverage of a firm. Operating leases should be capitalized to give a true measure of leverage.

A company's bank lines often constitute a significant portion of its total debt. These lines should be analyzed closely in order to determine the flexibility afforded to the company. The lines should be evaluated in terms of undrawn capacity as well as security interests granted. In addition, the analyst should determine whether the line contains a "material adverse change" (MAC) clause under which the line could be withdrawn. For example, a company that has drawn down its bank lines completely and is in jeopardy of activating its MAC clause may have trouble refinancing any debt. In a similar manner, undrawn lines should be evaluated in terms of their capacity to replace commercial paper, if needed. In the event that a company's commercial paper rating is downgraded, the company's access to the commercial paper market may evaporate quickly. In this scenario, the company may be forced to draw on its bank lines to replace its maturing commercial paper. A company whose commercial paper is fully backed by bank lines is in a stronger position than one whose bank lines do not cover its outstanding commercial paper.

Exhibit 43–2 shows the key leverage ratios used by Standard & Poor's and the formula for calculating each ratio.

Cash Flow

A third important ratio is cash flow as a percent of total debt. *Cash flow* is often defined as net income from continuing operations plus depreciation, depletion, amortization, and deferred taxes. In calculating cash flow for credit analysis, the analyst also should subtract noncash contributions from subsidiaries. In essence, the analyst should be concerned with cash from operations. Any extraordinary sources or uses of funds should be excluded when determining the overall trend of cash-flow coverage. Cash dividends from subsidiaries also should be questioned in terms of their appropriateness (too high or too low relative to the subsidiary's earnings) and also in terms of the parent's control over the upstreaming of dividends. Is there a legal limit to the upstreamed dividends? If so, how close is the current level of dividends to the limit?

Net Assets

A fourth significant ratio is net assets to total debt, which gauges a company's ability to repay debt by liquidating assets to generate cash. This is not something companies do under normal circumstances; their ordinary practice is to refinance debt as it comes due or repay it from operating cash flow. Asset liquidation for debt repayment is most apt to occur when a company is under financial strain, when asset values are likely to be depressed. Therefore, analysts must be mindful that at the point at which liquidation value becomes relevant, it may differ significantly from the value currently reflected on the balance sheet and also from the present market value.

Discrepancies between book value and liquidation value arise from the inherently illiquid nature of many fixed assets. Consider a specialized piece of heavy equipment in a mine in a remote area. The balance sheet value associated with this asset is its purchase price less depreciation charges recorded since the equipment was acquired. Not reflected in that valuation are the costs of transporting the equipment to a buyer. Moreover, the depreciation charges, which were set at the time of the machinery's purchase, may not take into account the possibility of subsequent introduction of a competing, more cost-effective model, which would reduce the value of earlier-generation equipment.

To identify gaps between book value and liquidation value, analysts can obtain information on sales of comparable assets. In the energy sector, for example, widely reported sales of oil reserves provide dollars-per-barrel benchmarks. Acquisitions of retailing chains and restaurants similarly furnish useful estimates of current market value of comparable properties.

Even when such market-based data can be found, however, debt holders must be cautious about concluding that their principal will be fully covered in liquidation. For example, suppose that during a period of airline industry prosperity an airline sells bonds collateralized by planes. The prices then being paid for used aircraft may imply that the collateral's asset value comfortably exceeds the face amount of the bonds. The bonds may come due, however, when the notoriously cyclical airline business is in a downturn, making it difficult for the borrower to refinance the debt. Demand for used aircraft is likely to be minimal at that point, reducing the liquidation value of the collateral to much less than the bonds' face amount.

Takeovers, recapitalizations, and other restructurings increase the importance of asset coverage protection. Unfortunately for some bondholders, mergers or takeovers may decimate their asset coverage by adding layers of debt to the corporate structure that is senior to their holdings. While the analyst may find it difficult to predict takeovers, it is crucial to evaluate the degree of protection from takeovers and other restructurings that the bond indenture offers.

In extreme cases, the analyst must consider asset coverage in the case of bankruptcy. This is particularly important in the case of lease obligations because the debtor has the ability to reject leases in bankruptcy. In the case of lease rejections, the resulting asset protection may depend on a legal determination

of whether the underlying lease is a true lease or a financing arrangement. Even if the lease if determined to be a true lease, the determination of asset protection is further complicated by a determination of whether the lease relates to nonresidential real property or to personal property. The difference in security (i.e., recovery in a bankruptcy) is significant. Damages under a lease of nonresidential real property are limited to three years of lease payments. Damages under a lease of personal property are typically based on all amounts still due under the lease.

In addition to the major variables just discussed, the analyst also should consider several other financial variables, including intangibles, unfunded pension liabilities, the age and condition of the plant, and working capital adequacy.

Intangibles

Intangibles often represent a small portion of the asset side of a balance sheet. Occasionally, particularly with companies that have or have had an active acquisition program, intangibles can represent a significant portion of assets. In this case, the analyst should estimate the actual value of the intangibles and determine whether this value is in concert with a market valuation. A carrying value significantly higher than market value indicates a potential for a write-down of assets. The actual write-down may not occur until the company actually sells a subsidiary with which the intangibles are identified. However, the analyst should recognize the potential and adjust capitalization ratios accordingly.

Unfunded Pension Liabilities

Unfunded pension liabilities also can affect a credit decision. Although a fully funded pension is not necessary for a high credit assessment, a large unfunded pension liability that is 10% or more of net worth can be a negative. Of concern is the company with unfunded pension liabilities high enough to interfere with corporate planning.[2] For example, in the late 1980s, a steel company with high unfunded pension liabilities might have delayed or decided against closing an unprofitable plant because of the pension costs involved. The analyst also should be aware of a company's assumed rate of return on its pension funds and salary-increase assumptions. The higher the assumed rate of return, the lower the contribution a company must make to its pension fund, given a set of actuarial assumptions. Occasionally, a company having difficulty with its earnings will raise its actuarial assumption and thereby lower its pension contribution and increase earnings. The impact on earnings can be dramatic. In other cases, companies have attempted to "raid" the excess funds in an overfunded retirement plan to enhance earnings.

2. For a discussion of the impact of accounting for defined benefit pension plans on key financial measures (leverage, earnings, and cash flow) and a methodology to adjust these measures to reflect the true economic impact of pension plans, see David Zion and Bill Carcache, *The Magic of Pension Accounting: Part II*, Equity Research, Credit Suisse First Boston (October 15, 2003).

In periods of declining interest rates, the analyst also must consider the discount rate companies use to discount their future obligations. Companies generally use the yield of AA corporate bonds as a discount factor, a benchmark that has been criticized by market analysts.

Age and Condition of Plant

The age of a company's plant also should be estimated, if only to the extent that it differs dramatically from industry standards. A heavy industrial company with an average plant age well above that of its competitors is probably already paying for its aged plant through operating inefficiencies. In the longer term, however, the age of the plant is an indication of future capital expenditures for a more modern plant. In addition, underdepreciation of the plant significantly increases reported earnings.

The availability of information regarding the average age and condition of plants varies among companies. On the one hand, airline carriers readily provide the average age of their fleet and the money they will save as they replace older aircraft with more fuel-efficient aircraft that require fewer people in the cockpit. On the other hand, the average age of a plant compared with the industry average is not always available for some companies such as paper producers. Furthermore, companies with older plants generally emphasize the capital improvements that have been made to them over the years, which distort direct comparisons. In this case, it is helpful to read closely several years of management's explanation of operating results in the annual reports. Often this section will include mentions of above-average maintenance expense and machines that were out of service for a period of time for maintenance. Such comments indicate that the plants and machines may not be as efficient as portrayed initially.

Working Capital

A final variable in assessing a company's financial strength concerns the strength and liquidity of its working capital. *Working capital* is defined as current assets less current liabilities. Working capital is considered a primary measure of a company's financial flexibility. Other such measures include the current ratio (current assets divided by current liabilities) and the acid test (cash, marketable securities, and receivables divided by current liabilities). The stronger the company's liquidity measures, the better it can weather a downturn in business and cash flow.

In assessing this variable, the analyst should consider the normal working capital requirements of a company and industry. The components of working capital also should be analyzed. Although accounts receivable are considered to be liquid, an increase in the average days a receivable is outstanding may be an indication that a higher level of working capital is needed for the efficient running of the operation. Furthermore, companies frequently have account receivable financing, some with recourse provisions. In this scenario, comparisons among companies in the same industry may be distorted.

The state of contraction or expansion also should be considered in evaluating working capital needs. Automobile manufacturers typically need increased working capital in years when automobile sales increase.

Analysis of the Components of Return on Equity

Once the preceding financial analysis is complete, the bond analyst traditionally examines the earnings progression of the company and its historical return on equity (ROE). This section of analysis often receives less emphasis than the traditional ratio analysis. It is equally important, however, and demands equivalent emphasis. An analysis of earnings growth and ROE is vital in determining credit quality because it gives the analyst necessary insights into the components of ROE and indications of the sources of future growth. Equity analysts devote a major portion of their time to examining the components of ROE, and their work should be recognized as valuable resource material.

A basic approach to examining the components of ROE breaks down return on equity into four principal components: pretax margins, asset turnover, leverage, and one minus the tax rate.[3] These four variables multiplied together equal net income/stockholders' equity, or return on equity, as shown below:

$$\text{Net income/equity} = (\text{net pretax income/sales} + \text{operating pretax income/sales}) \times (\text{sales/assets}) \times (\text{assets/equity}) \times (1 - \text{tax rate})$$

The analyst should examine the progression of these four components of ROE for a minimum of five years and through at least one business cycle. The progression of each variable should be compared with the progression of the same variables for the industry, and deviations from industry standards should be further analyzed. For example, perhaps two companies have similar ROEs, but one company is employing a higher level of leverage to achieve its results, whereas the other company has a higher asset-turnover rate. Since the degree of leverage is largely a management decision, the analyst should focus on asset turnover. Why have sales for the former company turned down? Is this downturn a result of a general slowdown in the industry, or is it that assets have been expanded rapidly, and the company is in the process of absorbing these new assets? Conversely, a relatively high rise in asset-turnover rate may indicate a need for more capital. If this is the case, how will the company finance this growth, and what effect will the financing have on the firm's embedded cost of capital?

The analyst should not expect similar components of ROE for all companies in a particular industry. Deviations from industry norms are often indications of management philosophy. For example, one company may emphasize asset turnover, and another company in the same industry may emphasize profit margin. As in any financial analysis, the trend of the components is as important as the absolute levels.

3. The formula was first presented in Jerome B. Cohen, Edward D. Zinbarg, and Arthur Zeikel, *Investment Analysis and Portfolio Management* (Homewood, IL: Richard D. Irwin, 1977).

Nonfinancial Factors

After the traditional bond analysis is completed, the analyst should consider some nonfinancial factors that might modify the evaluation of the company. Among these factors are the degree of foreign exposure, the quality of management, and ownership. The amount of foreign exposure should be ascertainable from the annual report. Sometimes, however, specific country exposure is less clear because the annual report often lists foreign exposure by broad geographic divisions. If there is concern that a major portion of revenue and income is derived from potentially unstable areas, the analyst should carefully consider the total revenue and income derived from the area and the assets committed. Further consideration should be given to available corporate alternatives should nationalization of assets occur. Additionally, the degree of currency exposure should be determined. If currency fluctuations are significant, has management hedged its exposure?

The internationalization of the bond markets and the ability of countries to issue debt in other countries highlight the importance of understanding the effect of currency risks. For example, many Mexican companies issued U.S. dollar–denominated debt in the early 1990s. This issuance had a positive impact on the financials of these Mexican companies because of the generally lower interest rates available in the United States relative to Mexico. However, when the peso was devalued significantly in December 1994, the ability of some of these companies to meet their U.S. dollar–denominated obligations was questioned. Of particular concern were the companies whose revenues were largely denominated in pesos but whose interest expense was denominated in U.S. dollars.

The quality and depth of management are more difficult to evaluate. The best way to evaluate management is to spend time with management, if possible. Earnings progress at the firm is a good indication of the quality of management. Negative aspects would include a firm founded and headed by one person who is approaching retirement and has made no plan for succession. Equally negative is the firm that has had numerous changes of management and philosophy. On the other hand, excessive stability is not always desirable. In discussing the factors it considers in assigning a credit rating, Moody's Investors Service notes the following regarding the quality of management:

> Although difficult to quantify, management quality is one of the most important factors supporting an issuer's credit strength. When the unexpected occurs, it is a management's ability to react appropriately that will sustain the company's performance.[4]

In assessing management quality, the analysts at Moody's, for example, try to understand the business strategies and policies formulated by management. Following are factors that are considered: (1) strategic direction, (2) financial

4. "Industrial Company Rating Methodology," *Moody's Investors Services: Global Credit Research*, July 1998, p. 6.

philosophy, (3) conservatism, (4) track record, (5) succession planning, and (6) control systems.

In recent years, focus has been on the corporate governance of the firm and the role of the board of directors. The bylaws are the rules of governance for the corporation. The bylaws define the rights and obligations of officers, members of the board of directors, and shareholders. Several firms have developed services that assess corporate governance. One type of service provides confidential assessment of the relative strength of a firm's corporate governance practices. The customer for this service is a corporation seeking external evaluations of its current practice. The second is a service that rates (or scores) the corporate governance mechanisms of companies. Generally, these ratings are made public at the option of the company requesting an evaluation.

Analysts should also consider the ownership of a company. If a single family or small group of investors holds a controlling interest, the company may tend to be overly conservative in its response to changes in its markets. Owners also should be judged in terms of whether they are strategic or financial. Often financial buyers invest for the short to intermediate term, hoping to sell their positions (or the entire company) at a profit. If such a sale involves a leveraged buyout, the credit quality of the bonds is lowered, sometimes dramatically.

COMBINING FINANCIAL AND NONFINANCIAL ANALYSIS

The ultimate credit judgment on a company must consider both its financial risk profile and its business risk profile. Strength in one aspect of credit quality may be offset by weakness in the other. Exhibit 43–3 illustrates one approach to integrating the two modes of analysis.

Standard & Poor's employs a matrix of six levels of business risk, from "excellent" to "vulnerable," and six levels of financial risk, from "minimal" to "highly leveraged." The table shows the midpoint of the range of ratings that may be assigned to a company within a given cell. The actual rating ordinarily will be within one notch of that rating. For example, in most cases a company with a "satisfactory" business risk profile and an "intermediate" financial risk profile will be rated in the range of BBB+ to BBB–.

Certain cells, such as "excellent" business risk profile/"highly leveraged" financial risk profile, are blank. This is because such combinations are extremely improbable. For some companies, overarching risks such as major litigation and balance-sheet-straining acquisitions fall outside the matrix. Finally, the matrix excludes ratings lower than CCC+ because by definition, companies in those categories reflect an acute vulnerability or impending crisis.

Specific obligations may be rated higher than the company rating, based on security, or lower than the company rating, based on subordination within the capital structure. Subordination includes *structural subordination*, whereby servicing of a holding company's debt depends on receiving dividends from

EXHIBIT 43–3

Business and Financial Risk Profile Matrix

Business Risk Profile	Financial Risk Profile					
	Minimal	Modest	Intermediate	Significant	Aggressive	Highly Leveraged
Excellent	AAA	AA	A	A–	BBB	—
Strong	AA	A	A–	BBB	BB	BB–
Satisfactory	A–	BBB+	BBB	BB+	BB-	B+
Fair	—	BBB–	BB+	BB	BB–	B
Weak	—	—	BB	BB–	B+	B–
Vulnerable	—	—	—	B+	B	CCC+

These rating outcomes are shown for guidance purposes only. Actual rating should be within one notch of indicated rating outcomes.

subsidiaries. By law, dividends can be paid only after the subsidiaries' own debt has been serviced.

Exhibit 43–4 provides a key to the classifications of companies within the six financial risk profile categories. For example, a company with funds flow from operations to debt of 45% to 60%, debt/earnings before interest, taxes, depreciation, and amortization (EBITDA) of 1.5 to 2×, and debt/capital of 25% to 35% is deemed to have "modest" financial risk. S&P characterizes these benchmark ratios as guidelines rather than absolute rules. For instance, a company with very stable financial ratios may qualify for a particular financial risk category despite a somewhat lower FFO/debt percentage or a higher debt/capital percentage than shown in the exhibit. Electric utilities benefit from this leeway because of their demonstrated superiority in access to capital, their liquidity, and their effective management of capital programs and maturity schedules.

EXHIBIT 43–4

Financial Risk Indicative Ratios (Corporate)

	FFO/Debt (%)	Debt/EBITDA (x)	Debt/Capital (%)
Minimal	Greater than 60	Less than 1.5	Less than 25
Modest	45–60	1.5–2	25–35
Intermediate	30–45	2–3	35–45
Significant	20–30	3–4	45–50
Aggressive	12–20	4–5	50–60
Highly Leveraged	Less than 12	Greater than 5	Greater than 60

INDENTURE PROVISIONS

An *indenture* is a contract that defines the legal rights and obligations of the issuer and the bondholders, represented through the trustee, with respect to a bond issue. The indenture establishes fundamental rules for three primary investor concerns: (1) payments by the issuer to bondholders; (2) limits on the kinds of issuer behavior that may harm bondholders' prospects for repayment; and (3) the enforcement mechanisms available to bondholders if issuers do not fulfill their obligations.

First, the indenture and the related note that represents the debt enshrine a bondholder's individual right to the timely payment of principal and interest. The bond may also be subject to special pricing and redemption provisions, such as a ratings-based coupon step-up, a call schedule, a make-whole redemption, a sinking fund, or a maintenance and replacement fund. These payment provisions are discussed in Chapter 12.

Second, the indenture will contain provisions called *covenants* that attempt to limit some issuer behavior that could increase credit risk. For example, if an issuer doubles its amount of outstanding debt in order to pay dividends to shareholders while neglecting reinvestment in its business, then bondholders will face a greater risk of a payment default on their bonds. A strong Debt covenant or Restricted Payments covenant could limit this kind of recapitalization event. Indenture analysis is principally focused on restrictive covenants not only to help evaluate contractual protections against risky behavior by issuers, but also to consider the upside possibility of a consent solicitation or a premium tender for their bonds if the issuer wants to take actions that otherwise would be restricted by the bond covenants. Covenant protections can have important market pricing implications, especially in the leveraged-buyout (LBO) context. When the Texas power company TXU Corp. was acquired in 2007, it had significant bonds outstanding at three different legal entities. The TXU holding company bonds had very weak covenant protections and remained outstanding and traded well below par for years after the LBO, while the TXU Energy subsidiary bonds had stronger covenant protections that would have impeded the optimal LBO financing, and so they were redeemed at a premium. The value of a third set of bonds was relatively protected because they had been issued by a different, state-regulated subsidiary with limits on its ability to borrow.

Covenant protections can vary enormously even among bonds of the same issuer, but they can generally be described as being investment-grade or high-yield type covenants. Some industry groups such as real estate investment trusts (REITs) and finance companies have special covenant features, as explained below. Bear in mind that covenants vary over time as investors become more or less sensitive to event risk and the view of what is "market" practice changes. For example, Change of Control puts and secured debt restrictions became very important for investment-grade bond investors following the 1988 LBO of RJR Nabisco, but then generally waned over the next two decades, until the buyout boom of the mid-2000s and resulting bondholder losses resurrected these kinds of protections.

Enforcement is the third primary concern. If there is a *default* under the indenture, then the enforcement of bondholder rights is handled according to detailed rules that are generally similar among all corporate indentures. Generally, if there is *payment default* because a principal or interest payment is not made on time, then the trustee may act on its own to sue for payment, although an individual bondholder can also sue for payment. If there is a *covenant default,* such as selling an asset in violation of an Asset Sales covenant, then enforcement could occur in several ways. The issuer might realize its mistake and attempt to *cure,* or remedy, the breach if possible. The issuer might ask bondholders for permission in a *consent solicitation* for a *waiver* from having to comply with the indenture provision or for an *amendment* to the indenture so that the covenant is changed. Bondholders or the trustee might become aware of a default and formally give notice of a default to try to *accelerate* the bonds for early payment. Sometimes, the issuer, trustee, and bondholders might disagree about the meaning of an indenture covenant and litigate the matter. For example, when Tyco International split its businesses into three separate, publicly traded companies, bondholders sued to stop the transaction based on a violation of the Mergers covenant, and Tyco paid to settle the litigation. Typically, either the trustee or 25% of bondholders must act in order to declare a default and attempt to accelerate the bonds.

Bond indentures should be considered in light of the covenants in bank credit agreements. Frequently, loan covenants can be more restrictive than bond covenants. In particular, credit agreements often contain *maintenance covenants* that require the borrower to maintain a certain level of consolidated net worth, a ratio of total debt to cash flow, or some other financial metrics that serve as a proxy for the creditworthiness of the borrower. If a maintenance covenant is breached, then the lenders can seek to accelerate. Bondholders sometimes hope that the more restrictive bank credit agreements will provide some aura of protection to bondholders, but investors should be cautious about this idea. Borrowers often ask lenders for waivers and amendments, and in recent years there are numerous examples in which some market participants took credit views based on expected covenant breaches that turned out to be incorrect, such as when MGM Mirage (Resorts) obtained a series of amendments from its lenders in 2009 that involved pledging additional collateral. Similarly, some analysts expected Clear Channel to face insolvency based on noncompliance with its leveraged-based maintenance covenant in 2009, but this view was based on a misunderstanding of the credit agreement definitions.

Note that the prospectus or offering memorandum for a bond will contain a description of the covenants, but it is the indenture that controls as the legally binding contract, and so the indenture should be used for covenant analysis. The indenture of a U.S. issuer usually can be obtained from the SEC's EDGAR website if the issuer is a public company or otherwise files with the SEC. Alternately, the indenture may be obtained from the trustee who is listed in the prospectus or sometimes directly from the issuer.

Outlined below are the most common indenture covenants, and how they vary for investment-grade versus high-yield bonds. Following that is an explanation of some special industry and bond types. Bear in mind that covenants work together as a kind of "system" where one corporate action can implicate multiple indenture provisions.

Typical Bond Covenants

Guarantees/Future Guarantors Covenant

A bond is primarily the obligation of the issuer. Often the issuer is a holding company that relies on its own subsidiaries to upstream cash for the issuer to make payments to bondholders. If the issuer fails to make a payment, then bondholders may want to make a claim for payment against the subsidiaries that hold the operating assets. This is possible if there are *subsidiary guarantees* by which the issuer's subsidiaries promise to pay interest and principal if the issuer does not. A bond may have subsidiary guarantees when it is issued, or a *Future Guarantors covenant* may require subsidiaries to provide guarantees in the future. Guarantees are an important determinant of recoveries in bankruptcy, especially when there may be significant debt, trade claims, or other liabilities against subsidiaries. A guarantee can put the bondholders' claims on an equal footing with other claims against subsidiaries.

Investment-grade bonds usually do not have subsidiary guarantees, while high-yield bonds typically are offered with these guarantees.

Debt Covenant

The *Debt covenant* limits the amount of additional borrowings by the issuer. A Debt covenant has become rare among investment-grade bonds, but is customary for high-yield issues. The typical version says that the issuer and its subsidiaries generally cannot incur debt unless a *Ratio test* is met, which typically requires meeting a pro forma 2× EBIDTA: interest expense coverage ratio or a maximum debt: EBITDA leverage ratio. However, even when the Ratio test cannot be met, certain types of *Permitted Debt* are allowed. Permitted Debt includes specific carveouts such as for a set amount of credit facilities, project and acquisition financing, and a general purpose debt basket. Generally, a Debt covenant is designed to allow an issuer to borrow more money when its EBITDA and total asset base are increasing. The risk to bondholders is that the new debt remains even if financial results decline, because the Debt covenant is not a maintenance covenant.

Importantly, for the Debt covenant and other restrictive covenants, investors must confirm which entities in the capital structure must obey the covenants. Ideally, the issuer and all its subsidiaries would be subject to the covenants, but many indentures exempt so-called unrestricted subsidiaries.

Subsidiary Debt Covenant

Investment-grade bonds occasionally have a *Subsidiary Debt covenant* that is intended to limit the amount of money that can be borrowed by subsidiaries, and therefore reduce the risk of structural subordination.

Negative Pledge/Liens Covenant

Bondholders generally do not want other debt to be secured ahead of or alongside their bonds, because secured debt will recover ahead of unsecured debt in bankruptcy. This concern is addressed by one of two similar provisions that have an important substantive difference. A *Negative Pledge covenant* is used for almost all unsecured bonds and generally requires that if some other debt becomes secured, then the bonds must be equally and ratably secured. The Negative Pledge for an investment-grade bond will typically only restrict pledging some subset of the issuer's total assets (for example, manufacturing plants), allow exceptions to finance capital expenditures and asset acquisitions, and have a *general secured debt carveout* equal to 10% to 15% of a balance sheet metric such as consolidated net tangible assets or stockholders' equity. For a high-yield bond, the covenant will typically apply to all of the issuer's assets, but a lengthy list of *Permitted Liens* will have carveouts matched to particular items of Permitted Debt and other exceptions.

In comparison, a secured bond should have a true *Liens covenant,* which restricts securing other debt and does not give the issuer the option to secure new debt by ratably securing the existing bonds, but would still allow some Permitted Liens.

Sale/Leaseback Covenant

A *Sale/Leaseback covenant* is standard for investment-grade bonds and is especially important when there is significant credit support from owned manufacturing facilities or high value real estate, such as department stores with owned locations. If a company sells real estate and then takes back a lease on that property, the bondholder is harmed twice: first, as there would be fewer assets to recover against in bankruptcy, and second, as the issuer will have committed itself to future lease payments. Therefore, the covenant usually blocks a sale/leaseback transaction unless it is used to finance a new location, or the proceeds of the sale are used to repay long-term debt or acquire new assets. This covenant has been fading from usage in high-yield bonds, in part because the sale would be addressed by the Asset Sales covenant of a high-yield bond, while aspects of the lease would be addressed by the Debt and Liens covenant.

Restricted Payments Covenant

A *Restricted Payments covenant* primarily limits the amount of dividends that can be paid to stockholders. While these dividend restrictions might occasionally appear in investment-grade bond issues, they are now generally restricted to

high-yield bonds. Typically, 50% of the issuer's net income can be paid to stockholders, on the theory that the other half of profits should be reinvested in the business or used to pay down debt. Paying dividends based on net income is also usually conditioned upon meeting the pro forma Ratio test of the Debt covenant. This same Restricted Payments covenant will also generally limit stock purchases, repaying subordinated debt before its maturity, and making so-called restricted investments in entities such as joint ventures that might not be obligated to obey the indenture covenants.

Asset Sales Covenant

The Asset Sales covenant is rare for investment-grade bonds but standard for high-yield bonds. The covenant does not prevent asset sales, but generally requires that the proceeds of a sale be used to acquire new assets or repay debt that is secured or otherwise effectively senior to the bonds. If that is not done, then the issuer usually must offer to buy back the bonds at par within a year.

Mergers Covenant

The *Mergers covenant,* also known as the successor obligor provision, is designed to ensure a degree of continuity between the bond debt and the issuer's assets that support the debt. If the issuer merges with another company or transfers "substantially all" of its assets to another company, then the bond obligation must remain with the merged company or bulk of the assets. Otherwise, investment-grade bondholders could be left holding bonds of a mere shell company that has sold off its assets, because an investment-grade bond usually does not have an Asset Sales covenant.

High-yield bonds have a similar Mergers covenant, but their version would generally require meeting the Debt covenant's Ratio test as a condition to the merger or asset transfer.

Change of Control Covenant

The *Change of Control covenant* is nearly universal for high-yield bonds and allows bondholders to put bonds back to the issuer at 101% upon a defined Change of Control. This covenant is currently common for nonfinancial investment-grade bonds, but with the additional requirement that the bonds become rated below investment-grade. The Change of Control definition may include one or more triggers such as: (1) a sale of substantially all assets; (2) the acquisition of more than half of the issuer's voting stock by a third party; (3) a merger with another company; (4) a liquidation of the company; and (5) a hostile change in the board of directors. The Change of Control put can be blunt protection against the risk of credit-damaging leverage in an LBO, a chance to assess the new ownership of the issuer, or a simple 101% put opportunity for a bond trading below par.

Special Covenants and Situations

Some industries and special situations have bond covenants that vary from the common pattern and we outline these below.

Real Estate Investment Trusts

REITs are almost always investment-grade issuers, and their covenants have a great degree of similarity to each other. The REIT indenture usually has one or more maintenance covenants based on levels of secured debt, unsecured debt, and interest coverage.

Utilities

Utilities tend to be investment-grade issuers yet have traditionally issued secured debt, often under the title of First Mortgage Bonds with indentures that have been used for decades, and sometimes feature maintenance and replacement funds and sinking funds. These secured bonds may limit the amount of additional debt that may be issued under the mortgage to a certain percentage of net property. Today, many utilities issue bonds with limited covenants that look like those of other investment-grade issuers, with only a standard make-whole redemption option. However, investors have some comfort that state utility regulations may effectively limit the leverage of these companies.

Finance Companies

Finance companies are usually investment-grade issuers and have less complex covenants than in the past. A negative pledge type Liens covenant is common, and if the issuer is a finance subsidiary of an operating company, such as GE Capital is a business of General Electric, then the parent may have a support guarantee in which the parent promises to invest in the finance subsidiary for it to maintain a certain net worth or other credit metric.

Banks and Insurance Companies

The holding companies for banks and insurance companies are typically rated investment-grade and their bonds will have a limited Liens covenant that restricts pledging shares of major subsidiaries and perhaps a limited kind of Asset Sales covenant that restricts selling significant minority stakes in major subsidiaries. The regulated subsidiaries may issue their own, higher-rated debt, in which the covenants are often less important because state and federal laws practically limit borrowing by regulated subsidiaries.

Split-Rated Issuers

Bonds issued with one investment-grade rating and one high-yield rating often have investment-grade covenants, but perhaps with the addition of a strong Future Guarantors covenant or a limited Restricted Payments covenant that controls dividend payments.

Secured High-Yield Bonds

Traditionally, bank loans were secured and bonds were not. This began to change significantly in the 2000s as bank lenders became comfortable with the idea of allowing bonds to be sold with second liens that would recover behind the bank loans. In 2010 over one-fourth of U.S. high-yield bonds were sold with some collateral protection, and both first and second liens are now common. These bonds are often subject to an *intercreditor agreement* that affirms the primacy of the lenders' liens and limits somewhat the arguments that bondholders can make in bankruptcy.

Private Bonds

So-called private bonds are usually small offerings that are sold to just a handful of institutions, tend not to trade frequently, and are generally not covered by research or media outlets. These bonds can often be more heavily negotiated and include loan-like maintenance covenants.

UTILITIES

Historically, utilities have been regulated monopolies. These companies generally operate with a high degree of financial leverage and low fixed-charge coverage (relative to industrial companies). These financial parameters have been accepted historically by investors owing to the regulation of the industry and the belief that there is minimal, if any, bankruptcy risk in those securities because of the essential services they provide.

The changing structure of the electric utility industry brought about by significant investment in nuclear generating units and their inherent risk, as well as the transition to deregulation, has changed this belief. Initially, the faltering financial position of General Public Utilities precipitated by the Three Mile Island nuclear accident and the regulatory delays in making a decision regarding the units highlighted the default risk that exists in the industry. Subsequently, the defaults of several Washington Public Power Supply System issues, the restructuring of Tucson Electric Company, and the bankruptcies of Public Service Company of New Hampshire and El Paso Electric Company and the transition to deregulation reemphasized the default risk. In addition, the industry is faced with the acid rain issue and increased uncertainty in construction costs and growth rates.

Segments within the Utility Industry

There are three major segments within the utility industry: electric companies, gas companies, and telephone companies. This chapter will deal primarily with electric utilities. Many companies are involved in both electric and gas service, so analysis requires a working knowledge of both businesses. A working knowledge of the different facets of the electric utility industry is also required as traditional electric

utilities diverge in their strategies, with some companies emphasizing transmission and distribution exclusively while other companies emphasize generation.

Nonfinancial Factors

Although financial factors are important in analyzing any company, nonfinancial factors are particularly important in the electric utility industry and may alter a credit assessment. The following nonfinancial factors are of particular importance to the utility industry: (1) regulation, (2) source of the company's energy, (3) growth and stability of the company's territory, (4) capital structure, (5) degree of activity in international and nonutility investments, and (6) competitive position.

To reflect the importance of nonfinancial factors, S&P utilizes a 10-point business risk assessment. In June 2004 S&P assigned new business profile scores to refine its assessment of relative risk among the utility and power companies. At that point the rating agency also divided the group into subsectors to allow more in-depth statistical analysis of the distribution of its ratings and its rating changes. The subsectors are Transmission and Distribution—Water, Gas, and Electric; Transmission Only—Electric, Gas, and Other; Integrated Electric, Gas, and Combination Utilities; Diversified Energy and Diversified Non-Energy; and Energy Merchant/Developers/Trading and Marketing.

Regulation

The utility industry includes both regulated and unregulated entities. In some cases, the two types coexist as subsidiaries within a single corporate structure. Power generation has been deregulated in some states, with merchant power companies selling electricity at competitive rates, but remains regulated in others. The transmission segment remains highly regulated. Retail distribution is deregulated, with consumers free to choose their providers based on such factor as price and quality of service.

For regulated entities, regulation is perhaps the most important credit analysis variable. Regulators, operating mainly at the state level, largely determine how much profit these businesses earn and retain. If a company has regulated operations in more than one state, the analyst should weight the evaluation of the regulatory environment by the revenues generated in each state. Evaluating regulatory commissions is a dynamic process.

The evaluation of regulatory commissions is a dynamic process. The composition of commissions changes because of retirements, appointments, and elections. The implications of personnel changes are not clear until decisions are made. For example, it is not always the case that elected commissioners are pro-consumer and appointments by a conservative governor are pro-business. Several brokerage firms can assist in evaluations of commissions.

In addition, the Federal Energy Regulatory Commission (FERC) regulates interstate operations and the sale of wholesale power. Currently, FERC regulation

is considered to be somewhat more favorable than that of the average state regulatory commission.

Utilities that are constructing or operating nuclear reactors are also subject to the regulation of the Nuclear Regulatory Commission (NRC). The NRC has broad regulatory and supervisory jurisdiction over the construction and operation of nuclear reactors. Importantly, the NRC approves licensing of nuclear reactors, as well as the transfer of licenses.

Regulation is best quantified by recent rate decisions and the trend of these decisions. Although a company being analyzed may not have had a recent rate case, the commission's decisions for other companies operating within the state may be used as a proxy. Regulatory commissions are either appointed or elected. In either case, the political atmosphere can have a dramatic effect on the trend of decisions.

The regulators determine innumerable issues in a rate decision, although analysts often mistakenly focus only on the allowed rate of return on equity or the percentage of request granted. For example, a commission might rule that an electric utility must reduce rates by 10%. However, if the commission allows the utility to accelerate its depreciation, the negative effect on the cash flow of the company from the rate reduction may be largely offset, particularly if the company had been or was expected to exceed its allowed ROE. The commissions also determine how much of construction work in progress (CWIP) is allowed into the rate base. A company may appear to have a favorable allowed ROE but be hurt by the fact that only a small portion of the company's capital is permitted to earn that return, and the CWIP earns nothing. Allowance of CWIP in the rate base was of critical importance during the 1980s because of the high construction budgets for nuclear generating plants and the length of time these plants were under construction. Some companies have had more than half their capital in CWIP that was not permitted to earn a return.

The importance of whether CWIP is allowed in the rate base is highlighted by the financial distress and January 1988 bankruptcy filing of Public Service Company of New Hampshire (PSNH). PSNH's Seabrook Nuclear Unit I was virtually complete in 1986. However, licensing delays and New Hampshire's statutory prohibition of CWIP in the rate base were major contributing factors in the bankruptcy filing.

In addition, regulators have a high degree of control over the cash flow of a company through the allowance or disallowance of accounting practices and the speed with which decisions are made on cases.

Source of the Company's Energy

The source of the company's energy is a second important variable, with the impact on fuel cost being especially important for merchant generators. Each fuel must be evaluated in the context of the overall cost of operating a plant. For many years, nuclear generation was out of favor because of extensive licensing requirements, high capital costs, and heavy decommissioning expenses. Companies with

large dependence on nuclear power were viewed less favorably than those with natural gas or coal units. More recently, nuclear-based generation companies have gained popularity among investors as they have written down their capital costs, while coal has suffered from escalating pollution concerns and the cost of oil and natural gas has risen. Additionally, in the mid 2000s, a number of nuclear-powered utilities were successful in their requests for 20-year license renewals.

Growth and Stability of the Company's Territory

The energy-source variable relates to a third variable—the growth and stability of the company's territory. Although above-average growth is viewed positively in an industrial company, above-average growth gets mixed reviews with respect to an electric utility. An electric utility with above-average growth may face construction earlier than its competitors depending on the supply/demand balance and regulation in its service territory.

Slow growth is not necessarily positive if it places a utility in a position of excess capacity. The increase in cogeneration and the mergers executed in order to better match supply and demand can place a utility at risk. This can result if utility A is selling power to utility B. If the expiration of the contract coincides with utility B's ability to purchase power for less and results in utility B's nonrenewal of the contract, utility A may be negatively affected unless it can sell the power to a third utility. The issue of growth has been complicated by deregulation and the requirement in many states for disaggregation of generation from transmission and distribution, as well as the requirement that customers be allowed to choose their supplier. In this new era, utilities engaged in generation must be able to match supply and demand for power.

Corporate Structure

A fourth variable, whether or not a company is a subsidiary of a holding company, also should be considered. Holding-company status permits nonutility subsidiaries, but these subsidiaries (even if successful) will not necessarily improve the overall credit quality of the company. This depends on the regulatory atmosphere. Furthermore, when there are several electric utility subsidiaries, the parent is more likely to give relatively large equity infusions to the relatively weak subsidiaries. The stronger subsidiary may have to support the other subsidiaries. Finally, holding companies should be analyzed in terms of consolidated debt. Although a particular subsidiary may have relatively strong financial parameters, off-balance-sheet financing may lower the overall assessment.

Competitive Position

A final nonfinancial factor is the competitive position of a utility. An electric utility with a comparatively low rate structure is generally in a stronger position politically to request rate increases or to request a rate freeze than one with rates higher than national averages and particularly one with rates higher than regional averages.

The competitive position of an electric utility is increasingly important as customer choice increases. Companies with high overall rates, and particularly those with high commercial rates, may find themselves losing customers as access to transmission and distribution lines increases.

Financial Analysis

The changing competitive nature of the electric industry resulting from deregulation requires that the traditional evaluation of an electric utility be modified. Although historic ratio analysis still should be conducted, an electric company also should be evaluated in the context of its new competitive situation. Is new generation being constructed in its territory that produces energy at a lower cost than the established generation? How does the company plan to expend its excess cash flow? In an era of consolidation, will the company be acquired or be an acquirer? Will the company remain in generation or sell its generation and deal solely with transmission and distribution? Location is also important. Some merchant power plants have been constructed too far from the power grid to succeed.

The following major financial ratios should be considered in analyzing an electric utility: (1) leverage, (2) pretax interest coverage, (3) cash-flow/capital expenditures, and (4) cash flow/capital.

Leverage

In calculating the debt leverage of an electric utility, long-term debt/capitalization is standard. However, the amount of short-term debt also should be considered because this is generally variable-rate debt. A high proportion of short-term debt also may indicate the possibility of the near-term issuance of long-term bonds. In addition, several companies guarantee the debt of subsidiaries (regulated or nonregulated). The extent of these guarantees should be considered in calculating leverage.

Fixed-charge coverage for the electric utilities is low relative to coverage for industrial companies. This is accepted by investors because of the stability of the industry. However, emphasis should be placed not only on the exact coverage figures but also on the trend and quality of the coverage.

A third important ratio is net cash-flow/capital expendures. This ratio should be approximated for three years (the typical electric company's construction forecast). The absolute level, as well as the trend of this ratio, gives important insights into the trend of other financial parameters. An improving trend indicates that construction spending probably is moderating, whereas a low net cash flow/spending ratio may indicate inadequate rates being approved by the commissions and a heavy construction budget. Estimates for construction spending are published in the company's annual reports. Although these are subject to revision, the time involved in building generation makes these forecasts reasonably reliable. In calculating cash flow, the standard definition outlined earlier

should be followed. However, allowance for funds used during construction (AFUDC) also should be subtracted.

FINANCE COMPANIES

Finance companies are essentially financial intermediaries. Their function is to purchase funds from public and private sources and to lend them to consumers and other borrowers of funds. Finance companies earn income by maintaining a positive spread between what the funds cost and the interest rate charged to customers. The finance industry is highly fragmented in terms of type of lending and type of ownership. This section will briefly outline the major sectors in the industry and then discuss the principal ratios and other key variables used in the analysis of finance companies.

Segments within the Finance Industry

The finance industry can be segmented by type of business and ownership. Finance companies lend in numerous ways in order to accommodate the diverse financial needs of the economy. Five of the major lending categories are (1) sales finance, (2) commercial lending, (3) wholesale or dealer finance, (4) consumer lending, and (5) leasing. Most often companies are engaged in several of these lines rather than one line exclusively. Sales finance is the purchase of third-party contracts that cover goods or services sold on a credit basis. In most cases, the sales finance company receives an interest in the goods or services sold. Commercial finance is also generally on a secured basis. However, in this type of financing, the security is most often the borrower's accounts receivable. In factoring, another type of commercial lending, the finance company actually purchases the receivables of the company and assumes the credit risk of the receivables.

Dealer or wholesaler finance is the lending of funds to finance inventory. This type of financing is secured by the financed inventory and is short term in nature. Leasing, on the other hand, is intermediate- to long-term lending—the lessor owns the equipment, finances the lessee's use of it, and generally retains the tax benefits related to the ownership.

Consumer lending historically has involved short-term, unsecured loans of relatively small amounts to individual borrowers. In part because of the more lenient bankruptcy rules and higher default rates on consumer loans, consumer finance companies have dramatically expanded the percentage of their loans for second mortgages. The lower rate charged to individuals for this type of loan is offset by the security and lower default risk of the loan.

There are numerous other types of lending in addition to those just described. Among these are real estate lending and export/import financing.

The ownership of a finance company can significantly affect evaluation of the company. In some instances, ownership is the most important variable in the analysis.

There are three major types of ownership of finance companies: (1) captives, (2) wholly owned, and (3) independents.

Captive finance companies, such as Ford Motor Credit, are owned by the parent corporation and are engaged solely or primarily in the financing of the parent's goods or services. Generally, maintenance agreements exist between the parent and the captive finance company under which the parent agrees to maintain one or more of the finance company's financial parameters, such as fixed-charge coverage, at a minimum level. Because of the overriding relationship between a parent and a captive finance subsidiary, the financial strength of the parent is an important variable in the analysis of the finance company. However, captive finance companies can have ratings either above or below those of the parent.

A wholly owned finance company differs from a captive in two ways. First, it primarily finances the goods and services of companies other than the parent. Second, maintenance agreements between the parent and the subsidiary generally are not as formal. Frequently, there are indenture provisions that address the degree to which a parent can upstream dividends from a finance subsidiary. The purpose of these provisions is to prevent a relatively weak parent from draining a healthy finance subsidiary to the detriment of the subsidiary's bondholders.

Independent finance companies are either publicly owned or closely held. Because these entities have no parent, the analysis of this finance sector is strictly a function of the strengths of the company.

Financial Analysis

In analyzing finance companies, several groups of ratios and other variables should be considered. There is more of an interrelationship between these ratios and variables than for any other type of company. For example, a finance company with a high degree of leverage and low liquidity may be considered to be of high investment quality if it has a strong parent and maintenance agreements. Variables should be viewed not in isolation but rather within the context of the whole finance company–parent company relationship.

Asset Quality

The most important variable in analyzing a finance company is asset quality. Unfortunately, there is no definitive way to measure asset quality. However, there are several variables that in the aggregate present a good indication of asset quality.

Diversification is one measure of portfolio quality. Is the portfolio diversified across different types of loans? If the company is concentrated in or deals exclusively in one lending type, is there geographic diversification? A company that deals exclusively in consumer loans in the economically sensitive Detroit area would not be viewed as favorably as a company with broad geographic diversification. Accounting quality is also an important factor in

assessing portfolio quality. The security for the loans is also an important variable in portfolio quality. The stronger the underlying security, the higher is the loan quality. Analysts should be concerned primarily with the level of loans compared with levels of similar companies and the risk involved in the type of lending. For example, the expected loan loss from direct unsecured consumer loans is higher than for consumer loans secured by second mortgages. However, the higher fees charged for the former type of loan should compensate the company for the higher risk.

Numerous ratios of asset quality such as loss reserves/net charge-offs, net losses/average receivables, and nonperforming loans/average receivables give good indications of asset quality. However, finance companies have a high level of discretion in terms of what they consider and report to be nonperforming loans and what loans they charge off. Therefore, unadjusted ratios are not comparable among companies. In addition, companies periodically change their charge-off policies.

Despite the drawbacks of the asset-quality ratios, they are useful in indicating trends in quality and profitability. Of these ratios, loss reserves/net charge-offs is perhaps the most important ratio in that it indicates how much cushion a company has. A declining ratio indicates that the company may not be adding sufficient reserves to cover future charge-offs. Such a trend may lead to a future significant increase in the reserves and therefore a decrease in earnings as the increase is expensed. Net losses/average receivables and nonperforming loans/average receivables are other indicators of asset quality. An increasing ratio indicates a deterioration in quality. Declines may be exacerbated by an overall contraction or slow growth in the receivables. On the other hand, because of different accounting treatments, a stable net losses/average receivables ratio under deteriorating economic conditions may indicate a delay in loss recognition. Consideration also should be given to the age of receivables. In recent years, some finance companies have increased their lending dramatically over a short period of time and reported material improvement in their overall financial parameters. These results have been misleading in some cases where the dramatic improvement has been driven by inadequate reserves. Often the dramatic improvement has been followed by increased losses as the portfolio ages.

The long-term history of a company is also an indicator of credit quality. Does management have a history of managing risk conservatively? How long has management been in place? Is there pressure on management to accelerate growth? Has management responded to this type of pressure by expanding into more risky businesses either through acquisition or internal expansion?

Leverage

Leverage is a second important ratio used in finance company analysis. By the nature of the business, finance companies typically and acceptably are more highly leveraged than industrial companies. The leverage is necessary to earn a sufficient return on capital. However, the acceptable range of leverage depends on

other factors, such as parental support, portfolio quality, and type of business. The principal ratio to determine leverage is total debt to equity, although such variations as total liabilities to equity also may be used. In a diversified company with high portfolio quality, a leverage ratio of 5 to 1 is acceptable. On the other hand, a ratio as high as 7 to 1 is acceptable for a captive with a strong parent and maintenance agreements. The analyst always should view the leverage of a finance company in comparison with similar companies.

Liquidity

The third important variable in finance company analysis is liquidity. Because of the capital structure of finance companies, the primary cause of bankruptcies in this industry is illiquidity. If for some reason a finance company is unable to raise funds in the public or private market, failure can follow quickly. This inability to raise funds could result from internal factors, such as a deterioration in earnings, or from external factors, such as a major disruption in the credit markets. Whatever the cause, a company should have some liquidity cushion. The ultimate fallback, a sale of assets, is only a last resort because the sales could have long-term detrimental effects on earnings. The traditional liquidity ratio is cash, cash equivalents, and receivables due within one year divided by short-term liabilities. The higher this ratio, the higher is the margin of safety. Also to be considered are the liquidity of the receivables themselves and the existence of bank lines of credit to provide a company with short-term liquidity during a financial crisis. Liquidity calculations also should consider contractual obligations to fund loans. In general, the smaller and weaker companies should have a higher liquidity cushion than companies with strong parental backing that can rely on interest-free loans from their parents in times of market stress. Finally, analysts should take into account a company's ability to raise secured funding, either from banks or private investors or through asset-backed securities facilities.

Asset Coverage

A fourth important variable in the analysis of finance companies that is related to the three variables just discussed is the asset coverage afforded the bondholder. In assessing asset protection, the analyst should consider the liquidation value of the loan portfolio.

A definitive assessment of the value of assets is difficult because of the flexibility finance companies have in valuing assets. For example, a finance company that plans to liquidate its commercial real estate portfolio over 12 months in a depressed real estate environment will value its assets much lower than if it planned to sell the same assets systematically over a three- to five-year period. The value of interest-only securities (IOs) created from a finance company's asset securitizations is also subjective and depends on future credit experience and prepayments. Is management conservative or aggressive in valuing these instruments? How has management valued the residuals of automobile leases? Are there periodic write-offs or gains on these loans?

Earnings Record

The fifth variable to be considered is the finance company's earnings record. The industry is fairly mature and is somewhat cyclical. The higher the annual EPS growth, the better. However, some cyclicality should be expected. In addition, the analyst should be aware of management's response to major changes in the business environment. The easing of personal bankruptcy rule over the years and the fact that personal bankruptcy is becoming more socially acceptable have produced significantly higher loan losses in direct, unsecured consumer loans. Many companies have responded to this change by contracting their unsecured personal loans and expanding their portfolios invested in personal loans secured by second mortgages.

Management

The sixth variable to be considered is the finance company's management. This variable is difficult to assess. However, a company visit combined with an evaluation of business strategies and credit scoring methodologies (analysis used for assessing loan applicants) will provide some insight into this variable.

Size

A final factor related to the finance company or subsidiary is size. In general, larger companies are viewed more positively than smaller companies. Size has important implications for market recognition in terms of selling securities and of diversification. A larger company can more easily diversify the types and geographical location of its loans, thereby lessening the risk of its portfolio, than a smaller company can.

In addition to an analysis of the financial strength of the company according to the preceding variables, the analyst must incorporate the net effect of any affiliation the finance company has with a parent. If this affiliation is strong, it may be the primary variable in the credit assessment. The affiliation between a parent company and a finance subsidiary is straightforward; it is captive, wholly owned, or independent. However, the degree to which a parent will support a finance subsidiary is not as straightforward. Traditionally, the integral relationship between a parent and a captive finance subsidiary has indicated the highest level of potential support. However, it is becoming increasingly clear that a wholly owned finance subsidiary can have just as strong an affiliation. For example, General Electric Capital finances few or no products manufactured by its parent, General Electric Company (GE). GE, however, receives substantial tax benefits from its consolidation of its tax return with GE Capital. Additionally, GE has a sizable investment in the finance subsidiary. In this case, the parent also has a formal agreement with GE Capital by which it is committed to infuse capital if fixed charge coverage of $1.1 \times$ is not maintained. Even aside from that mechanism, there is a strong presumption that GE would protect its investment in GE Capital if the finance subsidiary were to need assistance. In other cases, the benefit of a strong affiliation and maintenance agreement may be offset by weakness in the parent company's financial position.

In addition to affiliation, affiliate profitability, and maintenance agreements, the analyst also should examine any miscellaneous factors that could affect the credit standing of the finance company. For example, new legislation could produce significant changes in the finance industry's structure or profitability. Cases in point of recent years include the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 and the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010.

THE ANALYSIS OF HIGH-YIELD CORPORATE BONDS

High-yield bonds, sometimes disparagingly referred to as "junk bonds," are corporate issues rated speculative grade (below Baa/BBB–). Like all corporate bonds, they combine interest rate risk with credit risk, but unlike investment-grade issues, credit risk dominates their price movements. The high-yield universe is split between fallen angels, which are bonds rated investment-grade at issuance and subsequently downgraded to speculative grade, and original issue high-yield bonds that were rated speculative grade at issuance. Fallen angels have the disadvantage of the looser covenants associated with their original ratings. In many cases, however, they are run by managers who are strongly motivated to recapture their investment-grade ratings through prudent financial policies that can lead to upgrading. Original issue high-yield bonds offer the advantage of stronger covenants and in some cases, the possibility that as comparatively new issuers that are not yet widely known, they are underrated by the rating agencies and undervalued by bond investors.

Many of the tools employed in evaluating investment-grade bonds can also be applied to high-yield issues, but the emphasis of the analysis is different. In contrast to the investment-grade universe, where it is extremely rare for a company to go directly to default, an average of more than 4% of speculative grade issuers default each year.[5] As a consequence, high-yield analysts must focus intensely on the downside in a company's operations, its sources of liquidity, and the salvage value of its assets in the event of default.

The price of a company's high-yield bonds, like its stock price, can be highly sensitive to minor changes in the earnings outlook. High-yield analysts therefore operate much as equity analysts do in participating in companies' earnings calls and tracking industry data that may shed light on future profits. They go beyond their equity counterparts in studying the details of the issuers' funding capability and covenant provisions, which become highly pertinent under conditions of financial stress.

The following sections address aspects of credit analysis that require expanded attention in the analysis of high-yield corporate bonds.

5. Source: Moody's Investors Service.

Competition

In the popular mind, high-yield companies are small players in their markets, yet over the years there have been many exceptions to this stereotype. Examples include the three largest U.S. automakers (General Motors, Ford Motor Company, and Chrysler), the world's largest operator of health care facilities (HCA), and the world's largest casino operator (Caesars Entertainment). Size does not automatically confer a competitive advantage, nor do smaller companies invariably report inferior profit margins due to a lack of scale economies. Instead of participating in all market segments, including mature and highly competitive ones, some small companies manage to carve out highly profitable niches. They do not strive to minimize unit costs by maximizing volume, but instead obtain premium prices by offering superior selection or convenience.

By the same token, analysts should not accept at face value the glib assertions of high-yield market promoters that the rating agencies arbitrarily and mistakenly penalize companies for being small. The agencies do not rate companies speculative grade because they are small, but rather because of certain consequences of their smallness.

Some small companies lack geographical diversification and are therefore highly vulnerable to a regional economic downturn. Others have no credible succession plans in place because domination by strong-willed founders makes it difficult for them to attract and retain capable candidates at the next level of management. Neither should analysts assume, as private equity firms probably would like them to, that a high level of equity ownership by key employees is so powerful a motivator that corporate failure is inconceivable.

Cash Flow

One of the most important elements in analyzing a high-yield security is cash flow. In recent years, analysts have concentrated increasingly on *free cash flow* (FCF), defined as cash flow from operations minus capital expenditures. FCF can be calculated as follows:

EBIT × (1 – Tax Rate)
+ Depreciation and Amortization
– Changes in Working Capital
– Capital Expenditures
= Free Cash Flow

A company that generates free cash flow is not dependent on external financing and therefore should not be stymied by a temporary unavailability of credit. In addition, FCF generators are best positioned to refinance maturing debt during periods when capital markets are open, but only to the strongest high-yield

borrowers. For a company in this select group, investors theoretically need concern themselves only with the risk that positive FCF generation will prove unsustainable.

The rise in popularity of free cash flow is partly a reaction to abuse of a popular cash-flow proxy of earlier decades, EBITDA. In the 1990s, competition for deals pushed the debt loads on leveraged buyouts (LBOs) to an extreme that made issuers look very weak by standard financial ratios such as EBITDA/Interest Expense. Underwriters responded by promoting "adjusted EBITDA." The newfangled ratio conveniently eliminated the impact of operating losses that were deemed to reflect "restructurings," which was too often a euphemism for failed investments. Even before this distortion of reality became common, EBITDA had serious shortcomings as a cash-flow measure by virtue of ignoring capital expenditures and working capital requirements. These are essential cash uses that a company may have difficulty funding in a period of tight credit.

For all its faults, EBITDA remains the high-yield market's standard for calculating leverage. Analysts view a company's total debt outstanding as some number of "turns" of EBITDA. Suppose, for instance, that a company's debt is equivalent to four × its EBITDA at a time when corporate buyers and LBO sponsors are paying six × EBITDA to acquire comparable companies. Bondholders will feel comfortable that in the event of default they will fully recover their principal from the proceeds of a sale of the company in bankruptcy. As with free cash flow, the key assumption is that the level of cash generation will not fall. Proceeds equivalent to six × a greatly reduced EBITDA will not be as great as the company's debt load.

Net Assets

In analyzing a bond, the analyst must ascertain or at least approximate the liquidation value of the assets. Are these assets valued properly on the balance sheet? Of particular interest may be real estate holdings. For example, in analyzing the gaming companies, a market assessment of land holdings should be included. On the other hand, one also should consider the likelihood of those assets being available for liquidation, if necessary. To whom do they belong? Are they mortgaged or being used as collateral? Assets are occasionally spun off to the equity owners of the company. In such a circumstance, the bondholders may experience a sudden and dramatic deterioration of credit quality. Other bondholders are secured by specific assets such as railroad cars or a nuclear power station. In these circumstances, the value and marketability of the collateral must be ascertained. Collateral, by definition, must be specific, and so must be the analysis. Ten railroad engines may appear to provide adequate collateral until it is discovered that the engines are not only obsolete but have not been maintained for a number of years. Five aircraft may appear to be adequate collateral until it is discovered that the engines were financed separately and do not constitute collateral.

Particular attention must be paid to the asset protection in a takeover situation. In this instance, assets that originally provided protection for an investor's holdings could be used to secure new debt senior to the investor's position.

The analyst also must focus on the location of the assets. If the assets are in a foreign country, the analyst should be familiar with that country's laws regarding expatriation of funds. In the extreme case, the analyst should be familiar with that country's laws regarding bankruptcy proceedings. Notwithstanding high-yield investors' traditional claim that they focus on the verifiable values of hard assets, it is in fact common to attribute substantial value to certain items that do not even qualify as assets under generally accepted accounting principles. For example, media and telecommunications companies are often evaluated by attributing a dollar amount to each customer or potential customer. Current valuations may be justified by the prices being paid for comparable properties in mergers and acquisitions transactions. In the future, however, the value of these unofficial assets may evaporate as new technologies emerge to provide communications services more cheaply or more effectively. There is also a risk that if a company becomes financially distressed its existing customers (particularly business customers) may switch to other providers.

Management

Management is a critical element in the assessment of any company. Given enough time, poor management can bankrupt the most prosperous enterprise. Conversely, good management is essential to the long-run survival of all firms.

Many successful firms are launched by the top engineers or salespeople at industry-leading firms. They may bring strong talent and motivation, but analysts must evaluate the entire team to ensure that all key functions are in capable hands. Does the company have a strong financial manager? Are proper controls in place? Incentives can also play a significant role in determining a company's long-run success. Ownership of a significant portion of the company by management is generally a positive, if not necessarily a panacea.

There are two principal ways to evaluate management. The first is to judge the team by its results. This is accomplished through financial analysis. The second way is to meet with senior managers to judge first-hand their vision for the firm as well as their understanding of the business. This is achieved by attending new-financing road shows, as well as arranging one-on-one meetings where possible, and participating in companies' quarterly earnings calls.

An analyst must be well-prepared for meetings with management. Lack of preparation creates the risk of being swayed by a slick presentation that lacks true substance. In one presentation to potential bond investors, the senior management of a company that manufactured gas pump nozzles stated that European operations would generate major growth because of increased environmental requirements to reduce gasoline fumes at service stations. In an effort to estimate the potential for this new revenue opportunity, an analyst asked management to

discuss the state of European environmental laws and how they differed from laws in the United States. Management was unable to answer the question. The company subsequently filed for bankruptcy.

Leverage

Companies that issue high-yield bonds generally are highly leveraged. Leverage per se is not harmful and in many circumstances is beneficial to growth. However, the degree of leverage should be evaluated in terms of its effect on the financial flexibility of the firm. As pointed out earlier, leverage should be calculated on absolute and market-adjusted bases. The most common approach to market adjustment is to calculate a market value for the equity of the firm. To the extent that the common stock is selling below book value, leverage will be understated by a traditional approach. Some firms also adjust the market value of debt in calculating leverage. This approach is interesting, but a consistent approach must be employed when convertibles are considered in the equity equation. The benefit of adjusting the equity side of the leverage equation is clear. As the market values a company's equity upward, the market is indicating a willingness to support more leverage. A similar increase in the market adjustment of a firm's debt may indicate an upward appraisal of creditworthiness or an overall lowering of interest rates. In either case, the company probably would have the opportunity to refinance at a lower cost and thereby increase profitability.

Care also should be taken to evaluate sources of leverage that are not stated clearly on the balance sheet. These sources arise from the use of complicated financings.[6] For example, consider deferred-coupon bonds that are commonly used by high-yield issuers. Deferred-coupon bonds permit the issuer to postpone interest payment to some future year. As a result, the interest burden is placed on future cash flow to meet the interest obligations. Because of this burden, the presence of deferred-coupon bonds may impair the ability of the issuer to improve its credit quality in future periods. Moreover, if senior bonds have deferred-coupon payments, the subordinated bonds will be adversely affected as the amount of senior bonds increases over time relative to the amount of subordinated bonds. For example, one type of deferred-coupon bond that has been widely used in some years is the payment-in-kind (PIK) bond. With this bond structure, a high-yield issuer has the option either to pay interest in cash or pay the equivalent of interest with another bond with the same coupon rate. If the issuer does not have the ability to pay the interest in cash, payment with another bond will increase future interest expense and thereby adversely affect the issuer's future cash flow. If the PIK bonds are senior bonds, subordinated bonds are adversely affected over time as more senior bonds are added to the capital structure and future interest expense is increased further.

6. William A. Cornish, "Unique Factors in the Credit Analysis of High-Yield Bonds," in Frank K. Reilly (ed.), *High-Yield Bonds: Analysis and Risk Assessment* (Charlottesville, VA: Association for Investment Management and Research, 1990).

Corporate Structure

High-yield issuers usually have a holding-company structure. The assets to pay creditors of the holding company will come from the operating subsidiaries. It is therefore, critical to analyze the corporate structure. Specifically, the analyst must understand how cash will be passed between subsidiaries and the parent company and among the subsidiaries. The corporate structure may be so complex that the payment structure becomes confusing.

For example, in the mid 2000s Charter Communications created a dizzyingly complex corporate structure. The cable television systems operator capitalized on its rapidly growing EBITDA to create and further leverage a succession of new intermediate holding companies. Eventually, the operating subsidiaries stood beneath a parent operating company and eight layers of holding companies with names such as Charter Communications Holding Company, LLC, Charter Communications Holdings, LLC, and CCH I Holdings, LLC.

Simply calculating financial ratios for the consolidated company did not produce an accurate picture of Charter's debt-servicing capability. Each holding company's ability to make interest payments depended on dividends from the companies positioned below it on the corporate totem pole. Those companies could not lawfully pay dividends before meeting their own debt service requirements and they were further constrained by restrictions, tied to leverage covenants, on upstreaming of dividends. This was an especially acute concern for holders of a convertible bond of the ultimate holding company, Charter Communications, Inc. (CCI).

Charter kept its highly leveraged web of companies solvent by frequently tapping the capital markets to retire maturing debt. Extensive intercompany loans further complicated the picture. The game ended when a financial crisis shut the markets down. Charter filed for bankruptcy in 2009 and the importance of mastering the intricacies of high-yield analysis once again became apparent. Senior secured lenders at the parent operating company and at the holding companies just above it, who were closest to the assets, recovered 100% of their principal. In contrast, note holders at some of the more remote holding companies recovered negligible amounts. Somewhat anomalously, convertible bond holders at CCI, who were furthest of all from the assets, enjoyed a higher percentage recovery than creditors of some intermediate holding companies. This was achieved partly with cash proceeds of the sale of the convertible issue, which had been retained at CCI to cover interest payments.

Covenants

While an analyst should consider covenants when evaluating any bond issue (investment-grade or high-yield), it is particularly important for the analysis of high-yield issuers. The importance of understanding covenants was summarized by one high-yield portfolio manager as follows:

> Covenants provide insight into a company's strategy. As part of the credit process, one must read covenants within the context of the corporate strategy. It is not sufficient to hire a lawyer to review the covenants because a lawyer might miss the critical factors necessary to make the appropriate decision. Also, loopholes in covenants often provide clues about the intentions of management teams.[7]

Note, however, that some specialized consulting firms offer assistance in interpreting covenants, combining financial sophistication with legal expertise.

Definitions

Great care must be paid to definitions. As discussed earlier with respect to cash flow, definitions can materially skew cash-flow projections. When asked to define certain terms, management often will state that its definitions are "standard." There is no standard definition.

Definitions also should be evaluated in covenants. For example, a "change of control" typically triggers a 101% put option for the bondholder, but the term does not necessarily refer to all changes in controlling interest in the company. A change of control may be defined to include an acquisition of the company but not a merger (in which the company's separate corporate structure disappears). In some cases, acquisition by a major existing shareholder is excluded from the definition.

CREDIT SCORING MODELS

To this point in the chapter, the focus has been on traditional ratios and other measures that credit analysts use in assessing default risk. Several researchers have used these measures as input to assess the default risk of issuers using the statistical technique of multiple discriminant analysis (MDA). This tool is primarily a classification technique that is helpful in distinguishing between or among groups of objects and in identifying the characteristics of objects responsible for their inclusion in one or another group. One of the chief advantages of MDA is that it permits a simultaneous consideration of a large number of characteristics and does not restrict the investigator to a sequential evaluation of each individual attribute. For example, MDA permits a credit analyst studying ratings of corporate bonds to examine, at one time, the total and joint impact on ratings of multiple financial ratios, financial measures, and qualitative factors. The analyst is thereby freed from the cumbersome and possibly misleading task of looking at each characteristic in isolation from the others. MDA seeks to form groups that are internally as similar as possible but that are as different from one another as possible.

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7. Robert Levine, "Unique Factors in Managing High-Yield Bond Portfolios," in *High-Yield Bonds: Analysis and Risk Assessment*. p. 35.

From the preceding description of MDA it can be seen why it has been applied to problems of why bonds get the ratings they do and what variables seem best able to account for a bond's rating. Moreover, MDA has been used as a predictor of bankruptcy. While the steps involved in MDA for predicting bond ratings and corporate bankruptcies are a specialist topic, the following discussion addresses the results of the work of Edward Altman, the primary innovator of MDA for predicting corporate bankruptcy.[8] The models of Altman and others involved in this area are updated periodically. Here the purpose is only to provide an illustration of how MDA models work.

In one of Altman's earlier models, referred to as the "Z-score model," he found that the following MDA could be used to predict corporate bankruptcy.[9]

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5$$

where

X_1 = working capital/total assets (in decimal)
X_2 = retained earnings/total assets (in decimal)
X_3 = earnings before interest and taxes/total assets (in decimal)
X_4 = market value of equity/total liabilities (in decimal)
X_5 = sales/total assets (number of times)
Z = Z-score

Given the value of the five variables for a given firm, a Z-score is computed. The Z-score is used to classify firms with respect to whether or not there is potentially a serious credit problem that would lead to bankruptcy. Specifically, Altman found that Z-scores of less than 1.81 indicated a firm with serious credit problems, whereas a Z-score in excess of 3.0 indicated a healthy firm.

Subsequently, Altman and his colleagues revised the Z-score model based on more recent data. The resulting model, referred to as the "zeta model" found that the following seven variables were important in predicting corporate bankruptcies and were highly correlated with bond rating:[10]

- Earnings before interest and taxes (EBIT)/total assets
- Standard error of estimate of EBIT/total assets (normalized) for 10 years
- EBIT/interest charges
- Retained earnings/total assets

8. See Chapters 8 and 9 in Edward I. Altman, *Corporate Financial Distress and Bankruptcy: A Complete Guide to Predicting and Avoiding Distress and Profiting from Bankruptcy*, 2d ed. (Hoboken, NJ: Wiley, 1993).
9. Edward I. Altman, "Financial Bankruptcies, Discriminant Analysis and the Prediction of Corporate Bankruptcy," *Journal of Finance* (September 1968), pp. 589–609.
10. Edward I. Altman, Robert G. Haldeman, and Paul Narayann, "Zeta Analysis: A New Model to Identify Bankruptcy Risk of Corporations," *Journal of Banking and Finance* (June 1977), pp. 29–54.

- Current assets/current liabilities
- Five-year average market value of equity/total capitalization
- Total tangible assets, normalized

While credit scoring models have been found to be helpful to analysts and bond portfolio managers, they do have limitations as a replacement for human judgment in credit analysis. Quantitative models are effective in identifying companies that share certain characteristics with defaulting companies, but many of the companies identified by the models do not default. One thing a statistical model cannot readily spot is the possibility of bringing in new management that will turn the company around and prevent a default. Therefore, an investor who is faced with a potentially large loss on a distressed company may benefit from assessing a company's prospects for redirecting itself, rather than selling based solely on a quantitative score. In practice, professional high-yield bond and distressed-debt managers do not rely entirely on models such as the Z-score, but at most use them to supplement their own hands-on analysis.

KEY POINTS

- Credit analysis has evolved from exclusive focus on default risk in a buy-and-hold strategy to playing a role in active management of corporate bond portfolios.
- Equity-related information can help to create a systematic analysis, but it is important also to consider other determinants of credit risk.
- Key areas of a credit assessment include industry analysis, financial analysis, and indenture provisions.
- Analysis of high-yield, or speculative-grade, corporate bonds requires particular focus on the downside in a company's operations, its cash flow, and the quality of its management.
- Quantitative credit scoring models cannot replace hands-on credit analysis, but can usefully supplement it.

CHAPTER
FORTY-FOUR

THE CREDIT ANALYSIS OF MUNICIPAL GENERAL OBLIGATION AND REVENUE BONDS

SYLVAN G. FELDSTEIN, PH.D.
Director
Investment Department
Guardian Life Insurance Company of America

ALEXANDER GRANT
Portfolio Manager, RS Tax-Exempt and
RS High Yield Municipal Bond Funds

DAVID RATNER, CFA
Industry Consultant

The degree of safety of investing in municipal bonds has been considered second only to that of U.S. Treasury bonds, but beginning in the fourth quarter of the last century, ongoing concerns developed among many investors and underwriters about the potential default risks of municipal bonds.

One concern resulted from the well-publicized billion-dollar general obligation note defaults in 1975 of New York City. Not only did specific investors face the loss of their principal, but the defaults sent a loud and clear warning to municipal bond investors in general. The warning was that regardless of the supposedly ironclad legal protections for the bondholder, when issuers have severe budget-balancing difficulties, the political hues, cries, and financial interests of public employee unions, vendors, and community groups may be dominant forces in the initial decision-making process.

This reality was further reinforced by the new federal bankruptcy law that took effect on October 1, 1979, which makes it easier for municipal bond issuers to seek protection from bondholders by filing for bankruptcy. One by-product of the increased investor concern is that since 1975, the official statement, which is the counterpart to a prospectus in an equity or corporate bond offering and is to contain a summary of the key legal and financial security features, has become more comprehensive. As an example, before 1975 it was common for a city of New York

official statement for a general obligation bond sale to be only six pages long, whereas for a bond sale at the end of 2003 it was 165 pages long.

More recently, with the recession that began in December of 2007 and the well-publicized bond defaults of both Vallejo, California (in Chapter 9 under the U.S. Bankruptcy Code), and Harrisburg, Pennsylvania (considering a Chapter 9 filing) as well as the budgetary stresses of many large states and cities, the credit quality of municipal bonds has received increased attention.

The second reason for the increased interest in credit analysis was derived from the changing nature of the municipal bond market. It is now characterized by strong buying patterns by private investors and institutions. The patterns were caused in part by high federal, state, and local income tax rates. Tax-exempt bonds increasingly have become an important and convenient way to shelter income. One corollary of the strong buyers' demand for tax exemption has been an erosion of the traditional security provisions and bondholder safeguards that had grown out of the default experiences of the 1930s. General obligation bond issuers with high tax and debt burdens, declining local economies, and chronic budget-balancing problems had little difficulty finding willing buyers. Also, revenue bonds increasingly were rushed to market with legally untested security provisions, modest rate covenants, reduced debt reserves, and weak additional-bond tests. Because of this widespread weakening of security provisions, it has become more important than ever before that the prudent investor carefully evaluate the creditworthiness of a municipal bond before making a purchase.

This concern has been increased when the rating agencies in 2009 recalibrated their ratings upward on many general obligation and essential service revenue bonds. They argued that municipal bond issues probably should have slightly better ratings relative to corporate bonds in the context of both historical default rates and recovery levels following default. This resulted in higher ratings on many municipal bonds.

In analyzing the creditworthiness of a general obligation, tax-backed, or pure revenue bond, the investor should cover five categories of inquiry: (1) legal documents and opinions, (2) politics/management, (3) underwriter/financial advisor, (4) general credit indicators and economics, and (5) red flags, or danger signals.

The purpose of this chapter is to set forth the general guidelines that the investor should rely upon in asking questions about specific bonds.

THE LEGAL OPINION

Popular opinion holds that much of the legal work done in a bond issue is boilerplate in nature, but from the bondholder's point of view the legal opinions and document reviews should be the ultimate security provisions because, if all else fails, the bondholder may have to go to court to enforce his or her security rights. Therefore, the integrity and competency of the lawyers who review the documents and write the legal opinions that usually are summarized in the official statements are very important.

The relationship of the legal opinion to the analysis of municipal bonds for both general obligation and revenue bonds is threefold. First, the lawyer should check to determine whether the issuer is indeed legally able to issue the bonds. Second, the lawyer is to see that the issuer has properly prepared for the bond sale by enacting the various required ordinances, resolutions, and trust indentures and without violating any other laws and regulations. This preparation is particularly important in the highly technical areas of determining whether the bond issue is qualified for tax exemption under federal law and whether the issue has been structured in such a way as to not violate federal arbitrage regulations. Third, the lawyer is to certify that the security safeguards and remedies provided for the bondholders and pledged by either the bond issuer or third parties (such as banks with letter-of-credit agreements) are actually supported by federal, state, and local government laws and regulations.

General Obligation Bonds

General obligation bonds are debt instruments issued by states, counties, towns, cities, and school districts. They are secured by the issuers' general taxing powers. The investor should review the legal documents and opinion as summarized in the official statement to determine what specific *unlimited* taxing powers, such as those on real estate and personal property, corporate and individual income taxes, and sales taxes, are legally available to the issuer, if necessary, to pay the bondholders. Usually for smaller governmental jurisdictions, such as school districts and towns, the only available unlimited taxing power is on property. If there are statutory or constitutional taxing power limitations, the legal documents and opinion should clearly describe how they affect the security of the bonds.

For larger general obligation bond issuers, such as states and big cities that have diverse revenue and tax sources, the legal opinion should indicate the claim of the general obligation bondholder on the issuer's general fund. Does the bondholder have a legal claim, if necessary, to the first revenues coming into the general fund? This is the case with bondholders of state of New York general obligation bonds. Does the bondholder stand second in line? This is the case with bondholders of state of California general obligation bonds. Or are the laws silent on the question altogether? This is the case for most other state and local governments.

Additionally, certain general obligation bonds, such as those for water and sewer purposes, are secured in the first instance by user charges and then by the general obligation pledge. (Such bonds are popularly known as being "double barreled.") If so, the legal documents and opinion should state how the bonds are secured by revenues and funds outside the issuer's general taxing powers and general fund.

Revenue Bonds

Revenue bonds are issued for project or enterprise financings that are secured by the revenues generated by the completed projects themselves, or for general

public-purpose financings in which the issuers pledge to the bondholders tax and revenue resources that were previously part of the general fund. This latter type of revenue bond, sometimes known as a "dedicated tax bond," is usually created to allow issuers to raise debt outside general obligation debt limits and without voter approvals. The trust indenture and legal opinion for both types of revenue bonds should provide the investor with legal comfort in six bond-security areas:

- The limits of the basic security
- The flow-of-funds structure
- The rate, user-charge, or dedicated revenue and tax covenants
- The priority of pledged revenue claims
- The additional-bonds test
- Other relevant covenants and issues

The Limits of the Basic Security

The legal documents should explain what the pledged revenues for the bonds are and how they may be limited by federal, state, and local laws. The importance of this is that although most revenue bonds are structured and appear to be supported by identifiable revenue streams, those revenues sometimes can be negatively affected directly by other levels of government. For example, the state of Wyoming in the early 1980s issued Mineral Royalties Revenue Bonds. On the surface, the bond issue had all the attributes of a revenue bond. The bonds had a first lien on the pledged revenues, and additional bonds could only be issued if a coverage test of 125% was met. Yet the revenues to pay bondholders were to be received by the state from the federal government as royalty payments for mineral production on federal lands. The U.S. Congress was under no legal obligation to continue this aid program. Therefore, the investor must read carefully the legal documents to learn if there are shortcomings of the bond security.

More recently, in 2011 the governor of California proposed eliminating local redevelopment agencies and transferring their tax increment revenues to other purposes. In a worst-case scenario if all the revenues were taken away, there would be no monies left to pay the redevelopment agency bondholders. The governor did not propose this, but the legal documents should indicate that this could happen.

The Flow-of-Funds Structure

The legal documents should explain what the bond issuer has promised to do concerning the pledged revenues received. What is the order of the revenue flows through the various accounting funds of the issuer to pay for the operating expenses of the facility, payments to the bondholders, maintenance and special capital improvements, and debt service reserves? This sometimes is referred to as

the "waterfall." Additionally, the legal documents should indicate what happens to excess revenues after they pass through the waterfall. Do they go to the issuer's general fund or do they stay within the indenture to be used to call bonds or make capital repairs.

The flow of funds of many revenue bonds is structured as *net revenues* (i.e., debt service is paid to the bondholders immediately after revenues are paid to the basic operating and maintenance funds, but before paying all other expenses). A *gross revenues* flow-of-funds structure is one in which the bondholders are paid even before the operating expenses of the facility are paid. Examples of gross revenue bonds are those issued by the New York Metropolitan Transportation Authority. However, although it is true that these bonds legally have a claim to the fare-box revenues before all other claimants, it is doubtful that the system could function if the operational expenses, such as wages and electricity bills, were not paid first.

The Rate, User-Charge, or Dedicated Revenue and Tax Covenants

The legal documents should indicate what the issuer has legally committed itself to do to safeguard the bondholders. If user rates are involved do they only have to be sufficient to meet expenses, including debt service, known as one times debt service coverage. Is the one-time coverage test calculated for the *average annual debt* service requirement or for the higher *maximum annual debt service* one? Additionally, is the coverage requirement for higher amounts such as 1.1 times or 1.25 times so as to provide for reserves? The legal documents should indicate whether or not the issuer has the legal power to increase rates or charges of users without having to obtain prior approvals by other governmental units.

The Priority of Pledged Revenue Claims

The legal documents should state whether or not other levels of government or claimants can legally tap the revenues of the issuer even before they start passing through the issuer's flow-of-funds structure. An example would be the highway revenue bonds issued by the Puerto Rico Highway Authority. These bonds are secured in part by the revenues from the Commonwealth of Puerto Rico gasoline tax. Yet, if in a worst case scenario no other funds are available to pay their debt service, under the Commonwealth's constitution the moneys are first to be applied to the Commonwealth's own general obligation bonds.

The Additional-Bonds Test

The legal documents should indicate under what circumstances the issuer can issue additional bonds that share equal claims to the issuer's revenues. Usually, the legal requirement is that the maximum annual debt service on the new bonds as well as on the old bonds be covered by the projected net revenues by a specified minimum amount. This can be as low as one times coverage. Some revenue bonds have stronger additional-bonds tests to protect the bondholders. Also, how the historical revenues are calculated is important. Can the issuer select specific

prior months to be used such as 12 out of the last 15 months? Who determines the projection numbers for the future revenues? Is it an independent consultant with expertise in the area? How conservative are the projections and how are they certified? Additionally, the definition of revenues is important. Does it include revenues generated by the enterprise, or could it also include special supplemental payments? These are all questions that have to be addressed by the analyst in reviewing the additional bonds test formula.

Other Relevant Covenants and Issues

Lastly, the legal documents should indicate whether there are other relevant covenants for the bondholder's protection. These usually include pledges by the issuer of the bonds to insure the project (if it is a project-financing revenue bond), to have the accounting records of the issuer annually audited by an outside certified public accountant and provide timely reports to investors, and to employ independent engineers to annually review the capital plant and make mandatory recommendations to keep the facility operating for the life of the bonds.

In addition to the above aspects of the specific revenue structures of general obligation and revenue bonds, two other developments over the recent past make it more important than ever for the investor to carefully review the legal documents and opinions summarized in the official statements. The first development involves the mushrooming of new financing techniques that may rest on legally untested security structures. The second development is the increased use of legal opinions provided by local attorneys who may have little prior municipal bond experience. (Legal opinions traditionally have been written by experienced municipal bond attorneys.)

Legally Untested Security Structures and New Financing Techniques

In addition to the more traditional general obligation bonds and toll road, bridge, and tunnel revenue bonds, there are now more non-voter-approved, innovative, and legally untested security mechanisms. These innovative financing mechanisms include lease-rental bonds, moral obligation housing bonds, "dedicated tax-backed" and structured "asset-backed" bonds, take-and-pay power bonds with step-up provisions requiring the participants to increase payments to make up for those that may default, commercial bank-backed letter-of-credit "put" bonds, and tax-exempt commercial paper. What distinguishes these newer bonds from the more traditional general obligation and revenue bonds is that they have little history of court decisions and other case law to firmly protect the rights of the bondholders. For the newer financing mechanisms, the legal opinion should include an assessment of the probable outcome if the bond security were challenged in court. Note, however, that most official statements do not provide this to the investor.

The Need for Reliable Legal Opinions

For many years, concern over the reliability of the legal opinion was not as important as it is now. As a result of the numerous bond defaults and related shoddy legal opinions in the nineteenth century, the investment community demanded that legal documents and opinions be written by recognized municipal bond attorneys. As a consequence, over the years, a small group of primarily Wall Street-based law firms and certain recognized firms in other financial centers dominated the industry and developed high standards of professionalism.

Now, however, more and more issuers have their legal work done by local law firms, a few of whom have little experience in municipal bond work. This development, along with the introduction of more innovative and legally untested financing mechanisms, has created a greater need for reliable legal opinions. An example of a specific concern involves the documents the issuers' lawyers must complete so as to avoid arbitrage problems with the Internal Revenue Service.

By 2011, there were thousands of attorneys located throughout the country who were listed in the *Bond Buyers'* Municipal Marketplace directory. They presented themselves as being experts in municipal finance law and provided various security structure and tax opinions. Sorting out quality distinctions in their work and who is well grounded in the law, and who is not, is challenging.

On negotiated bond issues, one remedy has been for the underwriters to have their own counsels review the documents and to provide separate legal opinions.

THE NEED TO KNOW WHO REALLY IS THE ISSUER

Still another general question to ask before purchasing a municipal bond is just what kind of people are the issuers? Are they conscientious public servants with clearly defined public goals? Do they have histories of successful management of public institutions? Have they demonstrated commitments to professional and fiscally stringent operations? Additionally, issuers in highly charged and partisan environments in which conflicts chronically occur between political parties or among political factions or personalities are clearly bond issuers to scrutinize closely and possibly to avoid. Such issuers should be scrutinized regardless of the strength of the surrounding economic environment.

For General Obligation and Tax-Backed Bonds

For general obligation bond issuers, focus on the political relationships that exist among chief executives such as mayors, county executives, and governors, and among their legislative counterparts. Issuers with unstable political elites are of particular concern. Of course, rivalry among politicians is not necessarily bad. What is undesirable is competition so bitter and personal that real cooperation among the warring public officials in addressing future budgetary problems may

be precluded. An example of an issuer that was avoided because of such dissension *was* the city of Cleveland. The political problems of the city in 1978 and the bitter conflicts between Mayor Kucinich and the city council resulted in a general obligation note default in December of that year.

For Revenue Bonds

When investigating revenue bond issuers, it is important to determine not only the degree of political conflict, if any, that exists among the members of the bond-issuing body but also the relationships and conflicts among those who make the appointments to the body. Additionally, the investor should determine whether the issuer of the revenue bond has to seek prior approval from another governmental jurisdiction before the user fees or other charges can be levied. If this is the case, then the stability of the political relationships between the two units of government must be determined.

An important example involves the creditworthiness of the water and electric revenue bonds and notes issued by Kansas City, Kansas. Although the revenue bonds and notes were issued by city hall, it was the six-member board of public utilities, a separately elected body, that had the power to set the water and electricity rates. In the spring of 1981, because of a political struggle between a faction on the board of public utilities and the city commissioners (including the city's finance commissioner), the board refused to raise utility rates as required by the covenant. The situation came under control only when a new election changed the makeup of the board in favor of those supported by city hall.

In addition to the preceding institutional and political concerns, for revenue bond issuers in particular, the technical and managerial abilities of the staff should be assessed. The professional competency of the staff is a more critical factor in revenue bond analysis than it is in the analysis of general obligation bonds. The reason is that unlike general obligation bonds, which are secured in the final instance by the full faith and credit and unlimited taxing powers of the issuers, many revenue bonds are secured by the ability of the revenue projects to be operational and financially self-supporting.

The professional staffs of authorities that issue revenue bonds for the construction of nuclear and other public power-generating facilities, apartment complexes, hospitals, water and sewer systems, and other large public works projects, such as convention centers and sports arenas, should be reviewed carefully. Issuers who have histories of high management turnovers, project cost overruns, or little experience should be avoided by the conservative investor or at least considered higher risks than their assigned commercial credit ratings may indicate. Additionally, it is helpful for revenue bond issuers to have their accounting records annually audited by outside certified public accountants so as to provide the investor with a more accurate picture of the issuer's financial health.

ON THE FINANCIAL ADVISOR AND UNDERWRITER

Shorthand indications of the quality of the investment are (1) who the issuer selected as its financial advisor, if any; (2) its principal underwriter if the bond sale was negotiated; and (3) its financial advisor if the bond issue came to market competitively. Additionally, many prudent underwriters will not participate if there are significant credit-quality concerns. Therefore, it is also useful to learn who was the underwriter for the bond sales as well.

Identifying the financial advisors and underwriters is important for two reasons.

The Need for Complete, Not Just Adequate, Investment Risk Disclosures

The first reason relates to the quality and thoroughness of information provided to the investor by the issuer. The official statement, or private-placement papers if the issue is placed privately, is usually prepared with the assistance of lawyers and a financial advisor or by the principal underwriter. There are industry-wide disclosure guidelines that generally are adhered to, but not all official statements provide the investor with complete discussions of the risk potentials that may result from either the specific economics of the project or the community settings and the operational details of the security provisions. It is usually the author of this document who decides what to emphasize or downplay in the official statement. The more professional and established the author is in providing unbiased and complete information about the issuer, the more comfortable the investor can be with information provided by the issuer and in arriving at a credit-quality conclusion.

The Importance of Firm Reputation for Thoroughness and Integrity

By itself, the reputation of the issuer's financial advisor and/or underwriter should not be the determinant credit-quality factor, but it is a fact the investor should consider, particularly in the case of marginally feasible bond issues that have complex flow-of-funds and security structures. The securities industry is different from other industries, such as real estate, in that trading and investment commitments are usually made over the phone or electronically with a paper trail following days later. Many institutional investors, such as banks, bond funds, and property and casualty insurance companies, have learned to judge issuers by the company they keep. Institutions tend to be conservative, and they are more comfortable with financial information provided by established financial advisors and underwriters who have recognized reputations for honesty. Individual investors and analysts would do well to adopt this approach.

GENERAL CREDIT INDICATORS AND ECONOMIC FACTORS IN THE CREDIT ANALYSIS

The last analytical factor is the economic health or viability of the bond issuer or specific project financed by the bond proceeds. The economic factors cover a variety of concerns. When analyzing general obligation bond issuers, one should look at the specific budgetary and debt characteristics of the issuer, as well as the general economic environment. For project-financing, or enterprise, revenue bonds, the economics are limited primarily to the ability of the project to generate sufficient charges from the users to pay the bondholders. These are known as *pure revenue bonds*.

For revenue bonds that rely not on user charges and fees but instead on general purpose taxes and revenues, the analysis should take basically the same approach as for the general obligation bonds. For these bonds, the taxes and revenues diverted to the bondholders would otherwise go to the state's or city's general fund.

As an example, the bonds of the New York State Municipal Assistance Corporation for the City of New York Bonds (MAC), secured by general New York City sales taxes and annual state-aid appropriations, were structured to appear as pure revenue bonds, but in essence they were not. They incorporated a bond structure created to bail out New York City from severe budget deficits. The creditworthiness of the bond was tied to that of the underlying jurisdiction, which has had portions of its taxing powers and general fund revenues diverted to secure this new revenue-type bailout bond. Besides looking at the revenue features, the investor therefore must look at the underlying jurisdiction. These MACs were first issued in 1975 and refunded through the years. It should be noted that in 2004, the MACs were refunded, now with "Sales Tax *Asset* Receivable Corporation" bonds and stretched out to 2033 for paying off operating deficits of the 1960s.

For General Obligation Bonds

For general obligation bonds, the economic concerns include questions in four specific areas: debt burden, budget soundness, tax burden, and the overall economy.

Debt Burden

In relation to the debt burden of the general obligation bond issuer, some of the more important concerns include the determination of the total amount of debt outstanding and to be issued that is supported by the general taxing powers of the issuer as well as by earmarked revenues.

For example, general obligation bonds issued by school districts in New York State are general obligations of the issuer and are also secured by state-aid payments due the issuer. If the issuer defaults, the bondholder can go to the state comptroller and be paid from the next state-aid payment due the local issuer. An example of another earmarked-revenue general obligation bond is the State of Illinois General

Obligation Transportation, Series A Bond. For these state general obligations, debt service is secured by gasoline taxes in the state's transportation fund.

Key debt ratios that reveal the burden on local taxpayers include determining the per capita amount of general obligation debt as well as the per capita debt of the overlapping or underlying general obligation bond issuers. Other key measures of debt burden include determining the amounts and percentages of the outstanding general obligation bonds as well as the outstanding general obligation bonds of the overlapping or underlying jurisdictions to real estate valuations. These numbers and percentages can be compared with most recent year medians, as well as with the past history of the issuer, to determine whether the debt burden is increasing, declining, or remaining relatively stable.

In addition to the general obligation bonds outstanding, the debt of the general obligation bond issuer could include leases, certificates of participation (COPs), appropriation, and "moral obligation" bonds.

Additionally, the amount of the unfunded pension liabilities should be determined. What is the difference between the expected assets of the public employee system at current annual contribution rates, the future benefits to be paid out, and if the issuer has a reasonable plan to eliminate the unfunded liability? Can pension benefits unilaterally be reduced by the local governments? Such steps are allowed in some jurisdictions, but not in others. An example of the latter is New York State, where the state constitution prevents the reduction of pension benefits once they are granted. Therefore, the unfunded pension liabilities of local governments in New York must be taken much more seriously than in states where such guarantees do not exist.

Still another special debt figure that came into the forefront in the first decade of the twenty-first century involves the actuarially determined costs of providing health care for retirees. These are postemployment benefits. In many jurisdictions they are not legally mandatory and are paid on a pay-as-you-go basis. There are usually strong political groups such as unions and the retirees themselves that support these benefits. In some jurisdictions the potential size of this liability is greater than the outstanding general obligation bonds.

For purposes of determining the special debt figure—which represents the potential liability in a worst-case environment—the COPs, appropriation and lease obligations, the moral obligations, the unfunded pension liabilities, and the retiree health care costs should be shown and broken out.

Budgetary Soundness

Concerning the budgetary operations and budgetary soundness of the general obligation bond issuer, some of the more important questions include how well the issuer over at least the previous five years has been able to maintain balanced budgets and fund reserves. How dependent is the issuer on short-term debt to finance annual budgetary operations? How have increased demands by residents for costly social services been handled? That is, how frugal is the issuer? How well have the public-employee unions been handled? They usually lobby for

higher salaries, liberal pensions, and other costly fringe benefits. Clearly, it is undesirable for the pattern of dealing with the constituent demands and public-employee unions results in raising taxes and drawing down nonrecurring budget reserves. Last, another general concern in the budgetary area is the reliability of the budget and accounting records of the issuer. Are interfund borrowings reported? Who audits the books?

It should be noted that by 2011, e-commerce and Internet usage were steadily growing among American consumers. Many states, counties, and city governments over the past 50 years have derived substantial revenues from sales taxes that are not always applied to Internet sales. In some jurisdictions, over 20% of an issuer's revenues may come from local sales taxes. How the growth of the Internet affects this revenue source is uncertain at this time, but at some future date could be a significant negative for the budgets of at least some issuers as well as for their bonds secured by these taxes.

Tax Burden

Concerning the tax burden, it is important to learn two things initially. First, what are the primary sources of revenue in the issuer's general fund? Second, how dependent is the issuer on any one revenue source? If the general obligation bond issuer relies increasingly on a property tax, wage and income taxes, or sales tax to provide the major share of financing for annually increasing budget appropriations, taxes could quickly become so high as to drive businesses and people away. Many larger northern states and cities with their relatively high income, sales, and property taxes appear to be experiencing this phenomenon. Still another concern is the degree of dependency of the issuer on intergovernmental revenues, such as federal or state revenue sharing and grants-in-aid, to finance its annual budget appropriations. Political coalitions on the state and federal levels that support these financial transfer programs are not permanent and could undergo dramatic change very quickly. Therefore, a general obligation bond issuer that currently has a relatively low tax burden but receives substantial amounts of intergovernmental monies should be reviewed carefully by the investor. If it should occur that the aid monies are reduced, as has been occurring under many federal and state programs, certain issuers primarily may increase their taxes instead of reducing their expenditures to conform to the reduced federal grants-in-aid.

Overall Economy

The fourth and last area of general obligation bond analysis concerns the issuer's overall economy. For local governments, such as counties, cities, towns, and school districts, key items include learning the annual rate of growth of the full value of all taxable real estate for the previous 10 years and identifying the 10 largest taxable properties. What kinds of business or activity occur on the respective properties? What percentage of the total property tax base do the 10 largest properties represent? What has been the building permit trend for at least the

previous five years? What percentage of all real estate is tax-exempt, and what is the distribution of the taxable ones by purpose (such as residential, commercial, industrial, railroad, and public utility)? Last, who are the five largest employers? Concerning the final item, communities that have one large employer are more susceptible to rapid adverse economic change than communities with more diversified employment and real estate bases. For additional information that reveals economic health or decline, one must determine whether the population of the community over the previous 10 years has been increasing or declining by age and income and how the monthly and yearly unemployment rates compare with the national averages, as well as with the previous history of the community.

For state governments that issue general obligation bonds, the economic analysis should include many of the same questions applied to local governments. In addition, the investor should determine on the state level the annual rates of growth for the previous five years of personal income and retail sales and how much the state has had to borrow from the Federal Unemployment Trust Fund to pay unemployment benefits. This last item is particularly significant for the long-term economic attractiveness of the state because employers in states with large federal loans in arrears may be required to pay increased unemployment taxes to the federal government.

For Revenue Bonds

Airport Revenue Bonds

For airport revenue bonds, the economic questions vary according to the type of bond security involved. There are two basic security structures.

The first type of airport revenue bond is one based on traffic-generated revenues that result from the competitiveness and passenger demand of the airport. The financial data on the operations of the airport should come from audited financial statements going back at least three years. If a new facility is planned, a feasibility study prepared by a recognized consultant should be reviewed. The feasibility study should have two components: (1) a market and demand analysis to define the service area and examine demographic and airport use trends and (2) a financial analysis to examine project operating costs and revenues.

Revenues at an airport may come from landing fees paid by the airlines for their flights, passenger facility charges (PFCs), concession fees paid by restaurants, shops, newsstands, and parking facilities, and from airline apron and fueling fees.

Also, in determining the long-term economic viability of an airport, the investor should determine whether or not the wealth trends of the service area are upward, whether the airport is dependent on tourism or serves as a vital transfer point, whether passenger enplanements and air cargo handled over the previous five years have been growing, whether increased costs of jet fuel and airport safety would make other transportation such as trains and automobiles more attractive in that particular region, and whether the airport is a major domestic hub for an airline,

which could make the airport particularly vulnerable to route changes caused by schedule revisions and changes in airline corporate management.

The second type of airport revenue bond is secured by a lease with one or more airlines for the use of a specific facility such as a terminal or hangar. The lease usually obligates them to make annual payments sufficient to pay the expenses and debt service for the facility. For many of these bonds, the analysis of the airline lease is based on the credit quality of the lessee airline. Whether or not the lease should extend as long as the bonds are outstanding depends on the specific airport and facility involved. For major hub airports, it may be better not to have long-term leases because without leases, fees and revenues can be increased as the traffic grows, regardless of which airline uses the specific facility. Of course, for regional or startup airports, long-term leases with trunk (i.e., major airline) carriers are preferred.

After 9/11, air travel suffered a unique temporary downturn. While air travel remains an essential service, after the terrorist attacks, the analysis of the credit quality of airports and airlines with related bankruptcy issues has undergone increased scrutiny.

Charter School Bonds

Charter school bonds are for publicly funded private schools that offer more institutional and academic flexibility than local public schools. State-aid funding usually follows the student who goes from a traditional public school to a charter school. Bond proceeds go for capital improvements.

Some important credit questions to ask include: (1) How long is the charter granted by the state or local school district, and is it renewable? (2) What is the charter school enrollment history—is it growing? (3) Does the school serve a specialty academic niche, or is it just relieving overcrowding at local public schools? (4) What is its reputation in the community? (5) Is there competition? (6) Is there a waiting list? (7) Is the school prudently run with cash reserves, i.e., how many days of cash are on hand? and (8) How reasonable are the operating and maintenance expenses in relationship to the revenues and debt service requirements?

Continuing Care Retirement Community Bonds

A continuing care retirement community (CCRC) provides housing accommodations and health-related services to elderly persons, typically for the duration of their lifetimes. These nonprofit organizations finance a portion of development and operating costs by issuing bonds secured by the entrance fees and monthly fees paid by their residents. The potential demand for a CCRC is largely affected by the number of elderly persons in the nearby area with qualifying assets and income, the presence and proximity of competitor facilities, and the strength of the local real estate market. Other important considerations include whether advance fee deposits are partially or fully refundable, the experience of the general contractor and management, the background of the sponsor, and the amount of cash reserves on hand. A careful analysis of the data and assumptions of any feasibility study formed is essential.

Dedicated Tax-Backed and Structured/Asset-Backed Bonds

More recently, states and local governments have issued increasing amounts of bonds where the debt service is to be paid from so-called dedicated revenues such as sales taxes, tobacco settlement payments, fees, and penalty payments. Many are structured to mimic the asset-backed bonds that are common in the taxable market. The "assets" providing the security for the municipal bonds are the "dedicated" revenues instead of credit card receivables, home equity loans, and auto loan repayments that are commonly used to secure the taxable asset-backed bonds.

Additionally, the municipal bonds are usually subject to some form of annual legislative appropriation and result from statutes specially created to pledge the identified taxes and revenues and allow for the bond sales. In good economic times many investors as well as the rating agencies tend to blur the credit distinctions between these bonds and the issuer's own general obligation bonds. In fact, many such bonds carry higher credit ratings than the underlying general obligation bonds because the "coverage" on the former appears to be so high. In most instances, the general obligation bonds are legally backed by specific state constitutional provisions, whereas, the dedicated tax and structured/asset-backed bonds are recent legislative creations and have not been tested yet in stressful budgetary, economic, and political environments.

Higher Education Bonds

Debt is often issued by institutions of higher education to finance the costs of building/renovating facilities or purchasing land for expansion. These bonds are secured by revenues of the given project, student charges, and/or a general obligation of the college or university. An investor in higher education bonds should carefully consider the following: (1) Is student demand for the issuing institution strong and growing? (2) Does the school have flexibility to increase tuition or enrollment if needed? (3) How experienced are senior management and the board of trustees? (4) What are the school's various sources of funding? (5) What is the endowment level and how is it trending? (6) How well does the school manage expenses and repay its debts? (7) What is the physical condition of school facilities? and (8) Are there any construction or project-specific risks?

Highway Revenue Bonds

There are generally two types of highway revenue bonds. The bond proceeds of the first type are used to build specific revenue-producing facilities such as toll roads, bridges, and tunnels. For these pure enterprise revenue bonds, the bondholders have claims to the revenues collected through the tolls. The financial soundness of the bonds depends on the ability of the specific projects to be self-supporting. Proceeds from the second type of highway revenue bond generally are used for public highway improvements, and the bondholders are paid by earmarked revenues such as gasoline taxes, automobile registration payments, and driver's license fees.

Concerning the economic viability of a toll revenue bond, the investor should ask a number of questions.

1. What is the traffic history, and how inelastic is the demand? Toll roads, bridges, and tunnels that provide vital transportation links are clearly preferred to those that face competition from interstate highways, toll-free bridges, or mass transit.
2. How well is the facility maintained? Has the issuer established a maintenance reserve fund at a reasonable level to use for such repair work as road resurfacing and bridge painting?
3. Does the issuer have the ability to raise tolls to meet covenant and debt reserve requirements without seeking approvals from other governmental actors such as state legislatures and governors? In those few cases where such approvals are necessary, the question of how sympathetic these other power centers have been in the past in approving toll-increase requests should be asked.
4. What is the debt-to-equity ratio? Some toll authorities have received substantial nonreimbursable federal grants to help subsidize their costs of construction. This, of course, reduces the amount of debt that has to be issued.
5. What is the history of labor-management relations, and can public-employee strikes substantially reduce toll collections?
6. When was the facility constructed? Generally, toll roads financed and constructed in the 1960s tend to be in better financial condition because the cost of financing was much less.
7. If the facility is a bridge that could be damaged by a ship and made inoperable, does the issuer have adequate use-and-occupancy insurance?

Those few toll revenue bonds that have defaulted have done so because of either unexpected competition from toll-free highways and bridges, poor traffic projections, or substantially higher than projected construction costs. An example of one of the few defaulted bonds is the West Virginia Turnpike Commission's Turnpike Revenue Bonds, issued in 1952 and 1954 to finance the construction of an 88-mile expressway from Charleston to Princeton, West Virginia. The initial traffic-engineering estimates were overly optimistic, and the construction costs came in approximately $37 million higher than the original budgeted amount of $96 million. Because of insufficient traffic and toll collections, between 1956 and 1979 the bonds were in default. By the late 1970s with the completion of various connecting cross-country highways, the turnpike became a major link for interstate traffic. The bonds became self-supporting in terms of making interest coupon payments. It was not until 1989 that all the still-outstanding bonds were finally redeemed.

More recently, a new group of start-up toll roads has been financed with municipal bonds. The revenue projections for several roads turned out to be overly optimistic. Some have had to draw on the debt reserves. Others have had to be restructured and even defaulted. Examples include the Santa Rosa Bay Bridge Authority in Florida, the Southern Connector Toll Road in South Carolina, and the San Joaquin Toll Road in California.

Concerning the economics of highway revenue bonds that are not pure enterprise type but instead are secured by earmarked revenues, such as gasoline taxes, automobile registration payments, and driver's license fees, the investor should ask the following questions:

- Are the earmarked tax revenues based on state constitutional mandates, such as the state of Ohio's Highway Improvement Bonds, or are they derived from laws enacted by state legislatures, such as the state of Washington's Chapters 56, 121, and 167 Motor Vehicle Fuel Tax Bonds? A constitutional pledge is usually more permanent and reliable.
- What has been the coverage trend of the available revenues to debt service over the previous 10 years? Has the coverage been increasing, stable, or declining?
- If the earmarked revenue is a gasoline tax, is it based on a specific amount per gallon of gasoline sold or as a percentage of the price of each gallon sold? With greater conservation and more efficient cars, the latter tax structure is preferred because it is not as susceptible to declining sales of gasoline and because it benefits directly from any increased gasoline prices at the pumps.
- What has been the history of statewide gasoline consumption through recessions and oil shocks?

Hospital Revenue Bonds

Two unique features of hospitals make the analysis of their debt particularly complex and uncertain. The first concerns their sources of revenue, and the second concerns the basic structure of the institutions themselves.

During the past 40 years, the major sources of revenue for most hospitals have been (1) payments from the federal (Medicare) and combined federal-state (Medicaid) hospital reimbursement programs, and (2) appropriations made by local governments through their taxing powers. It is not uncommon for hospitals to receive at least half of their annual revenues from these sources. How well the hospital management markets its service to attract more private-pay patients and commercial insurers, and how conservatively it budgets for the governmental reimbursement payments are key elements for distinguishing weak from strong hospital bonds.

Particularly for community-based hospitals (as opposed to teaching hospitals affiliated with medical schools), a unique feature of their financial structure

is that their major financial beneficiaries, physicians, have no legal or financial liabilities if the institutions do not remain financially viable over the long term. An example of the problems that can be caused by this lack of liability is found in the story of the Sarpy County, Nebraska, Midlands Community Hospital Revenue Bonds. These bonds were issued to finance the construction of a hospital three miles south of Omaha, Nebraska, that was to replace an older one located in the downtown area. Physician questionnaires prepared for the feasibility study prior to the construction of the hospital indicated strong support for the replacement facility. Many doctors had used the older hospital in downtown Omaha as a backup facility for a larger nearby hospital. Unfortunately, once the new Sarpy hospital opened in 1976, many physicians found that the new hospital could not serve as a backup because it was 12 miles further away from the major hospital than the old hospital had been. Because these physicians were not referring their patients to the new Sarpy hospital, it was soon unable to make bond principal payments and was put under the jurisdiction of a court receiver.

The preceding factors raise long-term uncertainties about many community-based hospitals, but certain key areas of analysis and trends reveal the relative economic health of hospitals that already have revenue bonds outstanding. The first area is the liquidity of the hospital as measured by the ratio of dollars held in current assets to current liabilities. In general, a five-year trend of high values for the ratio is desirable because it implies an ability by the hospital to pay short-term obligations and thereby avoid budgetary problems. Days cash on hand is an important measure as well. The second indicator is the ratio of long-term debt to equity, as measured in the unrestricted end-of-year fund balance. In general, the lower the long-term debt to equity ratio, the stronger the finances of the hospital are. The third indicator is the actual debt service coverage of the previous five years, as well as the projected coverage. The fourth indicator is the annual bed-occupancy rates for the previous five years. The fifth is the percentage of physicians at the hospital who are professionally approved (board certified), their respective ages, and how many of them use the hospital as their primary institution.

For new or expanded hospitals, much of the preceding data are provided to the investor in the feasibility study. One item in particular that should be determined for a new hospital is whether the physicians who plan to use the hospital actually live in the area to be served by the hospital. Because of its importance in providing answers to these questions, the feasibility study must be prepared by reputable, experienced researchers.

Housing Revenue Bonds

For housing revenue bonds, the economic and financial questions vary according to the type of bond security involved. There are two basic types of housing revenue bonds, each with a different type of security structure. One is the housing revenue bond secured by *single-family* mortgages, and the other is the housing revenue bond secured by mortgages on *multifamily* housing projects.

Concerning single-family housing revenue bonds, the strongly secured bonds usually have five characteristics:

- The single-family home loan bonds are collateralized by GNMA, FNMA, or FHLMC; or the loans are insured by the Federal Housing Administration (FHA), Department of Veteran Affairs (VA), or an acceptable private mortgage insurer or its equivalent. If the individual home loans are not insured, then they should have a loan-to-value ratio of 80% or less. Prior to 2007, many bonds had acceptable private mortgage insurance.
- If the conventional home loans have less than 100% primary mortgage insurance coverage, or are not backed by federal collateral, an additional 5% to 10% mortgage-pool insurance policy or its equivalent may be required.
- In addition, there is a mortgage reserve fund equal at least to 1% of the mortgage portfolio outstanding.
- The issuer of the single-family housing revenue bonds is in a region of the country that has stable or strong economic growth as indicated by increased real estate valuations, personal income, and retail sales, as well as low unemployment rates.
- State housing finance agency support.

In the 1970s, state agency issuers of single-family housing revenue bonds assumed certain prepayment levels in structuring the bond maturities. In recent years, most issuers have abandoned this practice but investors should review the retirement schedule for the single-family mortgage revenue bonds to determine whether or not the issuer has assumed large, lump-sum mortgage prepayments in the early year cash-flow projections. If so, how conservative are the prepayment assumptions, and how dependent is the issuer on the prepayments to meet the annual debt service requirements? Of course, while the focus of this chapter is on credit analysis, the investor should be aware that extraordinary redemptions of these bonds can occur from prepayments on the mortgages.

It should be noted that since the mid-1990s, issuers have adopted structures similar to those in the taxable mortgage-backed securities market that incorporate prepayment assumptions. In tax-exempt single-family housing bonds, these are usually the planned amortization class (PAC) structures.

State issuing agencies usually have professional in-house staffs that closely monitor the home mortgage portfolios, whereas the local issuers do not. Finally, many state issuing agencies have accumulated substantial surplus funds over the years that can be viewed as an additional source of bondholder protection.

For multifamily housing revenue bonds, there are four specific, although overlapping, security structures. The first type of multifamily housing revenue bond is one in which the bonds are secured by federally insured mortgages. Usually, the federal insurance covers all but the difference between the outstanding bond principal and collectible mortgage amount (usually 1%), and all but the *nonasset* bonds

(i.e., bonds issued to cover issuance costs and capitalized interest). The attractiveness of the federal insurance is that it protects the investor against bond default within the limitations outlined. The insurance protects the bondholders regardless of whether the projects are fully occupied and generating rental payments.

The second type of multifamily housing revenue bond is one in which the federal government subsidizes, under the HUD Section 8 program, all annual costs (including debt service) of the project not covered by tenant rental payments. Under Section 8, the eligible low-income and elderly tenants pay only 15% to 30% of their incomes for rent. Because the ultimate security comes from the Section 8 subsidies, which normally escalate annually with the increased cost of living in that particular geographic region, the bondholder's primary risks concern the developer's ability to complete the project, find tenants eligible under the federal guidelines to live in the project, and then maintain high occupancy rates for the life of the bonds. The investor should carefully review the location and construction standards used in building the project, as well as the competency of the project manager in selecting tenants who will take care of the building and pay their rents. In this regard, state agencies that issue Section 8 bonds usually have stronger in-house management experience and resources for dealing with problems than do the local development corporations that have issued Section 8 bonds. It should be noted that the federal government has eliminated appropriations for new Section 8 projects. Since 1995, the federal government has restricted automatic rent increases under the Section 8 program. This has introduced financial pressure.

The third type of multifamily housing revenue bond is one in which the ultimate security for the bondholder is the ability of the project to generate sufficient monthly rental payments from the tenants to meet the operating and debt service expenses. Some of these projects may receive governmental subsidies (such as interest-cost reductions under the federal Section 236 program and property tax abatements from local governments), but the ultimate security is the economic viability of the project. Key information includes the location of the project, its occupancy rate, whether large families or the elderly will primarily live in the project, whether or not the rents necessary to keep the project financially sound are competitive with others in the surrounding community, and whether or not the project manager has a proven record of maintaining good service and of establishing careful tenant selection standards.

A fourth type of multifamily housing revenue bond is one that includes some type of private credit enhancement to the underlying real estate. These credit enhancements can include guarantees or sureties of an insurance company, securitization by Fannie Mae (Federal National Mortgage Association or FNMA), or a bank letter-of-credit.

Other financial features desirable in all multifamily housing bonds include a debt service reserve fund, which should contain an amount of money equal to the maximum annual debt service on the bonds, a mortgage reserve fund, and a capital repair and maintenance fund.

Another feature of many multifamily housing revenue bond programs, particularly those issued by state housing agencies, is the state moral obligation pledge. Several state agencies have issued housing revenue bonds that carry a potential state liability for making up deficiencies in their one-year debt service reserve funds, should any occur. In most cases, if a drawdown of the debt reserve occurs, the state agency must report the amount used to its governor and state budget director. The state legislature, in turn, may appropriate the requested amount, although there is no legally enforceable obligation to do so. Bonds with this makeup provision are called *moral obligation bonds*.

The moral obligation provides a state legislature with permissive authority—*not mandatory authority*—to make an appropriation to the troubled state housing agency. Therefore, the analysis should determine (1) whether the state has the budgetary surpluses for subsidizing the housing agency's revenue bonds, and (2) whether there is a consensus within the executive and legislative branches of that particular state's government to use state general fund revenues for subsidizing multifamily housing projects.

Industrial Revenue Bonds

Generally, industrial revenue bonds are issued by state and local governments on behalf of individual corporations and businesses. The security for the bonds usually depends on the economic soundness of the particular corporation or business involved. If the bond issue is for a subsidiary of a larger corporation, one question to ask is whether or not the parent guarantees the bonds. Is it obligated only through a lease, or does it not have any obligation whatsoever for paying the bondholders? If the parent corporation has no responsibility for the bonds, then the investor must look very closely at the operations of the subsidiary in addition to those of the parent corporation.

For companies that have issued publicly traded common stock, operating data are readily available in the quarterly (10-Q) and annual (10-K) financial reports that must be filed with the Securities and Exchange Commission. For privately held companies, financial data are more difficult to obtain.

In assessing the economic risk of investing in an industrial revenue bond, another question to ask is whether the bondholder or the trustee holds the mortgage on the property. Although holding the mortgage is not an important economic factor in assessing either hospital or low-income multifamily housing bonds in which the properties have very limited commercial value, it can be an important strength for the holder of industrial development revenue bonds. If the bond is secured by a mortgage on a property of a major retailer, or an industrial facility such as a warehouse, the property location and resale value of the real estate may provide some protection to the bondholder, regardless of what happens to the company that issued the bonds. Of course, the investor always should avoid possible bankruptcy situations regardless of the economic attractiveness of the particular piece of real estate involved. The reason is that the bankruptcy process usually involves years of litigation and numerous court hearings, about which no investor should want to be concerned.

Land-Secured "Dirt" Bonds

Public infrastructure costs associated with new development projects on raw land are often financed by land-secured bonds, also known as "dirt" bonds. Revenue from the additional tax or assessment placed on the properties benefitting from these improvements is the primary security for the bondholders. Additional security is provided by the ability of the sponsoring governmental entity to commence foreclosure or tax sales if property owners are delinquent on their taxes or assessments. Important credit factors to consider include: (1) Is the development's location, demographics, and competitive position favorable? (2) Does the developer possess sufficient experience and financial resources? (3) Is there a debt service reserve and other funds, and how are they funded? (4) Is the lien created by the tax/assessment fixed or variable, and what is the resulting debt service coverage provided? (5) Is the value of the land relative to the outstanding liens sufficient to discourage property owners from walking away?

Lease-Rental Bonds

Lease-rental bonds usually are structured as revenue bonds, and annual payments, paid by a state or local government, cover all costs including operations, maintenance, and debt service. It should be noted that many Certificate of Participation Bonds, or COPs, are similar in security structure in that they too are dependent on the annual legislative appropriation process. The public purposes financed by these bond issues include public office buildings, fire houses, police stations, university buildings, mental health facilities, and highways, as well as office equipment and computers. In some instances, the payments may come from student tuition, patient fees, and earmarked tax revenues, and the state or local government is not legally obligated to make lease-rental payments beyond the amount of available earmarked revenues. However, for many lease-rental bonds, the underlying lessee state, county, or city is to make payment from its general fund subject to annual legislative appropriation. For example, the Albany County, New York, Lease Rental South Mall Bonds were issued to finance the construction of state office buildings. Although the bonds were technically general obligations of Albany County, the real security came from the annual lease payments made by the State of New York. These payments were appropriated annually. For such bonds, the basic economic and financial analysis should follow the same guidelines as for general obligation bonds.

Public Power Revenue Bonds

Public power revenue bonds are issued to finance the construction of electrical generating plants. An issuer of the bonds may construct and operate one power plant, buy electric power from a wholesaler and sell it retail, construct and operate several power plants, or join with other public and private utilities in jointly financing the construction of one or more power plants. This last arrangement is known as a joint-power financing structure. Although there are revenue bonds that can claim the revenues of a federal agency (e.g., the Washington Public Power

Supply System's Nuclear Project No. 2 Revenue Bonds, which if necessary could claim the revenues of the Bonneville Power Administration), and others may require the participating underlying municipal electric systems to pay the bondholders whether or not the plants are completed and operating, the focus here is how the investor determines which power projects will be financially self-supporting without these backup security features.

There are at least five major questions to ask when evaluating the investment soundness of a public power revenue bond:

- Does the bond issuer have the authority to raise its electric rates in a timely fashion without going to any regulatory agencies? This is particularly important if substantial rate increases are necessary to pay for new construction or plant improvements.
- How diversified is the customer base among residential, commercial, and industrial users?
- Is the service area growing in terms of population, personal income, and commercial/industrial activity so as to warrant the electrical power generated by the existing or new facilities?
- Are rates competitive with neighboring IOUs?
- What are the projected and actual costs of power generated by the system, and how competitive are they with other regions of the country? Power rates are particularly important for determining the long-term economic attractiveness of the region for industries that are large energy users.
- How diversified is the fuel mix? Is the issuer dependent on one energy source such as hydro dams, oil, natural gas, coal, or nuclear fuel?

Concerning electrical generating plants fueled by nuclear power, the aftermath of the Three Mile Island nuclear accident in 1979 has resulted in greater construction and maintenance reviews and costly safety requirements prompted by the Federal Nuclear Regulatory Commission (NRC). The NRC oversees this industry. In the past, although nuclear power plants were expected to cost far more to build than other types of power plants, it also was believed that once the generating plants became operational, the relatively low fuel and maintenance costs would more than offset the initial capital outlays. However, with the increased concern about public safety brought about by the Three Mile Island accident, repairs and design modifications are now expected to be made even after plants begin to operate. Of course, this increases the ongoing costs of generating electricity and reduces the attractiveness of nuclear power as an alternative to the oil, gas, and coal fuels.

Public-Private Partnerships

Privatization is a form of municipal financing where a private company pays a large payment to operate, and often build or improve, a governmental asset

(e.g., usually toll roads). The purchaser issues debt to help finance this large upfront cost, and the operating revenues are pledged to repay bondholders. The bonds issued are referred to as private-placement partnership bonds (PPP). Important questions to ask about these bonds are: (1) What is the length of the concession agreement? (2) How are prices or tolls set? (3) Does the governmental entity share in any revenue? (4) Are there any noncompete provisions? (5) What levels of maintenance, capital expenditures, and service are required? (6) What are the conditions and repercussions for nonperformance? and (7) What are the assumptions and conclusions of any feasibility study performed?

Tobacco Revenue Bonds

Some tobacco bonds are solely secured by revenues in the Master Settlement Agreement (MSA) annually paid to states by cigarette companies. Important credit issues include: (1) The credit quality of the cigarette companies making the annual payments; (2) the consumption assumptions used in sizing the original bond issue, i.e., the degree of leveraging used; (3) current consumption trends and their impacts on cash-flows and debt coverage; and (4) the status of the various court cases.

Tribal Casino Bonds

Native American governments in general finance the construction of their casino gaming facilities by issuing debt. Tribal casino bonds derive their revenues from the gaming operations of these facilities. Given the limited diversity of the revenue streams and the lack of hard collateral assets, evaluating the future viability and profitability of the new gaming facility is essential, including analysis of the relevant demographics, competitive factors, and quality of casino management. Buyers should also assess the financial strength, governance structure, and development project expertise of the issuing tribal entity. Other issues to consider include whether the cash trapping and debt service reserve fund features of the issued debt are sufficient, any gaming compact and revenue sharing arrangements with state governments, and potential regulatory changes. It should be noted that a U.S. Federal District court in Wisconsin recently ruled in favor of a tribal bond issuer seeking to abandon its payment obligation, claiming the related indenture breached federal tribal gaming regulations. This case was under appeal.

Water and Sewer Revenue Bonds

Water and sewer revenue bonds are issued to provide for a local community's basic needs and as such are not usually subject to general economic changes. Because of the vital utility services performed, their respective financial structures are usually designed to have the lowest possible user charges and still remain financially viable. Generally, rate covenants requiring that user charges cover operations, maintenance, and approximately 1.2 times annual debt service and reserve requirements are most desirable. On the one hand, a lower rate covenant provides a smaller margin for unanticipated slow collections or increased operating and plant maintenance costs caused by inflation. On the other hand,

rates that generate revenues more than 1.2 times the annual debt service and reserve requirements could cause unnecessary financial burdens on the users of the water and sewer systems.

A useful indication of the soundness of an issuer's operations is to compare the water or sewer utility's average quarterly customer billings to those of other water or sewer systems. Assuming that good customer service is given, the water or sewer system that has a relatively low customer billing charge generally indicates an efficient operation and therefore strong bond-payment prospects.

Key questions for the investor to ask include the following:

- Has the bond issuer, through local ordinances, required mandatory water or sewer connections? Also, local board of health directives against well water contamination and septic tank usage can often accomplish the same objective as the mandatory hookups.
- Does the issuer have to comply with an EPA consent decree and thereby issue significant amounts of bonds?
- What is the physical condition of the facilities in terms of plant, lines, and meters, and what capital improvements are necessary for maintaining the utilities as well as for providing for anticipated community growth?
- For water systems in particular, it is important to determine if the system has water supplies in excess of current peak and projected demands. An operating system at less than full utilization is able to serve future customers and bring in revenues without having to issue additional bonds to enlarge its facilities.
- What is the operating record of the water or sewer utility for the previous five years?
- If the bond issuer does not have its own distribution system but instead uses other participating local governments that do, are the charges or fees based on the actual water flow drawn (for water revenue bonds) and sewage treated (for sewer revenue bonds) or on gallonage entitlements?
- For water revenue bonds issued for agricultural regions, what crop is grown? An acre of oranges or cherries in California will provide the grower with more income than will an acre of corn or wheat in Iowa.
- For expanding water and sewer systems, does the issuer have a record over the previous two years of achieving net income equal to or exceeding the rate covenants, and will the facilities to be constructed add to the issuer's net revenues?
- Has the issuer established and funded debt and maintenance reserves to deal with unexpected cash-flow problems or system repairs?
- Does the bond issuer have the power to place tax liens against the real estate of those who have not paid their water or sewer bills? Although

the investor would not want to own a bond for which court actions of this nature would be necessary, the legal existence of this power usually provides an economic incentive for water and sewer bills to be paid promptly by the users.

Additional bonds should be issued only if the need, cost, and construction schedule of the facility have been certified by an independent consulting engineer and if the past and projected revenues are sufficient to pay operating expenses and debt service. Of course, for a new system that does not have an operating history, the quality of the consulting engineer's report is of the upper-most importance.

RED FLAGS FOR THE INVESTOR

In addition to the areas of analysis just described, certain red flags, or negative trends, suggest increased credit risks.

For General Obligation Bonds

For general obligation bonds, the signals that indicate a decline in the ability of a state, county, town, city, or school district to function within fiscally sound parameters include the following:

- Declining property values and increasing delinquent taxpayers
- An annually increasing tax burden relative to other regions
- An increasing property tax rate in conjunction with a declining population
- Declines in the number and value of issued permits for new building construction
- Actual general fund revenues consistently falling below budgeted amounts
- Increasing end-of-year general fund deficits
- Budget expenditures increasing annually in excess of the inflation rate
- The unfunded pension liabilities are increasing
- General obligation debt increasing while property values are stagnant
- Declining economy as measured by increased unemployment and declining personal income

For Revenue Bonds

For revenue bonds, the general signals that indicate a decline in credit quality include the following:

- Annually decreasing coverage of debt service by net revenues
- Use of debt reserve and other reserves by the issuer

- Growing financial dependence of the issuer on unpredictable federal and state-aid appropriations for meeting operating budget expenses
- Chronic lateness in supplying investors with annual audited financials
- Unanticipated cost overruns and schedule delays on capital construction projects
- Frequent or significant rate increases
- Deferring capital plant maintenance and improvements
- Excessive management turnovers
- Shrinking customer base
- New and unanticipated competition

INFORMATION SOURCES FOR THE ANALYST

The Official Statement

An official statement describing the issue and the issuer is prepared for new offerings. A preliminary official statement is issued prior to the final official statement. These statements are known as the OS and POS. These statements provide potential investors with a wealth of information. The statements contain basic information about the amount of bonds to be issued, maturity dates, coupons, the use of the bond proceeds, the credit ratings, a general statement about the issuer, and the name of the underwriter and members of the selling group. Much of this information can be found on the cover page or in the first few pages of the official statement. It also contains detailed information about the security and sources of payments for the bonds, sources and uses of funds, debt service requirements, relevant risk factors, issuer's financial statements, a summary of the bond indenture, relevant agreements, notice of any known existing or pending litigation, the bond insurance policy specimen (if insured), and the form of opinion of bond counsel. The official statement contains most of the information an investor will need to make an informed and educated investment decision.

Continuing Disclosure Under Rule 15c2-12

Rule 15c2-12, which took effect in 1995, required dealers to determine that issuers before issuing new municipal bonds made arrangements to disclose in the future financial information *at least* annually as well as notices of the occurrence of any of 11 "material event notices" as specified in the rule. By 2011, the amended rule contained 14 material event notices. Also by 2011, the annual report and notices of material events are to be filed with the Municipal Securities Rulemaking Board (MSRB), in an electronic format as prescribed by the MSRB. The MSRB designated its Electronic Municipal Market Access system (EMMA), found at http://emma.msrb.org as the sole repository for such disclosure filings.

It should be noted that many issuers, such as hospitals, toll roads, and CCRCs provide unaudited interim information to bondholders on a quarterly and even a monthly basis.

The National Federation of Municipal Analysts

The National Federation of Municipal Analysts (NFMA) was established in 1983 and by 2011 had a membership of 1,000 municipal professionals, drawing in part from the institutional investors in municipal bonds who advocated increased and timely information for investors. By 2011, its committees have developed detailed disclosure guidelines and risk factors in municipal securities ranging from specific credit sectors to swap structures. They are recommended for municipal bond issuers to use in providing ongoing financial and operating information to investors and analysts. The web site is www.nfma.org.

The Governmental Standards Accounting Board

The Governmental Standards Accounting Board (GSAB) is a nonprofit organization that sets generally accepted accounting standards (GAAP) for state and local governments. Established in 1984 it provides detailed guidelines. For many years it has improved financial reporting standards in reports of state and local governments that are used by analysts, auditors, and other users. By improving the transparency of state and local government accounting, it helps prevent issuers from obfuscating budget deficits and long-term liabilities that in the past had resulted in budgetary disasters and bond defaults. The web site is http://gasb.org.

KEY POINTS

- The five categories of inquiry when analyzing the creditworthiness of a general obligation, tax-backed, or pure revenue bond are (1) legal documents and opinions, (2) politics/management, (3) underwriter/financial advisor, (4) general credit indicators and economics, and (5) red flags, or danger signals.
- From the perspective of the bondholder, the legal opinions and document reviews should be the ultimate security provisions. The reason is that if all else fails, the bondholder may have to go to court to enforce his or her security rights. The relationship of the legal opinion to the analysis of municipal bonds for both general obligation and revenue bonds is the following: (1) the attorney should check to determine whether the issuer is indeed legally able to issue the bonds; (2) the attorney is to see that the issuer has properly prepared for the bond sale by enacting the various required ordinances, resolutions, and trust indentures and without violating any other laws and regulations;

and (3) the attorney is to certify that the security safeguards and remedies provided for the bondholders and pledged by either the bond issuer or third parties are actually supported by federal, state, and local government laws and regulations.

- Before purchasing a municipal bond the investor should investigate whether the issuer's officials (1) are conscientious public servants with clearly defined public goals; (2) have a history of successful management of public institutions; and (3) have demonstrated commitments to professional and fiscally stringent operations. In addition, it is important to scrutinize closely (and possibly avoid) issuers in highly charged and partisan environments in which conflicts chronically occur between political parties or among political factions or personalities.
- Indicators of the quality of the investment are (1) who the issuer selected as its financial advisor, if any; (2) its principal underwriter if the bond sale was negotiated; and (3) its financial advisor if the bond issue came to market competitively. It is also useful to find out who was the underwriter for the issue.
- An analytical factor to consider in assessing the creditworthiness of an issue is the economic health or viability of the bond issuer or specific project financed by the bond proceeds. The economic factors cover a variety of concerns. When analyzing general obligation bond issuers, the specific budgetary and debt characteristics of the issuer, as well as the general economic environment should be investigated. For project-financing, or enterprise, revenue bonds, the economics are limited primarily to the ability of the project to generate sufficient charges from the users to pay the bondholders. In the case of revenue bonds that rely not on user charges and fees, but instead on general purpose taxes and revenues, the analysis should take basically the same approach as for the general obligation bonds. For these bonds, the taxes and revenues diverted to the bondholders would otherwise go to the state's or city's general fund.

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CHAPTER
FORTY-FIVE

CREDIT-RISK MODELING

TIM BACKSHALL
Chief Credit Derivatives Strategist
Credit Derivatives Research Ltd.

KAY GIESECKE, PH.D.
Assistant Professor of Management Science and Engineering
Stanford University

LISA GOLDBERG, PH.D.
Executive Director of Research
MSCI and
Adjunct Professor of Statistics
University of California at Berkeley

Since the turn of the century, we have seen many theoretical developments in the field of credit-risk research. In view of the large-scale changes in market conditions, the entry of more sophisticated market participants, and the increase in complexity of investable assets, most of the research has focused on pricing of corporate debts. But many of these models have failed to describe real-world phenomena such as credit-spreads realistically. This practitioner-oriented chapter attempts to describe the history and future of modeling credit-risk and valuation of credit-risky assets.

Credit-risk is the distribution of financial losses owing to unexpected changes in the credit quality of the counterparty in a financial agreement. Examples range from agency downgrades to failure to service debt to liquidation. Credit-risk pervades virtually all financial transactions. The distribution of credit losses is complex. At its center is the probability of default, by which we mean any type of failure to honor a financial agreement. To estimate the probability of default, we need to specify

- A model of investor uncertainty
- A model of the available information and its evolution over time
- A model definition of the default event.

However, default probabilities alone are not sufficient to price credit-sensitive securities. We need, in addition,

- A model for the risk-free interest rate
- A model of recovery on default
- A model of the premium investors require as compensation for bearing systematic credit-risk

The credit premium maps actual default probabilities to market-implied probabilities that are embedded in market prices. To price securities that are sensitive to the credit-risk of multiple issuers and to measure aggregated portfolio credit-risk, we also need to specify

- A model that links defaults of different entities

There are three main quantitative approaches to analyzing credit. In the *structural approach,* we make explicit assumptions about the dynamics of a firm's assets, its capital structure, and its debt and share holders. A firm defaults if its assets are insufficient according to some measure. In this situation, a corporate liability can be characterized as an option on the firm's assets. The *reduced-form approach* is silent about why a firm defaults. Instead, the dynamics of default are given exogenously through a default rate, or intensity. In this approach, prices of credit-sensitive securities can be calculated as if they were default-free using an interest rate that is the risk-free rate adjusted by the intensity. The *incomplete-information approach* combines the structural and reduced-form models. While avoiding their difficulties, it picks the best features of both approaches: the economic and intuitive appeal of the structural approach and the tractability and empirical fit of the reduced-form approach.

In this chapter we review the three approaches in the context of the multiple facets of credit modeling that were just mentioned. Our goal is to provide a concise overview and a guide to the large and growing literature on credit-risk.[1]

STRUCTURAL CREDIT MODELS

The basis of the structural approach, which goes back to Black and Scholes[2] and Merton,[3] is that corporate liabilities are contingent claims on the assets of a firm. The market value of the firm is the fundamental source of uncertainty driving credit-risk.

Classical Approach

Consider a firm with market value V, which represents the expected discounted future cash-flows of the firm. The firm is financed by equity and a zero-coupon bond with face value K and maturity date T. The firm's contractual obligation is to repay the amount K to the bond investors at time T. Debt covenants grant bond investors absolute priority: if the firm cannot fulfill its payment obligation, then bondholders immediately will take over the firm.

1. A more mathematical introduction can be found in Kay Giesecke, "Credit-Risk Modeling and Valuation: An Introduction," in David Shimko (ed.), *Credit-Risk: Models and Management,* Vol. 2 (London: Riskbooks, 2004).
2. Fischer Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy* 81 (1973), pp. 81–98.
3. Robert C. Merton, "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," *Journal of Finance* 29 (1974), pp. 449–470.

EXHIBIT 45–1

Default Interpretation in the Classical Approach

Exhibit 45–1 shows several possible paths of firm value. Default occurs if the firm value at maturity is less than the face value of the debt K. The particular path the firm value has taken does not matter here; only the firm value at T is important. The probability of default therefore is equal to the probability that firm value is below debt face value at maturity. To calculate this probability, we make assumptions about the distribution of firm value at debt maturity. The standard assumption is that firm value is log-normally distributed. The probability of default then is given as the area under the log-normal firm value density between 0 and face value, as shown in the graph. This probability can be calculated explicitly in terms of K, the current firm value $V(0)$, the volatility of firm value, the growth rate of firm value and T.

Assuming that the firm can neither repurchase shares nor issue new senior debt, the payoffs to the firm's liabilities at debt maturity T are as summarized in Exhibit 45–2. If the asset value $V(T)$ exceeds or equals the face value K of the bonds, the bondholders will receive their promised payment K, and the shareholders will get the remaining $V(T) - K$. However, if the value of assets $V(T)$ is

EXHIBIT 45–2

Payoffs at Maturity in the Classical Approach

Event Description	Assets	Debt	Equity
No default	$V(T) \geq K$	K	$V(T) - K$
Default	$V(T) < K$	$V(T)$	0

EXHIBIT 45–3

Term Structure of Credit-Spreads, Varying Asset Volatility, in the Classical Approach

less than K, the ownership of the firm will be transferred to the bondholders, who lose the amount $K - V(T)$. Equity is worthless because of limited liability.

Summarizing, the value of the bond is equivalent to that of a portfolio composed of a default-free loan with face value K maturing at time T and a short European put position on the assets of the firm with strike K and maturity T. The value of the equity is equivalent to the payoff of a European call option on the assets of the firm with strike K and maturity T. Pricing equity and credit-risky debt thus reduces to pricing European options.

The credit-spread is the difference between the yield on a defaultable bond and the yield on an otherwise equivalent default-free zero bond. It gives the excess return demanded by bond investors to bear the potential default losses. The credit-spread is a function of maturity T, asset volatility (the firm's business risk), the initial leverage ratio $K/V(0)$, and risk-free rates.

Letting initial leverage be 80% and risk-free rates be 6%, in Exhibit 45–3 we plot the model term structure of credit-spreads for varying asset volatilities. We see clearly that as asset volatility (business risk) rises, then so does the spread required by the market to compensate for the risk of default. Other noticeable traits of this graph are the rapid fall to zero spreads at short maturities and the more pronounced hump-shaped curve as volatility rises higher.

First-Passage Approach

In the classical approach, firm value can dwindle to almost nothing without triggering default. This is unfavorable to bondholders, as noted by Black and

EXHIBIT 45–4

Default in the First-Passage Approach

Cox.[4] Bond indenture provisions often include safety covenants that give bond investors the right to reorganize a firm if its value falls below a given barrier.

First-passage time models generalize the classical model such that a default can occur not only at maturity of the debt contract but also at any point of time. They assume that default happens if the firm value V hits a specified default barrier D. The default barrier in general can be a stochastic process, as is the firm value. For tractability reasons, however, one often works with a simple time-dependent, nonstochastic barrier specification, or just a constant barrier.

Suppose that the default barrier D is a constant between zero and the initial firm value—this is reasonable because we would expect liabilities to be nonnegative and less than current assets. Then the default time is more realistically defined as when the value of the firm crosses below the default barrier. In other words, firms can default at times other than debt maturity. This relaxation of the European nature of the default event in the classical approach provides some more realistic behavior.

Exhibit 45–4 shows several possible paths of firm value and a constant default barrier D. Suppose for the moment that D is equal to the face value of the firm's debt. Default occurs if the firm value falls, at any time before the horizon T, below the default barrier. As shown, different firm-value paths correspond to different default times. Unlike the classical model discussed earlier, here the entire path the firm value follows is relevant. Firm-value paths that imply survival in the classical approach can

4. Fischer Black and John C. Cox, "Valuing Corporate Securities: Some Effects of Bond Indenture Provisions," *Journal of Finance* 31 (1976), pp. 351–367.

imply default in the first-passage approach. Therefore, the first-passage approach implies higher probabilities of default than the classical approach.

The probability of default is given by the probability that the minimum firm value at the horizon $M(T)$ is lower than the barrier D. In order to calculate this probability, we make an assumption about the distribution of future firm values, as in the classical approach. This determines also the distribution of the minimum firm value at the horizon. With log-normal firm values, this distribution is inverse gaussian. The default probability is given as the area under the inverse gaussian density curve between 0 and the default barrier D.

We consider the payoff to investors in the firm's liabilities. For simplicity, we assume that the default barrier is equal to the face value of firm debt. If the firm value never fell below the barrier over the term of the bond, then bond investors receive the bond's face value K and equity investors would receive the remaining $V(T) - K$. However, if the firm falls below the barrier at some point during the bond's term, then the firm defaults. In this case the firm stops operating, bond investors take over its remaining assets, and equity investors receive nothing.

Therefore, the equity position is equivalent to that of a down-and-out call on firm assets with strike equal to the face value of the debt, barrier level equal to the default barrier, and maturity equal to debt maturity. The value of the debt is given as the difference between firm value and equity value. Pricing equity and credit-risky debt thus reduces to pricing European barrier options.

We consider the credit-spread implied by a first-passage model in Exhibit 45–5. We assume that the default barrier is constant and equal to the face value of the bonds. We set leverage equal to 60% and risk-free rates to 6%,

EXHIBIT 45–5

Term Structure of Credit-Spreads, Varying Asset Volatility, in the First-Passage Model

as in Exhibit 45–3. We assume that in the event of default, bond investors recover a fraction of 50% of their initial investment.

With increasing maturity T, the spread asymptotically approaches zero. This is at odds with empirical observation; for many firms, spreads tend to increase with increasing maturity, reflecting the fact that uncertainty is greater in the distant future than in the near term. This discrepancy follows from two model properties: the firm value grows at a positive (risk-free) rate, and the capital structure is constant and assumed known with certainty. We can address this issue by assuming that the total debt grows at a positive rate or that firms maintain some target leverage ratio as in Collin-Dufresne and Goldstein.[5] A critical insight from this plot is that the level of spreads in the first-passage model is much higher and much more realistic than in the classical model. This is due to the fact that default probabilities are higher in the first-passage approach, as we discussed earlier.

Dependent Defaults

Credit-spreads of different issuers are correlated through time. Two patterns are found in time series of spreads. The first is that spreads vary smoothly with general macroeconomic factors in a correlated fashion. This means that firms share a common dependence on the economic environment, which results in cyclic correlation between defaults. The second relates to the jumps in spreads: we observe that these are often common to several firms or even entire markets. This suggests that the sudden large variation in the credit-risk of one issuer, which causes a spread jump in the first place, can propagate to other issuers as well. The rationale is that economic distress is contagious and propagates from firm to firm. A typical channel for these effects are borrowing and lending chains. Here the financial health of a firm also depends on the status of other firms as well.

We want to incorporate these two default correlation mechanisms into the structural approach to credit. To introduce cyclic correlation, it is natural to assume that firm values of several firms are correlated through time. This corresponds to common factors driving asset returns. We consider the simplest case with two firms whose firm values are log normal. Our definition of default follows the classical approach.

Exhibit 45–6 illustrates the situation. The axes show the marginal asset return distributions of the two firms. Individual asset returns are normally distributed, hence the bell shape. Individual returns are modeled through a linear factor model, which represents systematic and firm-specific risk. Systematic risk is modeled by a common latent factor X, which drives the systematic variation in the asset returns of both firms. The sensitivity of a firm's return to this common factor controls the asset correlation across firms. This asset correlation drives the default correlation between firms.

5. Pierre Collin-Dufresne and Robert Goldstein, "Do Credit-Spreads Reflect Stationary Leverage Ratios?" *Journal of Finance* 56 (2001), pp. 1929–1958.

EXHIBIT 45–6

Illustrative Example of Structural-Based Joint Default Modeling

The elliptical shapes represent lines of equal joint asset value probability. The shaded area on the bottom left illustrates the joint default probability, as defined by the area under which issuer 1's asset value is below its default barrier and issuer 2 is below its default barrier.

Asset correlation captures the dependence of firms on common economic factors in a natural way. Modeling default contagion effects is much more difficult. A straightforward idea is to consider a jump-diffusion model for firm value. We would stipulate that a downward jump in the value of a given firm triggers subsequent jumps in the firm values of other firms with some probability. This would correspond to the propagation of economic distress. This approach is difficult, however, because of the lack of closed-form results on the joint distribution of firms' historical asset lows. This is what we need to calculate the probability of joint default.

A more successful attempt is to introduce interaction effects through the default barriers D_i. Suppose that the barrier is random and depends on the firm's liquidity state, which, in turn, depends on the default status of the firm's counterparties. If a firm's liquidity reserves are stressed owing to a payment default of a counterparty, it finances the loss by issuing more debt. This increases the default,

barrier: the firm is now more likely to default, all else being equal. With no counterparty defaults the default barrier remains unaffected. This model allows a closed-form approximation of the credit portfolio loss distribution.

Credit Premium

Issuers of credit-sensitive securities share a common dependence on the economic environment. It follows that aggregated credit-risk cannot be diversified away. This undiversifiable or systematic risk commands a premium, which compensates risk-averse investors for assuming credit-risk.

The credit premium is empirically well documented. Its importance relates to the uses of a quantitative credit model. As a default probability forecasting tool, a credit model must reflect the historical default experience. As a tool for pricing credit-sensitive securities, it must fit observed market prices. To make use of both market data and historical default data in the calibration and application of a credit model, we need to understand the relationship between actual defaults and defaultable security prices.

Here the risk premium comes into play: it maps the actual likelihood of default $p(T)$ into the market-implied likelihood of default $q(T)$ that is embedded in security prices.

We examine the difference between the two using a simple example in Exhibit 45–7. We consider a one-period market with two securities, a risk-free bond paying 10 and trading at 10 (risk-free rates are zero) and a defaultable bond trading at 5 that pays 20 in case of no default and zero in case the issuer defaults by the end of the trading period.

EXHIBIT 45–7

Real-World versus Market-Implied Probability of Default

Suppose that the actual probability of default is $p = 0.5$ (50%, or a coin flip). This is, however, not the probability the market uses for pricing the bond: it would lead to a price of $p.20 + (1 - p).0 = 10$, which is double the price at which the bonds are actually trading. At this price, risk-averse investors would rather put their money into the risk-free bond that costs 10 as well, unless they get a discount as compensation for the default risk. The market requires a discount of 5, and the corresponding price reflects the market-implied probability of default q, which satisfies $5 = (1 - q).20$. This yields $q = 0.75$ (75% probability of default), which is bigger than the actual probability of default $p = 0.5$.

To account for risk aversion in calculating the expected payoff of the defaultable bond, the market puts more weight on the unfavorable states of the world in which the firm defaults. In the structural credit models with firm value dynamics as described previously and constant risk-free rates, the situation is only a little more complicated.

In the absence of arbitrage opportunities, the credit-risk premium α is uniquely determined through market prices of credit-sensitive securities such as equity or debt and is measured as the excess return on firm assets over the risk-free return per unit of firm risk measured in terms of asset volatility. If the market is risk-averse, then α is positive: investors in credit-risky firm assets require a return that is higher than the risk-free return. The excess return on any credit-sensitive security is given by its volatility times α.

Calibration

The calibration of a quantitative credit model is closely related to its use. To price single-name credit-sensitive securities using a structural model, we need to calibrate the risk-free rate, the asset volatility, the asset value, the face value of the debt, the default barrier, and the maturity of the debt. The default barrier is relevant only in the first-passage approach. To use the model to forecast actual default probabilities, we need to calibrate additionally the growth rate of firm assets or, equivalently, the credit-risk premium α. In a multiple-firm setting we need to estimate asset correlations in addition to the single-name parameters.

Firm values are not observable. The goal is to estimate the parameters of the firm-value process based on equity prices, which can be observed for public firms. Risk-free interest rates can be estimated from default-free Treasury bond prices via standard procedures. We bypass estimation of face value and maturity of firm debt from balance-sheet data, which is nontrivial given the complex capital structure of firms. In practice, these parameters often are fixed ad hoc, as some average of short- and long-term debt, for example. We introduce a more reasonable solution to this problem later.

We consider the classical approach, as briefly discussed earlier. Given equity prices and equity volatilities, Jones, Mason, and Rosenfeld and many others suggest

to back out asset values and asset volatilities by numerically solving a system of two equations.[6] The first equation relates the equity price to asset value, time, and asset volatility and follows from the Black-Scholes pricing function for a European call with strike K and maturity T. The second equation relates the equity price to asset and equity volatility, the delta of equity, and asset value. This relation is obtained from applying Ito's formula to the first equation.

We can use these two equations to "translate" a time series of equity values into a time series of asset values and volatilities. As for the equity volatility, we can use the empirical standard deviation of equity returns or a true forecasting model such as Barra Equity Risk models. Given a time series of asset returns, the empirical growth rate yields an estimate of the market price of credit-risk. The estimate of the firm growth rate, however, is very poor: it is based on two asset-return observations only.

Further, given the asset-return time series of several firms, asset correlation can be estimated. Alternatively, we can introduce a linear-factor model for normally distributed asset returns that expresses the idea that firms share a common dependence on general economic factors. This is similar to the idea we discussed earlier.

Can We Predict the Future?

To a certain extent, users of structural models implicitly assume that they can. In structural models, firm value is the single source of uncertainty that drives credit-risk. Investors observe the distance of default as it evolves over time. If the firm value has no jumps, this implies that the default event is not a total surprise. There are "predefault events" that announce the default of a firm. In the first-passage approach, we can think of a predefault event as the first time assets fall dangerously close to the default barrier (see Exhibit 45–8).

This has significant implications for the fitting of structural models to market prices. First, since default can be anticipated, the model price of a credit-sensitive security converges continuously to its recovery value. Second, the model credit-spread tends to zero with time to maturity going to zero.[7] Quite telling in this regard are the credit-spreads implied by the classical and first-passage approaches (see Exhibits 45–3 and 45–5). Both properties are at odds with intuition and market reality. Market prices do exhibit surprise downward jumps on default. Even for very short maturities in the range of weeks, market credit-spreads remain positive. This indicates that investors do have substantive short-term uncertainty about defaults, in contrast to the predictions of the structural models.

6. E. Jones, Scott Mason, and Eric Rosenfeld, "Contingent Claims Analysis of Corporate Capital Structures: An Empirical Investigation," *Journal of Finance* 39 (1984), pp. 611–627.
7. See Kay Giesecke, "Default and Information," *Journal of Economic Dynamics and Control*, 30 (2006), pp. 2281–2303.

EXHIBIT 45–8

Announcing the Default Timing by a Sequence of "Predefault" Events in the First-Passage Approach

REDUCED-FORM CREDIT MODELS

Reduced-form models were developed in the 1990s.[8] Here we assume that default occurs without warning. This means that investors face short-term credit-risk, which is absent from the structural models discussed previously. This is a desirable model property because it allows us to fit the model to market credit-spreads.

Default Intensity

The rate at which default occurs is called the *default intensity,* and we denote it by λ. We can think of the *intensity* at time t as the conditional probability that default will happen immediately, given that the firm has escaped default by t. As such, it describes the short-term credit-risk investors face.

The intensity is the central ingredient of all reduced-form models. It is modeled as a (nonnegative) stochastic process under the market-implied probability. The time evolution of the intensity reflects changes in the instantaneous default probability of a firm. The intensity model is calibrated from market prices

8. See Philippe Artzner and Freddy Delbaen, "Default Risk Insurance and Incomplete Markets," *Mathematical Finance* 5 (1995), pp. 187–195; Robert A. Jarrow and Stuart M. Turnbul, "Pricing Derivatives on Financial Securities Subject to Credit-Risk," *Journal of Finance* 50 (1995), pp. 53–86; and Darrell Duffie and Kenneth J. Singleton, "Modeling Term Structures of Defaultable Bonds," *Review of Financial Studies* 12 (1999), pp. 687–720.

of credit-sensitive securities issued by the firm. There is a one-to-one relation between the intensity and the corresponding default probabilities.

We give two simple but useful specifications for the intensity and the corresponding default probabilities.

- *Example 1*. Suppose that λ is a constant. Then default is a Poisson arrival, and the default time is exponential with parameter λ. The default probability thus is given by $q(T) = 1 - \exp(-\lambda T)$.
- *Example 2*. Suppose that $\lambda = \lambda(t)$ is a deterministic function of time t. Then default is an inhomogeneous Poisson arrival. A simple but useful parameterization that is frequently used is the assumption that $\lambda(t)$ is stepwise defined over finite periods across the spread curve—these stepwise constants can be calibrated easily from market data.

These examples constitute only a small sample of possible parameterizations of the default intensity. There are many more choices, often borrowed from the classical term-structure models based on the short-term interest rate. This is motivated by the close analogy of defaultable term-structure models and classical, nondefaultable term-structure models to which we turn next.

Valuation

The description of the default dynamics through the market-implied default intensity λ leads to tractable valuation formulas. Below we describe several different specifications of these formulas corresponding to different units for the value recovered by investors at default.

We consider a zero-coupon bond paying 1 at maturity T if there is no default and a fraction $0 < R < 1$ of an equivalent (face value 1, maturity T) but default-free bond at default if default occurs before maturity T. This recovery specification is often called *equivalent recovery*. Given the market-implied probability of default $q(T)$, and assuming that R is a constant, the present value of the bond can be written as $\exp(-rT) - \exp(-rT)(1 - R)q(T)$. Here, r is the constant risk-free rate of interest. Thus the value of the bond is the value of an otherwise equivalent risk-free bond minus the present value of the default loss $(1 - R)$. If the intensity is constant (Example 1) and recovery is zero, we obtain for the bond price today $\exp[-(r + \lambda)T]$. This means that the value of the defaultable bond is calculated as if the bond were risk-free by using a default-adjusted discount rate. The new discount rate is the sum of the risk-free rate r and the intensity λ. This parallel between pricing formulas for defaultable bonds and otherwise equivalent default-free bonds is one of the best features of reduced-form models.

An alternative recovery model is called *fractional recovery of predefault market value*. Here it is assumed that the bond recovers a fraction $0 < R < 1$ of the market value of the bond just prior to default. If the recovery rate and the intensity are constant (Example 1 above), we obtain the following convenient formula for

the bond price: $\exp\{-[r + \lambda(1 - R)]T\}$. This is the value of a zero-recovery defaultable bond when the issuer's default intensity is "thinned" to $\lambda(1 - R)$. The intuition behind this is as follows. Suppose that the bond defaults with intensity λ. At default, the bond becomes worthless with probability $(1 - R)$, and its value remains unchanged with probability R. Clearly, the predefault value of the bond is not changed by this way of looking at default. Consequently, for pricing, we can ignore the "harmless" default, which occurs with intensity λR. We then price the bond as if it had zero recovery and a default intensity of $\lambda(1 - R)$. The fractional-recovery pricing formula is then implied by the formula for equivalent recovery.

The results for the valuation of more complex credit-sensitive securities are analogous, and in the general case, a credit-sensitive security can be valued as if it were not sensitive to credit-risk by using an adjusted rate for discounting payoffs.

We take a closer look at the credit-spreads implied by reduced-form models. In the simple case where recovery is zero and some technical conditions are satisfied, we can show that short-term credit-spreads tend to λ and not zero. This should be contrasted with the structural models, where the spread goes to zero with time to maturity going to zero. In the reduced-form models, the default event is unpredictable; it comes without warning. There is always short-term uncertainty about the default event, for which investors demand a premium. This premium, expressed in terms of yield, is given by the intensity.

The unpredictability of default has another important consequence. In line with empirical observation, the model price of a credit-sensitive security will drop abruptly to its recovery value on default. This is in direct conflict with the structural models considered earlier, in which the price converges to its default contingent value and remains there as equity value drops to zero.

Default Correlation

In the reduced-form approach we can introduce cyclical default correlation by assuming that firms' default intensities are correlated through time. Similarly to the structural models of correlated default, we can introduce systematic and firm-specific factors that drive the intensities of firms. The sensitivity of a firm with respect to the systematic factors controls the intensity correlation across firms. This intensity correlation drives the dependence between firm defaults. Joint default probabilities can be calculated by observing that the intensity of the first default in a portfolio of names is the sum of the default intensities of the individual issuers in the portfolio.

Reduced-form models provide a flexible framework for modeling the dynamics of multiple-issuer credit-risk. However, calibration of the model to market variables is not trivial because of the scarcity of default data and the need to model a large number of parameters simultaneously. There are also studies that argue that the approach can be problematic for other reasons.

Taking account of contagious default correlation in the reduced-form approach is not an easy exercise. The idea is that there are correlated jumps in firms'

default intensities corresponding to the correlated jumps we observe in credit-spreads. A variant of this assumes that there are marketwide events that can trigger joint defaults.[9] Another variant assumes that the default intensity of a firm depends explicitly on the default status of related counterparty firms in the market.[10] To avoid running into a circularity problem, one can suppose that only the default of designated "primary" firms has an effect on other "secondary" firms.

While Jarrow and Yu[11] focus on the pricing of credit-sensitive securities in the presence of contagion effects, it is difficult to calculate joint default probabilities and portfolio loss distributions within this approach. As Davis and Lo[12] and Giesecke and Weber[13] show, one can obtain tractable closed-form characterizations of loss distributions at the cost of more restricting assumptions that relate to the homogeneity of firms and the symmetry in their counterparty relations.

Calibration

Reduced-form models typically are formulated directly under the market-implied probability. This suggests that we calibrate directly from market prices of various credit-sensitive securities. One often uses liquid debt prices or credit default swap spreads, although Jarrow argues that equity is a good candidate as well.[14] Depending on the characteristics of the calibration security, it may be necessary to make parametric assumptions about the recovery process as well. With fractional recovery and zero bonds, for example, the problem is to choose the parameters of the adjusted short rate model $r + \lambda(1 - R)$ such that model bond prices best fit observed market prices.

Here one can either parameterize the adjusted short rate directly or specify the component processes separately. With a separate specification, identification problems may arise because only the product $\lambda(1 - R)$ enters the pricing formula just described. In general, in the estimation problem one can draw from the experience related to nondefaultable term-structure models given the close analogy to reduced-form defaultable models.[15]

9. See Darrell Duffie and Kenneth J. Singleton, "Simulating Correlated Defaults," working paper, GSB, Stanford University, 1998; and Kay Giesecke, "A Simple Exponential Model for Dependent Defaults," *Journal of Fixed Income* 13 (2003), pp. 74–83.
10. This is due to Robert A. Jarrow and Fan Yu, "Counterparty Risk and the Pricing of Defaultable Securities," *Journal of Finance* 56 (2001), pp. 555–576.
11. Jarrow and Yu, "Counterparty Risk and the Pricing of Defaultable Securities."
12. Mark Davis and Violet Lo, "Infectious Defaults," *Quantitative Finance* 1 (2001), pp. 383–387.
13. Kay Giesecke and Stefan Weber, "Cyclical Correlations, Credit Contagion, and Portfolio Losses," *Journal of Banking and Finance* 28 (2004), pp. 3009–3036.
14. Robert A. Jarrow, "Default Parameter Estimation Using Market Prices," *Financial Analysts Journal* 5 (2001), pp. 1–18.
15. Dai and Singleton provide for an overview of available techniques [Qiang Dai and Kenneth Singleton, "Term Structure Dynamics in Theory and Reality," *Review of Financial Studies* 16 (2003), pp. 631–678]. Standard methods include maximum likelihood and least squares.

INCOMPLETE-INFORMATION CREDIT MODELS

For the purpose of measuring default risk, neither the structural nor the reduced-form model explicitly accounts for the fact that investors rely on information that is imperfect. The framework described in this section addresses this issue directly by giving a common perspective on reduced-form and structural models. This perspective leads to previously unrecognized hybrid models that incorporate the best features of both traditional approaches while avoiding their shortcomings.

Incomplete-information credit models were introduced by several researchers.[16] Giesecke and Goldberg[17] describe a structural reduced-form hybrid default model based on incomplete information. This model, hereafter denoted I^2, is a first-passage time model: it assumes that a firm defaults when its value falls below a barrier. All first-passage time models require descriptions of both firm value and a default barrier. What distinguishes the I^2 model from traditional first-passage time models as we described them earlier is that it assumes that investors do not know the default barrier. The importance of modeling uncertainty about the default barrier is highlighted by high-profile scandals at firms such as Enron, Tyco, and WorldCom. In these cases, public information led to poor estimates of the default barrier.

Both the expected default barrier and the uncertainty around it can be calibrated to available information in the I^2 model. Imagine that a firm is believed to be in good financial health but that a particular analyst thinks otherwise. The analyst can increase the forecasts to line up with her views by raising the expected value of the barrier. She also can adjust the variance of the default barrier to the level of her confidence in reported levels of the firm's liability.

Other incomplete-information models can be envisioned. We can think of a situation where we cannot observe firm values or receive noisy or lagged firm-value information. Another situation is when we are uncertain about both firm values and the default barrier.

With incomplete information, default becomes a surprise event. It cannot be anticipated any more, as it can in the traditional first-passage models. It follows that investors face short-term credit-risk as in the reduced-form models. With short-term uncertainty, the model prices generated by the incomplete-information models provide an excellent fit to market prices. In particular, model prices are consistent with the jumps in prices observed around the default announcement. Model spreads are consistent with the nonzero short-term spreads observed in the credit markets. Exhibit 45–9 shows the term structure of credit-spreads implied

16. See Darrell Duffie and David Lando, "Term Structures of Credit-Spreads with Incomplete Accounting Information," *Econometrica* 69 (2001), pp. 633–664; Giesecke, "Default and Information"; and Umut Cetin, Robert A. Jarrow, Philip Protter, and Yildiray Yildirim, "Modeling Credit-Risk with Partial Information," working paper, Cornell University, 2002. A nontechnical discussion of incomplete-information models is provided in Lisa R. Goldberg, "Investing in Credit: How Good Is Your Information?" *Risk* 17 (2004), pp. S15–S18.
17. Kay Giesecke and Lisa Goldberg, "Forecasting Default in the Face of Uncertainty," *Journal of Derivatives* 12 (2004), pp. 14–25.

EXHIBIT 45–9

Term Structure of Credit-Spreads, Varying Asset Volatility, in the I^2 Model

by the I^2 model, assuming risk-free rates of 6%. Strictly positive short spreads reflect the compensation for the short-term credit-risk that investors face.

Giesecke and Goldberg calibrate the I^2 model from market data and further analyze its empirical properties. In particular, the I^2 model output is compared empirically with a traditional first-passage model. Two main conclusions can be drawn. The I^2 model reacts more quickly because it takes direct account of the entire history of public information rather than just current values. Furthermore, the I^2 model predicts positive short spreads for firms in distress. The traditional first-passage model always predicts that short spreads are zero.

Dependent Defaults

Since incomplete-information models are based on the structural approach, we can model cyclical default correlation through firm-value correlation.

Contagious default correlation arises very naturally with incomplete information. Consider the I^2 model. With defaults of firms arriving over time, we learn about the unobserved default barriers of the surviving firms.[18] This means that we update the distribution we put on a firm's default barrier with the information we extract from the unanticipated defaults of counterparty firms and reassess firms' default probabilities. The situation in which we do

18. This is discussed in detail in Kay Giesecke, "Correlated Default with Incomplete Information," *Journal of Banking and Finance* 28 (2004), pp. 1521–1545.

EXHIBIT 45–10

Firm Value in the Incomplete-Information Model

not directly observe firm values is very similar.[19] In both scenarios, the "contagious" jumps in credit-spreads we observe in credit markets are implied by informational asymmetries.

Credit Premium

The credit-risk premium is the mapping between the actual probability and the market-implied probability. To understand the structure of the premium, we examine the dynamics of firm value and corporate liabilities in the I^2 model. We argued earlier that thanks to the unpredictability of default, prices of credit-sensitive claims including firm equity and debt drop precipitously at default. Empirical observation shows that equity drops to near zero. This makes sense because equity holders have no stake in the firm after default. The value of the bonds is diminished by bankruptcy costs, which is described by some fractional recovery R.

Consequently, firm value, which is equal to the sum of equity and debt values, also drops at default. This is shown in Exhibit 45–10. Therefore, there are two sources of uncertainty related to firm value:

- The first is the diffusive uncertainty.
- The second is the uncertainty associated with the downward jump at default.

19. This is analyzed in Pierre Collin-Dufresne, Robert Goldstein, and Jean Helwege, "Are Jumps in Corporate Bond Yields Priced: Modeling Contagion via the Updating of Beliefs," working paper, Carnegie Mellon University, 2002.

Giesecke and Goldberg show that in the I^2 model the credit-risk premium can be decomposed into two components, which correspond to the two sources of uncertainty:[20]

- The diffusive risk premium α compensates investors for the diffusive uncertainty in firm value. As in the traditional structural models, it is realized as a change to the drift term in firm-value dynamics.
- The default event risk premium β is not present in the traditional structural models. It compensates investors for the jump uncertainty in firm value and is realized as a change to the default probability. Driessen[21] empirically confirms that this event risk premium is a significant factor in corporate bond returns.

Giesecke and Goldberg demonstrate that the assumption of no arbitrage is realized in the mathematical relationships among α, β, the recovery rate assumed by the market, and the coefficients of the price processes of traded securities. The price processes depend explicitly on the leverage ratio, so the premia α and β do as well. As Giesecke and Goldberg discuss,[22] this violates an important condition for the Modigliani and Miller theorem.[23] The I^2 model therefore is not consistent with the Modigliani-Miller theorem. It provides a new way to measure the deviation of real markets from the idealized markets in which the Modigliani-Miller theorem holds.

The structure of the incomplete-information risk premium is analogous to the risk premium in reduced-form models considered in El Karoui and Martellini[24] and Jarrow, Lando, and Yu.[25] The diffusive premium related to the firm-value process corresponds to a premium for diffusive risk in the default intensity process. The event risk premium is analogous to the default event risk premium in intensity-based models. However, in the incomplete-information setting it is defined in the general reduced-form context where an intensity need not exist.

20. Kay Giesecke and Lisa Goldberg, "The Market Price of Credit-Risk," working paper, Cornell University, 2003.
21. Joost Driessen, "Is Default Event Risk Priced in Corporate Bonds," working paper, University of Amsterdam, 2002.
22. Kay Giesecke and Lisa Goldberg, "In Search of a Modigliani-Miller Economy," *Journal of Investment Management* 2 (2004), pp. 1–6.
23. Franco Modigliani and Merton H. Miller, "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review* 48 (1958), pp. 261–297.
24. Nicole El Karoui and Lionel Martellini, "A Theoretical Inspection of the Market Price for Default Risk," working paper, Marshall School of Business, University of Southern California, 2001.
25. Robert A. Jarrow, David Lando, and Fan Yu, "Default Risk and Diversification: Theory and Applications," working paper, Cornell University, 2003.

Calibration

There is a lively debate in the literature concerning which data should be used to calibrate credit. Jarrow[26] points to a division between structural and reduced-form modelers on this issue. Traditionally, structural models are fit to equity markets and reduced-form models are fit to bond markets. Jarrow argues that the equity and bond data can be used in aggregate to calibrate a credit model, and he gives a recipe for doing this in a reduced-form setting.

Giesecke and Goldberg[27] apply reasoning similar to that of Jarrow to calibrate the I^2 model. The estimation procedure makes use of historical default rates in conjunction with data from equity, bond, and credit default swap markets. Huang and Huang[28] give empirical evidence that structural models yield more plausible results if calibrated to both kinds of data. Importantly, the physical and market-implied probabilities are fit simultaneously. The output of the calibration includes estimates of the risk premium, market-implied recovery, model security prices, and physical probabilities of default.

One issue addressed in Giesecke and Goldberg[29] is the relationship between model and actual capital structures. In the classical setting, equity is a European option, with strike price and date equal to the face value and maturity of a zero bond. This model fits market data only to the extent that firm debt can be represented adequately as a zero bond. Giesecke and Goldberg make use of the flexibility imparted by incomplete information to give a more realistic picture of equity. Specifically, equity is a down-and-out call with a stochastic strike price. This approach sidesteps the intractable problem of describing a complex capital structure in terms of a single face value and maturity date.

KEY POINTS

- Credit-risk is the distribution of financial losses owing to unexpected changes in the credit quality of the counterparty in a financial agreement.
- Estimating probability of default requires the specification of a (1) model of investor uncertainty, (2) model of the available information and its evolution over time, and (3) model definition of the default event.
- Because default probabilities alone are not sufficient to price credit-sensitive securities, it is necessary to have a (1) model for the risk-free

26. Jarrow, "Default Parameter Estimation Using Market Prices."
27. Kay Giesecke, and Lisa Goldberg, "Calibrating Credit with Incomplete Information," working paper, Cornell University, 2004.
28. Jay Huang and Ming Huang, "How Much of the Corporate-Treasury Yield Spread Is Due to Credit-Risk?" working paper, Stanford University, 2003.
29. Giesecke and Goldberg, "Calibrating Credit with Incomplete Information."

interest rate, (2) model of recovery on default, and (3) model of the premium investors require as compensation for bearing systematic credit-risk.

- The credit premium maps actual default probabilities to market-implied probabilities that are embedded in market prices.
- In order to price securities that are sensitive to the credit-risk of multiple issuers and measure aggregated portfolio credit-risk, a model that links defaults of different entities must be specified.
- The three main quantitative approaches to analyzing credit are the structural approach, the reduce-form approach, and the incomplete-information approach.
- The basis of the structural approach is the Black-Scholes-Merton framework, in which corporate liabilities are contingent claims on the assets of a firm. The market value of the firm is the fundamental source of uncertainty driving credit-risk. The structural approach makes explicit assumptions about the dynamics of a firm's assets, its capital structure, and its debt and share holders. A firm defaults if its assets are insufficient according to some measure. In this situation, a corporate liability can be characterized as an option on the firm's assets.
- First-passage time structural models generalize the classical model such that a default can occur not only at maturity of the debt contract, but also at any point of time.
- Credit-spreads of different issuers are correlated through time and must be incorporated into a credit-risk model. Two patterns are found in time series of spreads: (1) spreads vary smoothly with general macroeconomic factors in a correlated fashion, and (2) there are jumps in spreads that are common to several firms or even entire markets.
- Reduced-form models assume that default occurs without warning. That is, this approach is silent about why a firm defaults. Instead, the dynamics of default are given exogenously through a default rate, or intensity. In this approach, prices of credit-sensitive securities can be calculated as if they were default-free using an interest rate that is the risk-free rate adjusted by the intensity. Default intensity is the rate at which defaults occur.
- The incomplete-information approach combines the best features of the structural and reduced-form models while at the same time avoiding the shortcomings of the two models. More specifically, it combines the economic and intuitive appeal of the structural approach and the tractability and empirical fit of the reduced-form approach.

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PART

SEVEN

MULTIFACTOR RISK MODELS

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CHAPTER
FORTY-SIX

INTRODUCTION TO MULTIFACTOR RISK MODELS IN FIXED INCOME AND THEIR APPLICATIONS

ANTHONY LAZANAS, PH.D.
Managing Director
Barclays Capital

ANTÓNIO BALDAQUE DA SILVA, PH.D.
Director
Barclays Capital

RADU GĂBUDEAN, PH.D.
Vice President
Barclays Capital

ARNE D. STAAL, PH.D.
Director
Barclays Capital

Risk management is an integral part of the investment process. Risk models are central to this practice, allowing managers to quantify and analyze the risk embedded in their portfolios. Risk models provide managers with insight into the different sources of risk in a portfolio, helping them to control their exposures and understand the contributions of different portfolio components to total risk. They help portfolio managers in their decision-making process by providing answers to important questions such as: How does my long-duration exposure affect portfolio risk? Does my underweight in diversified financials hedge my overweight in banks? Risk models are also widely used in various other areas such as in portfolio construction, performance attribution, and scenario analysis.

In this chapter we introduce linear multifactor risk models and illustrate how they can be helpful for the analysis of the risk of fixed income portfolios. We review the major sources of risk in fixed income securities and introduce a set of appropriate risk factors. We also present several applications of risk models for

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effective portfolio construction and management. In Chapter 47 we will go through a detailed risk model report of a specific portfolio and highlight the information and insights it can provide to a portfolio manager.

MOTIVATION AND STRUCTURE UNDERLYING FIXED INCOME MULTIFACTOR RISK MODELS

In this section, we discuss the motivation and structure behind fixed income multifactor risk models.

Let us assume that a portfolio manager wants to estimate and analyze the volatility of a large portfolio of fixed income instruments. A straightforward idea would be to compute the volatility of the historical returns of the portfolio and use this measure to forecast future volatility. However, this framework does not provide any insight into the relationships between different securities in the portfolio or the major sources of risk. For instance, it does not assist a portfolio manager interested in diversifying a portfolio or constructing a portfolio that has better risk-adjusted performance. Additionally, the characteristics of a fixed income portfolio change substantially over time, for instance, as instruments mature or are subject to credit events.

Instead of estimating the portfolio volatility using historical portfolio returns, a portfolio manager could utilize a different strategy. The portfolio return is a function of individual instrument returns (e.g., Treasury securities, corporate bonds, credit derivatives, municipal bonds, interest rate swaps, and so on) and the market weights of these securities in the portfolio. Using this, the forecasted volatility of the portfolio (σ_P^f) can be computed as a function of the weights (w) and the covariance matrix (Σ_S) of the instrument returns in the portfolio:

$$\sigma_P^f = \sqrt{w^T \times \Sigma_S \times w}$$

where the superscript T denotes a matrix transpose. This covariance matrix can be decomposed into individual instrument volatilities and the correlations between returns.

Volatilities measure the riskiness of individual instrument returns, and correlations represent the relationships between the returns of different instruments. By measuring these correlations and volatilities, the portfolio manager can gain insight into her portfolio related to the riskiness of different parts of the portfolio or how the portfolio can be diversified. As outlined above, to estimate the portfolio volatility we need to estimate the correlation between each pair of instruments. Unfortunately, this means that the number of parameters to be estimated grows quadratically with the number of instruments in the portfolio.[1] For most practical portfolios, the relatively large number of constituents makes it difficult to estimate the relationship between instrument returns in a robust way. Moreover, this framework uses the history of individual instrument returns to forecast future security return volatility. However,

1. As an example, if the portfolio has 10 instruments, we need to estimate 45 parameters, with 100 instruments we would need to estimate 4,950 parameters.

instrument characteristics are dynamic and hence using returns from different time periods may not produce good forecasts.[2] These drawbacks constitute the motivation for multifactor risk models discussed in this chapter.

One of the major characteristics of multifactor models is their ability to describe the return of a portfolio using a relatively small set of variables, called *factors*. These factors should be designed to capture broad (systematic) market fluctuations, but should also be able to capture specific nuances of individual portfolios. For instance, a broad fixed income market factor would capture the general movement in the fixed income markets, but not the varying behavior across types of instruments. If, for example, a portfolio is heavily biased toward the long end of the U.S. Treasury yield-curve, or is tilted toward credit bonds of particular industries, the broad market factor may not allow for a good representation of the portfolio's return. Other factors might be needed to capture these more specific sources of risk.

Most factor models are linear, in the sense that the total return is decomposed into the sum of the contributions of the factors (referred to as the *systematic return*) and an idiosyncratic component. *Systematic return* is the component of total return due to movements in the common (market-wide) risk factors. On the other hand, *idiosyncratic return* can be described as the residual component that cannot be explained by the systematic factors. Under most factor models, idiosyncratic returns are uncorrelated across issuers. Therefore, correlations across securities of different issuers are driven by their exposures to the systematic risk factors, and the correlation between those factors.

The following equation demonstrates the systematic and the idiosyncratic components of total return for security s:

$$r_s = L_s \times F + \varepsilon_s$$

The systematic return is the product of the instrument's loadings (L, also called sensitivities) to the systematic risk factors and the returns of these factors (F). The idiosyncratic return is given by ε_s.

Under these models, the portfolio volatility can be estimated as

$$\sigma_p^f = \sqrt{L_p^T \times \Sigma_F \times L_p + w^T \times \Omega \times w}$$

Here L_p are the loadings of the portfolio to the risk factors (determined as the weighted average of individual instrument loadings) and Σ_F is the covariance matrix of factor returns. Ω is the covariance matrix of the idiosyncratic security returns. Typically, the idiosyncratic return of securities is assumed uncorrelated. Therefore, this covariance matrix is diagonal, with all elements outside its diagonal being zero.[3] As a result, the idiosyncratic risk of the portfolio is diversified

2. This is especially the case over crisis periods, in which instrument characteristics can change dramatically over very short periods of time.
3. In more detailed factor models, idiosyncratic correlation may not be zero. For example, securities of the same issuer have typically positive correlation; in such case, the idiosyncratic covariance matrix is block-diagonal.

away as the number of securities in the portfolio increases. This is, of course, the diversification benefit attained when combining uncorrelated exposures.

For most practical portfolios, the number of factors is significantly smaller than the number of instruments in the portfolio. Therefore, the number of parameters in Σ_F is much smaller than in Σ_S, leading to a generally more robust estimation. Moreover, the factors can be designed in a way that they are relatively more stable than individual stock returns, leading to models with potentially better predictability. In this setting, the changing nature of each particular instrument can be captured through its loadings to the different risk factors.

Another very important advantage of using factor models is the detailed insight they can provide into the structure and properties of portfolios. These models characterize instrument returns in terms of systematic factors that (can) have intuitive economic interpretations. Linear factor models can provide important insights regarding the major systematic and idiosyncratic sources of risk and return. This analysis can help managers to better understand their portfolios and can guide them through the different tasks they perform, such as rebalancing, hedging, or tilting of their portfolios.

Naturally, the success of a risk model depends on its ability to interpret historical and current data in order to formulate estimates of future portfolio risk. It should therefore seek to discover properties of the data that are *quasi-predictable*; that is, that the error in the estimate of future realizations—given all information known today—is relatively small. For example, it is notoriously difficult to predict the expected return of a financial asset. On the other hand, historical data contain sufficient information to allow risk models to provide good estimates of the volatility of future returns. Nevertheless, one should never forget that even the most sophisticated risk model can only provide an *estimate* of risk. It is well known that financial markets are subject to *event risk* (i.e., a sudden change in market conditions cause by geopolitical or financial events). Such events are usually followed by a period of large negative returns of risky assets, large positive returns of assets considered as safe havens, significantly higher volatility, and very high (positive or negative) correlations. It is impossible for a risk model to predict when such events will occur. Therefore, it is useful to complement model-based risk management and portfolio construction with *what-if analysis,* which estimates portfolio return and risk under *stressed conditions*; that is, scenarios with extreme realizations of market returns and a covariance matrix with much higher volatilities and absolute correlations.

FIXED INCOME RISK MODELS

Fixed income securities are exposed to many different types of risk. Multifactor risk models in this area capture these risks by first identifying common sources along different dimensions, the *systematic fixed income risk factors*. All risk not captured by these systematic factors is considered *idiosyncratic*, and is determined by the choice of systematic risk factors. Typically, fixed income systematic risk

factors are divided into two sets: those that influence securities across asset classes (e.g., yield-curve risk) and those specific to a particular asset class (e.g., prepayment risk in securitized products).

There are many ways to define systematic risk factors. For instance, they can be defined purely by statistical methods, observed in the markets (e.g., a yield-curve), or estimated from asset returns. In fixed income, the standard approach is to use pricing models to calculate the analytics that are the natural candidates for risk factor loadings (L, in the notation presented earlier). In this setting, the risk factors are either observable (e.g., the movements in the yield-curve) or estimated from regressing cross-sectional asset returns on instrument sensitivities. This is the approach taken in the Barclays Capital Global Risk Model,[4] which is the model used for illustration throughout this chapter.

In this risk model, the forecasted risk of the portfolio is driven by both a systematic and an idiosyncratic (also called specific, nonsystematic, or concentration) component. The forecasted systematic risk is a function of the mismatch between the portfolio and the benchmark in the exposures to the risk factors, such as yield-curve or spreads. The (net) portfolio exposures are aggregated from security-level analytics. The systematic risk is also a function of the volatility of the risk factors, as well as the correlations between the risk factors. In this setting, the correlation of returns across securities is driven by the correlation of systematic risk factors these securities load on. Because the model uses security-level returns and analytics to estimate the factors, it can recover the idiosyncratic return for each security. This is the return net of all systematic factors. The use of detailed level analysis of idiosyncratic returns allows for the estimation of rich specifications of idiosyncratic risk.

Systematic Risk Factors

The precise definition of systematic risk factors depends on the purpose of the factor model, but in general we can highlight several categories of risk factors that drive fixed income risk.

Curve Risk

Curve risk is the major source of risk across fixed income instruments. This kind of risk is embedded in virtually all fixed income securities; therefore, mismatches in curve profiles relative to a benchmark are often the main drivers of portfolio risk.

4. The Barclays Capital Global Risk Model is available through POINT, Barclays Capital portfolio management tool. It is a multi-currency cross-asset model that covers many different asset classes across the fixed income and equity markets, including derivatives in these markets. At the heart of the model is a covariance matrix of risk factors. The model has several hundreds of factors, many specific to a particular asset class. The asset class models are periodically reviewed. Structure is imposed to increase the robustness of the estimation of such large covariance matrix. The model is estimated from historical data. It is calibrated using extensive security-level historical data and is updated on a monthly basis.

When analyzing curve risk, we should use the curve of reference in which we are interested. Depending on the portfolio and circumstances, this is typically the government or swap curve.[5] In calm periods, the behavior of the swap curve tends to match that of the government curve. However, during liquidity crises (e.g., the Russian crisis in 1998 or the credit crisis in 2008), they can diverge significantly. To capture these different behaviors adequately, one may use the following decomposition: for government products, the curve risk is assessed using the government curve. For all other products in the portfolio (that usually trade off the swap curve), this risk is measured using both the Treasury curve and swap spreads (i.e., the spreads between the swap and the government curve). Other curve decompositions are also possible.

The risk associated with each of these curves can be described by the exposure the portfolio has to different points along the curve combined with the volatility and correlation of the movement of such curve points. Sometimes a convexity term is required to capture the second-order exposure to curve changes of instruments with long tenors or embedded optionality, such as mortgage-backed securities. For a typical portfolio, a good description of the curve can be achieved by looking at a relatively small number of points along the curve (called key-rates), for example 6-month, 2-year, 5-year, 10-year, 20-year, and 30-year. An alternative set of factors used to capture yield-curve risk can be defined using statistical analysis of the historical realizations of the various yield-curve points. The statistical method used most often is *principal component analysis* (PCA). This method defines factors that are statistically independent of each other. Typically three or four such factors are sufficient to explain the risk associated with changes of yields across the yield-curve. PCA analysis has several shortcomings and must be used with caution. Using a larger set of economic factors like the key-rate points described above is more intuitive and captures the risk of specialized portfolios better. For these reasons, many portfolio managers favor the key-rates approach in most risk analysis problems.

Credit Risk

Instruments issued by corporations or entities that may default are said to have credit risk. The holders of these securities demand additional yield—in excess of the risk-free yield—to compensate for that risk. This extra yield is usually measured as a spread to a reference curve. For instance, for corporate bonds the reference curve is usually the swap curve. The level of credit-spreads determines to a large extent the credit risk exposure associated with the portfolio.[6]

There are several characteristics of credit bonds that are naturally associated with systematic sources of credit-spread risk. For instance, depending on the

5. Other curves that can be used are, for instance, the municipals (tax-free) curve, the inflation-adjusted (real rate) curve, etc.

6. Spreads are also compensation for sources of risk other than credit (e.g., liquidity), but for the sake of our argument, we treat them here as major indicators of credit risk.

business cycle, particular industries may be going through especially tough times. So industry membership is a natural systematic source of risk. Similarly, bonds with different credit ratings are usually treated as having different levels of credit risk. Credit rating could be another dimension one can use to measure systematic exposure to credit risk. Finally, the country of the issuer is another source of systematic risk for credit bonds. Given these observations, it is common to see factor models for credit risk using country, industry, and rating as the major systematic risk factors. Recent research suggests that risk models that directly use the spreads of the bonds instead of their ratings perform better for risk analysis over relatively short/medium horizons.[7] Under this approach, the loading of a particular bond to a credit-risk factor would be the commonly used spread duration, but now multiplied by the bond's spread. The loading is termed *D*uration *T*imes *S*pread (denoted DTS) and is described in Chapter 55. By directly using the spread of the bond in the definition of the loading to the credit risk factors, we do not need to assign specific risk factors to capture the rating or any similar quality-like effect. It will be automatically captured by the spread level incorporated into the bond's loading to the credit risk factor, and will adjust as the spread of the bond changes. In this setting, we still could use different systematic risk factors, for example, to distinguish among credit risk coming from different industries.[8]

Prepayment Risk

Securitized products are generally exposed to prepayment risk. The most common of the securitized products are the residential mortgage-backed securities (RMBS or simply MBS). These securities represent pools of deals that allow the borrower to prepay their debt before the maturity of the loan/deal, most typically when prevailing lending rates are lower. This option means an extra risk to the holder of the security, the risk of holding cash exactly when reinvestment rates are low. Therefore, these securities have two major sources of risk: interest rate (including convexity) and prepayment risk.

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7. For details, see Arik Ben Dor, Lev Dynkin, Patrick Houweling, Jay Hyman, Erik van Leeuwen, and Olaf Penninga, "A New Measure of Spread Exposure in Credit Portfolios," Barclays Capital Publications, February 2010.
8. The general principle of a risk model is that the historical returns of assets contain information that can be used to estimate the future volatility of portfolio returns. However, good risk models must have the ability to translate the historical asset returns to the context of the current environment. This translation is made when designing a particular risk model/factor and when implemented delivers risk factors that are as invariant as possible. This invariance makes the estimation of the factor distribution much more robust. In the particular case of the DTS, by including the spread in the loading (instead of using only the typical duration), we change the nature of the risk factor being estimated. The factor now represents percentage change in spreads, instead of absolute changes in spreads. The former has a significantly more invariant distribution. For more details, see Antonio B. Silva, "A Note on the New Approach to Credit in the Barclays Capital Global Risk Model," Barclays Capital Publications, September 2009.

Some part of the prepayment risk can be expressed as a function of interest rates via a prepayment model. This risk will be captured as part of interest-rate risk using the key-rate durations and the convexity. Convexity, which is usually negative for these instruments, is a significant source of risk. Negative convexity has a detrimental effect on the market value of an instrument—compared with one with positive or zero convexity—when interest rates move significantly in either direction. Indeed, decreasing interest rates cause prepayments to increase thereby reducing the price appreciation because of the falling rates. Conversely, rising interest rates intensify the price depreciation the instrument suffers with higher rates.

The remaining part of prepayment risk—that is not captured by the prepayment model—must be modeled with additional systematic risk factors. Typically, the volatility of prepayment speeds (and therefore of risk) on MBS depends on three characteristics: program/term of the deal, if the bond is priced at discount or premium (e.g., if the coupon on the bond is bigger than the current mortgage rates), and how seasoned the bond is. This analysis suggests that the systematic risk factors in a risk model should span these three characteristics of the securities.

Implied Volatility Risk

Many fixed income securities have embedded options (e.g., callable bonds). This means that the expected future volatility (implied volatility[9]) of the interest rate or other discount curves used to price the security plays a role in the value of that option. If expected volatility increases, options generally become more expensive, thereby affecting the prices of bonds with embedded options. For example, callable bonds will become cheaper with increasing implied volatility since the bondholder is short optionality (the right of the issuer to call the bond). Therefore, the exposure of the portfolio to the implied volatility of the yield-curve is also a source of risk that should be accounted for. The sensitivity of securities to changes of implied volatilities is typically measured by *vega*, which is calculated using the security pricing model. Implied volatility factors can be either calculated from the market prices of liquid fixed income options (caps, floors, and swaptions), or implied by the returns of bonds with embedded options within each asset class.

Liquidity Risk

Many fixed income securities are traded over-the-counter, in decentralized markets. Some trade infrequently, making them illiquid. It is therefore hard to establish their fair price. These bonds are said to be exposed to liquidity risk. The holder of illiquid bonds would have to pay a higher price to liquidate a position, usually meaning selling at a discount. This discount is uncertain and varies across the business cycle. For instance, the discount can be significant in a liquidity

9. The volatility is called implied because it is calculated from the market prices of liquid options with the help of an option-pricing model.

crisis, such as the one of 2008. The uncertainty about this discount means that, everything equal, a more illiquid bond will be riskier. This extra risk can be captured through liquidity risk factors. For instance, in the Treasury markets, one generally refers to the difference in volatility between an on-the-run and an off-the-run Treasury bond as liquidity risk.

Inflation Risk

Inflation-linked securities are priced based on the expectation of future inflation. Uncertainty about this variable adds to the volatility of the bond over and above the volatility from other sources of risk, such as nominal interest rates. Expected inflation is not an observed variable in the marketplace but can be extracted from the prices of inflation-linked government bonds and inflation swaps. Expected inflation risk factors can be constructed by summarizing this information. The sensitivity of securities to expected inflation is calculated using a specialized pricing model and is usually called *inflation duration*.

Tax-Policy Risk

Many municipal securities are currently tax-exempt. This results in added benefit to their holders. This benefit—incorporated in the price of the security—depends on the level of exemption allowed. Uncertainty around tax policy—tax-policy risk—adds to the risk of these securities. Once again, tax-policy risk factors cannot be observed in the marketplace and must be extracted from the prices of municipal securities. The return of municipal securities in excess of interest rates is driven partially by tax-policy expectations changes. However, it is also driven by changes in the creditworthiness of the municipal issuers as well as other factors. In this case, it is difficult to separate tax-policy risk factors from other factors driving municipal bond spreads. Therefore, instead of specific tax-policy factors, we usually extract factors representing the overall spread risk of municipal securities. This exercise is performed in a similar way to the credit risk model, in which securities are partitioned into groups of "similar" risk by geography, bond type (general obligation vs. revenue), tax status, and the like.[10]

There are other sources of systematic risk we did not detail in this section. They may be important sources of risk for particular portfolios. Specific risk models and factors can be designed to address them.

Idiosyncratic Risk

Once all systematic factors and loadings are determined, the residual idiosyncratic return of a security can be computed as the component of its total return that cannot be explained by the systematic factors. Idiosyncratic return can be a significant component of total return for individual instruments, but tends to decrease rapidly

10. For more discussion, see Arne Staal, "U.S. Municipal Bond Risk Model," Barclays Capital Publications, July 2009.

for portfolios of instruments as the number of instruments increases and concentration decreases (the aforementioned diversification effect).

The major inputs to the computation of idiosyncratic risk are instrument characteristics and historical idiosyncratic returns of the instruments. The use of idiosyncratic residual returns allows the risk modeler to find empirical relationships between characteristics such as instrument spread, spread duration, industry membership, and idiosyncratic volatility. This mapping of instrument characteristics to idiosyncratic volatility allows for the modeling of new issues and issues with characteristics that change over time. As mentioned before, idiosyncratic returns of different issuers are assumed to be uncorrelated. However different securities from the same issuer, or securitized products with related underlying instruments, can show a certain level of co-movement, as they are all exposed to specific events affecting their common issuer that are not captured by systematic risk factors. Interestingly, this co-movement is not perfect or static. Certain news can potentially affect the different securities issued by the same company (e.g., equity, credit default swaps, bonds, or equity options) in different ways. Moreover, this relationship changes with the particular circumstances of the firm. For instance, returns from securities with claims to assets of the firm should be more highly correlated if the firm is in distress. A good multi-asset class risk model should be able to capture these phenomena regarding idiosyncratic risk.

APPLICATIONS OF RISK MODELING

In this section, we illustrate several standard risk model applications used for portfolio management. All applications make use of the fact that the risk model translates the characteristics a portfolio may have across many different dimensions, into a common, comparable set of numbers. In some of them—risk budgeting and portfolio rebalancing—an optimizer that uses the risk model as an input is the optimal setting to perform the exercise.

The investment process of a typical portfolio manager involves different stages. Given the investment universe and objective, the steps usually consist of portfolio construction, risk prediction, and performance evaluation. These steps are iterated throughout the investment cycle over each rebalancing period. The examples in this section highlight the portfolio construction and risk analysis steps that employ a factor model. Additionally, scenario analysis can be employed in both the portfolio construction and risk evaluation phases of the portfolio process. This exercise allows the manager to gain additional intuition regarding portfolio exposures and how the portfolio may behave under particular economic circumstances. It usually takes the form of stress testing potential portfolio losses under historical or hypothetical scenarios. It can also show the sensitivity of the portfolio to particular movements in economic and financial variables. The last application in this chapter illustrates this kind of analysis.

Portfolio Construction and Risk Budgeting

As discussed, fixed income portfolios are exposed to a diverse set of risk factors. During the portfolio construction exercise, the manager must carefully choose the exposure to such factors in order to achieve the highest possible portfolio return subject to risk and other constraints. Risk models help portfolio managers achieve this in an objective and quantifiable way and are increasingly used for portfolio construction, usually with the help of an optimization engine. In this section, we illustrate how a portfolio manager would use this engine to formulate client objectives and constraints in the context of risk model-based portfolio construction.[11]

Portfolio managers can have a broad array of mandates. Some—typically referred to as *indexers*—are required to follow a given benchmark index with the minimum possible deviation. Their goal is to minimize the tracking error volatility of the portfolio versus the index while also keeping portfolio transaction costs as small as possible. Others, the *enhanced indexers*, are allowed some leeway to deviate from the benchmark in order to achieve superior returns. The leeway can be expressed as a set of rules constraining the exposure to risk factors, but it is often prescribed as a *risk budget*; that is, an upper limit in a statistical measure of deviation between the portfolio and its benchmark. The *tracking error volatility* (TEV) of the return of the portfolio net of the benchmark is the most common of such measures. Finally, the *absolute return* portfolio managers, do not have to track a benchmark but are instead aiming at the highest possible portfolio return, potentially subject to leverage, portfolio composition, exposure, and risk constraints. In all cases, the manager has to merge all views and constraints into a final portfolio. When constructing the portfolio, how can the competing views be managed, while respecting the risk budget? How can the views be combined to minimize the risk? What tradeoffs can be made? Risk models are widely used to perform this exercise in a systematic and objective manner: They can measure the risk of each view as well as the correlation between different views, and arrive at portfolios that optimally trade-off the risks and expected returns associated with each of the views.

We illustrate this by a simple example of a portfolio construction exercise using a risk model. Consider a fixed income portfolio manager who is benchmarked to the Barclays Capital U.S. Aggregate index. The manager's mandate is to outperform the benchmark with a risk-budget of 20 bp/month (i.e., the portfolio's TEV should remain within this bound on a monthly basis). Before formulating views and constraints, and deciding how to implement them, the manager needs to choose an investment universe. Since the benchmark is the Barclays Capital U.S. Aggregate Index, the manager could choose the investment universe to be all issues in this index with outstanding amount in excess of $300 million. The selection of this investment universe ensures that securities with small amounts of outstanding notional will not be selected in the portfolio, potentially increasing overall portfolio liquidity and decreasing transaction costs. With the

11. In our examples, we use the Barclays Capital POINT optimization engine.

risk budget in mind, the manager chooses to minimize total portfolio TEV relative to the benchmark. (The manager could potentially consider other risk-based objectives such as maximizing the Sharpe ratio.) This means the manager is giving leeway to the risk model to choose a portfolio from the tradable universe that minimizes the risk relative to the benchmark, in this case the Barclays Capital U.S. Aggregate Index. Finally, the manager formulates constraints and views.

Let us assume for the purpose of this illustration that the amount of funds to be invested is $100 million. With that in mind, and in order to avoid buying small amounts of securities, the manager decides to implement the portfolio using a maximum of 100 positions. Given views on the market environment, the manager wants the portfolio to be long duration against the benchmark, between 0.40 and 0.60 years, and have a spread advantage of 150 bp to 200 bp over the benchmark. Finally, to ensure a certain amount of diversification in portfolio positions, the manager imposes a maximum under/overweight of 3% per issuer relative to the benchmark.[12]

Our portfolio manager incorporates all these settings into an optimization problem, and finds a solution that reflects the optimal tradeoff between the constraints and risks through the optimization engine. The result is a recommended portfolio that satisfies the constraints while minimizing total risk. Specifically, the resulting portfolio—that we will follow throughout this section—consists of 100 securities, has a predicted TEV of 15.1 bp/month, interest-rate duration of 5.44 years, and option-adjusted spread of 206 bp (Exhibit 46–1). Using a factor-based risk model and an optimization engine, the resulting portfolio incorporates the manager's views while staying within its risk budget and ensuring that all additional constraints are satisfied.

Analyzing Portfolio Risk

The main application of risk models is risk measurement of portfolios relative to their benchmark. Risk analysis based on multifactor models can take many forms: from a relatively high-level aggregate approach, to an in-depth analysis of the risk

EXHIBIT 46–1

Portfolio and Benchmark Characteristics of Sample Portfolio

	Total TEV (bp/month)	Duration (years)	Spread Duration (years)	Spread (bp)
Portfolio	15.1	5.44	5.23	206
Benchmark		5.02	4.92	55

Source: Barclays Capital POINT.

12. Another way to ensure diversification would be to include the minimization of the idiosyncratic TEV as a specific goal in the objective function.

properties of individual instruments and groups of instruments. Multifactor fixed income risk models provide the tools to perform the analysis of portfolio risk in many different dimensions, including exposures to risk factors, security/factor contributions to total risk, and risk analysis at the issuer level. For instance, as previously described, this risk can be decomposed into a systematic and an idiosyncratic component. Exhibit 46–2 shows that the portfolio has total TEV of 15.1 bp/month, systematic TEV of 10.4 bp/month, and idiosyncratic TEV of 10.1 bp/month. Since systematic risk and idiosyncratic risk are independent, they constitute isolated (uncorrelated) risk sources of the portfolio and therefore we have

$$\text{Total TEV} = \sqrt{\text{Systematic TEV}^2 + \text{Idiosyncratic TEV}^2}$$

An alternative way to describe the manner in which different risk sources impact overall portfolio risk is through *risk attribution*. Risk attribution allows a manager to decompose portfolio volatility in an additive way into contributions to TEV. Exhibit 46–2 reports that the contribution to total TEV (CTEV) from systematic risk factors is 8.3 bp/month, whereas idiosyncratic risk contributes 6.8 bp/month.[13]

The risk attribution approach can be used to further decompose overall portfolio risk into contributions from different buckets. The buckets can represent groups of securities (e.g., industry buckets) or risk factors (e.g., factors related to curve or to credit-spreads). This flexible decomposition allows portfolio managers to gain a detailed understanding of how different securities and risk exposures affect overall portfolio risk.

Exhibit 46–3 shows the isolated TEV as well as the contributions to TEV for the sample portfolio. In this exhibit, we choose to partition risk across systematic risk factors (plus the idiosyncratic risk), but many other partitions are possible. In this example, the largest contribution within systematic risk comes

EXHIBIT 46–2

Portfolio Risk Results of Sample Portfolio in bp/Month

	Isolated TEV	CTEV
Total	15.1	15.1
Systematic	11.2	8.3
Idiosyncratic	10.1	6.8

Source: Barclays Capital POINT.

13. In this case, because the systematic and idiosyncratic components of the TEV are uncorrelated, the CTEV can be computed easily. Specifically, the CTEV from the systematic risk is computed as $11.2^2/15.1 = 8.3$ and from the idiosyncratic as $10.1^2/15.1 = 6.8$. Note that by definition they sum up to the total TEV. In Chapter 47 a more detailed and general discussion is provided.

EXHIBIT 46–3

Portfolio Risk Contributions of Sample Portfolio in bp/Month

Risk Factor Partition Bucket	Isolated TEV	CTEV
Total	15.1	15.1
Systematic	11.2	8.3
Curve	11.4	5.2
Swap Spreads	2.6	0.6
Volatility	0.4	0.0
Spread Gov-Related	3.4	0.0
Spread Credit and EMG	7.5	2.6
Spread Securitized	3.0	–0.1
Idiosyncratic	10.1	6.8

Source: Barclays Capital POINT.

from the exposure to "Curve" factors, with a CTEV of 5.2 bp/month. As we saw before, idiosyncratic exposure is also a large component of the risk in this portfolio, with a contribution of 6.8 bp/month to total risk. Notice the difference between isolated TEV and contribution to TEV for our factor partition—isolated TEV reflects the risk of the partition buckets in isolation—while contribution to TEV includes risk driven by correlations among the different buckets.

In addition to overall portfolio TEV and partition-based contributions to TEV, there are many additional risk analytics that can be computed on the basis of a linear factor risk model, such as betas with respect to the benchmark, liquidation effect to TEV, and marginal contributions to risk. Different users will use these analytics for different purposes and to different degrees.

Portfolio Rebalancing

Most managers rebalance their portfolios at regular intervals to reflect changing views and market circumstances. For instance, as time goes by, the characteristics of the portfolio may drift away from targeted levels. This may be due to the aging of its holdings, changes in the market environment, or issuer-specific events such as defaults. The periodic realignment of a portfolio to its investment guidelines and changing investment views is called *portfolio rebalancing*. Similar needs arise in many different contexts: when managers receive extra cash to invest, receive minor changes to their mandate, want to tilt positions toward their views, and the like. As with the initial portfolio construction, a risk model is very useful in the rebalancing exercise. During rebalancing, typically the portfolio manager

seeks to sell bonds currently held and replace them with others having properties more consistent with the overall portfolio goals. Such buy and sell transactions are costly and their cost must be weighed against the benefit from moving the portfolio closer to its desired profile. A risk model can tell the manager how much risk reduction (or increase) a particular set of transactions can achieve in order to evaluate the risk adjustment benefits relative to the transaction cost.

As an example, suppose the portfolio manager in our illustration wants to reduce the imbalances the portfolio has against the benchmark. Specifically, the manager wants to lower the net portfolio duration from 0.42 years to a value between 0.2 years and 0.4 years. After looking at the portfolio's industry profile, the manager also decides to reduce the existing 6% overweight in the banking industry to about 4%. In addition, the manager lowers the minimum acceptable excess spread to 100 bp. To avoid high transaction costs, the manager also imposes the rebalancing to be done with no more than 30 trades. Finally, let us assume no portfolio inflows or outflows so the portfolio market value must remain unchanged. Starting from the original portfolio of 100 securities, a risk model and optimization engine can be employed to achieve optimal rebalancing by adjusting some of the constraints to reflect the portfolio manager's new objectives.

Exhibit 46–4 shows the largest trades suggested by the optimizer, in terms of market value. Not surprisingly, the largest sell recommendations are of financial companies. To replace them, the optimizer—using the risk model—recommends

EXHIBIT 46–4

Proposed Trading List

Buys	
Identifier	**Description**
912828MZ	U.S. Treasury Notes
74913GAG	Qwest Corporation
03979GAL	Arden Realty INC
Sells	
Identifier	**Description**
16132NAV	Charter One Bank FSB
FNA 08000	FNMA Conventional
0258M0BZ	American Express Credit

Source: Barclays Capital POINT.

a larger position of Treasury and corporate bonds. (Corporates are required in order to keep the spread of the portfolio at the desired level.)

Interestingly, the rebalancing and extra constraints imposed on the optimization problem did not materially change the risk of the portfolio. Exhibit 46–5 shows that the total TEV of the portfolio actually decreased to 13.4 bp/month. This is largely due to an extra 13 positions added to the portfolio in the rebalancing (that now has 113 securities). These extra securities allowed the portfolio to reduce both its systematic and idiosyncratic risk.

Scenario Analysis

Scenario analysis is a popular tool both for risk management and portfolio construction. In this section, we illustrate a way to construct scenarios based on factor models. In this context, a portfolio manager express views on the returns of particular financial variables, indices, securities or risk factors and the scenario analysis tool (using the risk model) calculates their impact on the portfolio's (net) return.

Typically in this kind of scenario analysis, the views one has are only partial. This means one can have specific views on how particular macro variables, asset classes, or risk factors will behave, but it is unlikely to have views on all risk factors to which the portfolio under analysis is exposed. This is where risk models can be useful. At the heart of the linear factor models lies a set of risk factors and the covariance matrix between them. Under certain statistical assumptions, the covariance matrix can be used to "complete" specific partial views or scenarios and deliver a complete picture of the impact of the scenario in the return of the portfolio. Mechanically, what happens is the following. First, the manager translates the views into realizations of a subset of risk factors. Next the scenario is completed—using the risk model covariance matrix—to get the realizations of *all* risk factors. Finally, the portfolio's (net) loadings to all risk factors are used to get its (net) return under that scenario (by multiplying the loadings by the factor realizations under the scenario). This construction implies a set of assumptions that should be carefully understood. To begin with, it is assumed that the manager can represent or translate views as risk factor returns. So a view about the unemployment rate,

EXHIBIT 46–5

Rebalanced Portfolio and Benchmark Characteristics

	Total TEV (bp/month)	Duration (years)	Spread Duration (years)	Spread (bp)
Portfolio	13.4	5.31	5.06	153
Benchmark		5.02	4.92	55

Source: Barclays Capital POINT.

which is typically not used as a risk factor,[14] cannot be used in this context. Also, to "complete" the scenario, we generally assume a stationary and normal multivariate distribution among all factors. Although these assumptions make this analysis less appropriate for looking at extreme events or regime shifts, for instance, the analysis can be very useful in many circumstances.

As an example, consider using factor-based scenario analysis to compute the model-implied empirical durations of the original portfolio of a 100 securities (i.e., before rebalancing) analyzed in detail previously in this chapter. In particular, suppose the portfolio manager has the view that interest rates will fall by 25 bp over the next month. Exhibit 46–6 shows that under this scenario, the portfolio returns 116 bp, against the 111 bp of the benchmark. As expected given the longer duration, the portfolio outperforms the benchmark. Due to the other exposures present in the portfolio and benchmark and their average negative correlation with the curve factors—for instance, a 25 bp fall in rates under this setting implies a 5% increase in corporate spread levels—the model duration implied by the scenario for the portfolio is 4.64 (= 116/25), while the analytical duration is 5.44. The scenario shows a similar decrease in the benchmark's duration. The net model duration of the portfolio is only 0.22, almost half of its 0.42 net analytical duration.

Another characteristic imposed while constructing the portfolio was a targeted higher spread. The portfolio construction exercise resulted in an OAS for the portfolio of 206 bp against a spread level of 55 bp for the benchmark. The portfolio manager might be concerned with portfolio losses should spreads increase. To evaluate this risk, the portfolio manager can construct two scenarios. In the first scenario, credit-spreads widen by 20%, other spread risk factors move as implied by the credit-spread moves, but interest rates remain unchanged. In the second scenario, interest rates moves are implied by the credit-spread move. Exhibit 46–7 displays the results of the two scenarios. In the first scenario, the portfolio suffered significant losses of 0.84%. The benchmark which has a much lower spread suffers lower losses of 0.64% and the net result is –20

EXHIBIT 46–6

Scenario Analysis: Analytical and Model-Implied Durations

		Durations	
Universe	**Return under Scenario (bp)**	**Scenario (Model-Implied)**	**Analytical**
Portfolio	116	4.64	5.44
Benchmark	111	4.44	5.02

Source: Barclays Capital POINT.

14. Unemployment rate is not used as a factor in most short- and medium-term risk models.

EXHIBIT 46–7

Scenario Analysis: Corporate Spread Increase of 20%

	Restriction on YC Movement (returns in bp)	
Universe	**No Change**	**Implied by Spread Change**
Portfolio	–84	49
Benchmark	–64	58
Net	–20	–9

Source: Barclays Capital POINT.

bp of net return. This number is very different from a back of the envelope calculation that uses portfolio-level analytics to estimate the return. The calculation is much more intricate and takes into account the security level portfolio composition, as well as the implied moves of other sources of risk such as swap and mortgage spreads.

Things look better in the second scenario, where the net return of the portfolio versus the benchmark is only –9 bp. In fact, in this case both the portfolio and the benchmark exhibit positive returns of 0.49% and 0.58%, respectively, illustrating that this is a very different type of scenario. Indeed, the large spread widening implies a 25 bp fall in interest rates, which is sufficient to overcome the losses from the spread widening for both the portfolio and the benchmark. Since the portfolio has interest rate duration that is 0.42 years longer than the benchmark, it enjoys a relative improvement in net return of about -0.42×-25 bp = +10.5 bp that partially offsets the losses from the widening of credit spreads.

These very simple examples illustrate how one can look at reasonable scenarios to study the behavior of the portfolio or the benchmark under different environments. This type of factor-based scenario analysis can significantly increase the intuition the portfolio manager has regarding the results from the risk model.

KEY POINTS

- Risk models describe the different imbalances of a portfolio using a common language. The imbalances are combined into a consistent and coherent analysis reported by the risk model.
- Risk models provide important insights regarding the different tradeoffs existing in the portfolio. They provide guidance regarding how to balance them.

- The fundamental systematic risk of all fixed income securities is interest rate and term structure risk. This is captured by factors representing risk-free rates and swap spreads of various maturities.
- Excess (of interest rates) systematic risk is captured by factors specific to each asset class. The most important components of such risk are credit risk and prepayment risk. Other risks that can be important are volatility, liquidity, inflation, and tax policy.
- Idiosyncratic risk is diversified away in large portfolios and indices, but can become a very significant component of the total risk in small portfolios. The correlation of idiosyncratic risk of securities of the same issuer must be modeled very carefully.
- A good risk model provides detailed information about the exposures of a complex portfolio and can be a valuable tool for portfolio construction and management. It can help managers construct portfolios tracking a particular benchmark, express views subject to a given risk budget, and rebalance a portfolio while avoiding excessive transaction cost. Further, by identifying the exposures in which the portfolio has the highest risk sensitivity, it can help a portfolio manager reduce (or increase) risk in the most effective way.

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CHAPTER
FORTY-SEVEN

ANALYZING RISK FROM MULTIFACTOR FIXED INCOME MODELS

ANTHONY LAZANAS, PH.D.
Managing Director
Barclays Capital

ANTÓNIO BALDAQUE DA SILVA, PH.D.
Director
Barclays Capital

RADU C. GĂBUDEAN, PH.D.
Vice President
Barclays Capital

ARNE D. STAAL, PH.D.
Director
Barclays Capital

Portfolio managers constantly monitor their exposures, typically net of a benchmark, and routinely ask themselves: What is the portfolio interest-rate duration? How risky is the overexposure to Treasuries? How does it relate to the exposure to credit? What is the exposure to specific issuers? Knowing portfolio holdings and exposures are not enough for portfolio managers, they increasingly rely on quantitative techniques to translate this information into a standard risk language, which allows comparisons across diverse portfolios or situations. Risk models present a consistent view of the portfolio, its exposures, and how they relate to each other. They quantify the risk of each exposure and its contribution to the overall risk of the portfolio.

Chapter 46 covered linear factor models for fixed income portfolios. In this chapter we detail an application of the models for risk forecasting that can be used to monitor risk and gain insightful information regarding the exposures of a portfolio.

The authors would like to thank Bruce Phelps and Andy Sparks for their valuable comments.

APPROACHES USED TO ANALYZE RISK

Throughout this chapter we analyze the risk of a particular bond portfolio, going through the various aspects of risk typically looked at by a manager. We follow a portfolio manager. We assume the following:

- The Barclays Capital U.S. Aggregate Index is the portfolio manager's benchmark.
- The portfolio manager believes interest rates are coming down. To capitalize on this view, the manager seeks to create a portfolio with interest-rate duration longer than the interest-rate duration of the benchmark. A portfolio with interest-rate duration that exceeds that of the benchmark is referred to as being "long duration" and it outperforms the benchmark when interest rates fall and all other market factors remain unchanged.
- The manager seeks a portfolio with higher yield than the one of the benchmark. Such a portfolio creates superior carry return (also known as *income*) relative to the benchmark but is subject to increased risks. The total yield of a portfolio can be decomposed into a risk-free yield and a spread over the risk-free yield. Because the portfolio is expected to contain securities with longer maturities to satisfy the long duration target, it will earn a risk-free yield that is different from the risk-free yield of the benchmark (higher most of the time since typically interest-rate curves are upward sloping).To further enhance the portfolio yield, the manager wants to target a portfolio spread that is also higher than the spread of the benchmark. Higher spread typically exposes the portfolio to liquidity and issuer default risks. If defaults occur, or if the portfolio manager is forced to sell securities at a significant discount because of lack of liquidity, then the incurred losses may cancel out the higher yield advantage and could lead to portfolio underperformance relative to the benchmark. The manager must be comfortable that such risks are sufficiently compensated by the higher carry return associated with higher portfolio spread.
- The portfolio manager is required to maintain the difference between the returns of the portfolio and the benchmark at around 20 basis points, on a monthly basis. Therefore, the portfolio manager must calibrate the long duration and high-yield portfolio positions in order to abide by this constraint.

To summarize, the portfolio manager has the mandate to track the benchmark, but is allowed to deviate from it up to a point in order to express views that may lead to superior returns. As mentioned in Chapter 46, a portfolio manager with such a mandate is called an *enhanced indexer*. The amount of deviation allowed is called the *risk budget* (20 basis points in our example) and can be quantified using a risk

model. The risk model produces an estimate of the volatility of the difference between the portfolio and the benchmark returns, called *tracking error volatility* (TEV).[1] TEV gives the forecasted magnitude of the typical tracking error. The manager should keep the portfolio's TEV at a level equal to or less than that specified in risk budget. The final portfolio, which we will analyze, contains 100 securities and is consistent with the manager's views and risk budget.

Market Structure and Exposure Contributions

The portfolio manager starts the analysis by comparing the portfolio holdings with the holdings of the benchmark. Exhibit 47–1 shows that the portfolio composition has several important mismatches relative to the benchmark. The portfolio is underweighted in Treasuries and government-related securities by a combined 9.0%. This is compensated with a combined overweight of 11.2% in Corporates, especially in the Industrials and Financials sectors. These sectors have almost double the weight in the portfolio versus the benchmark. Other mismatches include an underweight in agency mortgage-backed securities (agency MBS) by

EXHIBIT 47–1

Market Weights for Portfolio and Benchmark

Asset Class	Portfolio	Benchmark	Difference
Total	**100.0**	**100.0**	**0.0**
Treasury & Govt-Related	**36.8**	**45.8**	**–9.0**
Treasury	30.8	33.8	–3.0
Government-Related	6.0	12.0	–6.0
Corporates	**29.9**	**18.7**	**11.2**
Industrials	17.2	9.9	7.3
Utilities	2.3	2.1	0.2
Financials	10.4	6.7	3.7
Securitized	**33.3**	**35.5**	**–2.2**
Agency MBS	28.9	32.7	–3.8
ABS	0.0	0.3	–0.3
CMBS	4.4	2.5	1.9

Source: Barclays Capital POINT

1. In this chapter we refer to TEV, risk, and "the standard deviation of the portfolio net returns" interchangeably.

3.8% and an overweight in commercial mortgage-backed securities (CMBS) by 1.9%. Notice that the quest for yield pushed the manager out of the relatively safe (in terms of default risk) Treasury and agency MBS sectors and into more risky corporate and CMBS sectors.

If the manager were focusing on equities instead of fixed income, this kind of information—for example, applied to the different industries or sectors of the portfolio—would be of paramount importance for portfolio risk analysis. For a fixed income portfolio, this is not the case. Although important, this analysis tells us little about the true active exposures of a fixed income portfolio, owing to the diverse nature of fixed income securities. What if the Treasuries in the portfolio have significantly longer duration than those in the benchmark— would we be really "short" in this asset class? What if the spreads from CMBS in the portfolio are much smaller than those in the benchmark—is the weight mismatch that important?

To answer these kinds of questions, we turn to another typical dimension of analysis: the portfolio exposure to major sources of risk, measured with analytics such as interest-rate duration. Exposures to other sources of risk typically monitored include spread duration, convexity, spread level, and Vega (if the portfolio has many securities with optionality, such as mortgages or callable bonds). Their associated risks have been discussed in Chapter 46.

In Exhibit 47–2 we present these analytics at the aggregate level for the portfolio, benchmark, and the difference between the two. We can see that

- The portfolio is long interest-rate duration (0.38 years), reflecting the forecast the manager has regarding the direction of interest rate moves.
- In terms of spread duration, the mismatch is smaller (0.29 years). The manager wants to minimize the exposure to spread changes as much as possible given the manager has no view on this source of risk. However,

EXHIBIT 47–2

Aggregate Analytics

Analytics	Portfolio	Benchmark	Difference
Interest-Rate Duration	5.36	4.98	0.38
Spread Duration	5.20	4.91	0.29
Convexity	0.14	–0.04	0.18
Vega	–0.03	–0.02	–0.01
Spread	204	56	148

Source: Barclays Capital POINT

the spread duration mismatch cannot be zero because spread risk is related to other risks that she does have a view on, such as rates.

- The portfolio and the benchmark have convexity with opposite signs (0.14 for the portfolio versus –0.04 for the benchmark). This is attributable to the smaller weight MBS have in the portfolio.
- The portfolio also has a higher negative Vega, but the number is reasonably small for both universes.
- The portfolio has significantly higher spread (148 bp) than the benchmark. This mismatch is consistent with the manager's goal of having a higher yield in her portfolio than the benchmark.

We can combine the analysis in Exhibits 47–1 and 47–2 to create a more detailed picture of where the different risk exposures are coming from. Exhibit 47–3 shows one such example for the portfolio interest-rate duration. The majority of the mismatch in interest-rate duration contribution (market weighted duration exposures) comes from the Treasury component of the portfolio (0.60 years). Interestingly, even though the portfolio is short in Treasuries, it is actually long in terms of interest-rate duration for that asset class. This means that a Treasury sell-off, meaning an increase in rates, would impact the portfolio more negatively than the benchmark. Because the portfolio is net short Treasuries, this result must mean that the Treasury portfolio is longer in interest-rate duration than the benchmark's Treasury component. Conversely, Corporates have negative contribution to net interest-rate duration, even though they are over-weighted in terms of market value. This means that on average the corporate bonds in the portfolio are significantly shorter in interest-rate duration than those in the benchmark. Note that this kind of analysis could be applied to other analytics of interest, such as to spread or spread duration.

EXHIBIT 47–3

Duration Contribution per Asset Class

Interest-Rate Duration Contribution	Portfolio	Benchmark	Difference
Total	**5.36**	**4.98**	**0.38**
Treasury	2.38	1.78	0.60
Government-Related	0.47	0.50	–0.03
Corporate	1.08	1.23	–0.15
Securitized	1.43	1.47	–0.04

Source: Barclays Capital POINT

Adding Volatility and Correlations into the Analysis

The analysis above gives the manager some basic understanding of the portfolio exposures to different kinds of risk. However, it is still hard to understand how the portfolio manager can compare the level of risk across these different exposures. What is more risky, the long interest-rate duration exposure of 0.38 years, or the extra spread of 148 bp? How can the portfolio manager quantify how serious is the portfolio's Vega mismatch? Specifically, the risk of the portfolio is a function of the exposures to the risk factors, but also of how "risky" each of the factors is.

To enhance the analysis we must bring factor volatilities into the picture. Exhibit 47–4 shows the outcome of this addition to our example. In particular, it displays the risk of the different exposures of the portfolio in isolation (that is, if the only active imbalances were those from that particular set of risk factors). For example, this exhibit shows that if the only active weight in the portfolio were the mismatch in the yield-curve exposures, the risk of the portfolio would be 11.3 bp/month. By adding volatilities into the analysis, the manager can now quantify that the mismatch of 0.38 years in interest-rate duration "costs" the portfolio 11.3 bp/month of extra volatility, when taken in isolation, and therefore refer to this as the Isolated TEV.[2] Remember that the portfolio's total risk budget is 20 bp/month. Similarly, if the only mismatch were the exposure to corporate spreads, the risk of the portfolio would be 6.9 bp/month. We also see that both the Government-Related and Securitized sectors have nontrivial risk. Interestingly, this is inconsistent with the small interest-rate duration imbalance reported in Exhibit 47–3. Therefore, these sectors must have other sources of risk that are important. By bringing volatilities into the analysis, we can now compare and quantify the impact of each of the portfolio imbalances.

EXHIBIT 47–4

Isolated Risk per Category

Risk Factors Categories	Risk
Curve	11.3
Volatility	0.2
Spread Government-Related	3.2
Spread Corporate	6.9
Spread Securitized	2.9

Source: Barclays Capital POINT

2. For an explanation of Isolated TEV, see Chapter 46.

For future reference, let us compute the volatility of the portfolio assuming that all these sources of risk are independent (e.g., correlations are zero). This number is 13.9 bp/month.[3] Of course, this scenario is unrealistic, as these sources of risk are not independent. Also, this analysis does not allow us to understand the interplay between the different imbalances. For instance, we know that the isolated risk associated with the curve is 11.3 bp/month. But this value can be achieved both by being long or short interest-rate duration. So the isolated number does not allow us to understand the impact of the curve imbalance to the total risk of the portfolio. The net impact certainly depends on the sign of the imbalance. For instance, a long exposure in curve may be diversified away by a long exposure in credit (due to negative correlation between rates and credit-spreads). In contrast, an opposite (short) curve exposure would add to the risk of the long exposure in credit. The risk is clearly smaller in the first case.

To alleviate these shortcomings, we bring correlations into the picture. They allow us to understand the net impact of the various exposures to the portfolio's total risk and to detect potential sources of diversification among the portfolio imbalances. Exhibit 47–5 reports the contribution of each of the risk factor groups to the total risk, once all correlations are taken into account. We refer to this quantity as the contribution to tracking error volatility, or CTEV.[4] The total risk (10.4 bp/month) is smaller than the zero-correlation risk calculated before (13.9 bp/month) due to generally negative correlations between the curve and the spread factors. The exhibit also allows us to isolate the main contributors to risk as being curve (6.9 bp/month) and credit-spreads (2.9 bp/month), in line

EXHIBIT 47–5

Contributions to Total Risk per Category

Risk Factors Categories	Risk
Total	**10.4**
Curve	6.9
Volatility	0.7
Spread Government-Related	0.0
Spread Corporate	0.0
Spread Securitized	2.9

Source: Barclays Capital POINT

3. We arrive at this number by taking the square root of the sum of squares of all the numbers in the table: $13.9 = \sqrt{(11.32+0.22+3.32+6.92+2.92)}$.
4. For a further discussion of this risk measure, see Chapter 46.

with the evidence from the earlier isolated analysis. However, the risk of the Government-Related and Securitized spreads is significantly smaller once correlations are taken into account.

The difference in analysis between the isolated risk reported in Exhibit 47–4 and the contributions to total risk in Exhibit 47–5 deserves further discussion. For simplicity, assume there are only two sources of risk in the portfolio—yield-curve (Y) and spreads (S). The total systematic variance of the portfolio (P) can be illustrated as follows:

$$\begin{aligned} VAR(P) &= VAR(Y+S) = VAR(Y) + VAR(S) + 2COV(Y, S) \\ &= Y \times Y + S \times S + 2(Y \times S) \end{aligned}$$

where we use the product to represent variances and covariances. Another way to represent this summation is using the following matrix:

$$\begin{bmatrix} Y \times Y & Y \times S \\ Y \times S & S \times S \end{bmatrix}$$

The sum of the four elements in the table is the variance of the portfolio. The isolated risk (in standard deviation units) reported in Exhibit 47–4 is the square root of the diagonal terms. So the isolated risk due to spreads is represented as:

$$Risk_{Spreads}^{Isolated} = \sqrt{S \times S}$$

It would be a function of the exposure to all spread factors, the volatilities of all these factors and the correlations among them.

The contribution to total risk reported in Exhibit 47–5 is:

$$Risk_{Spreads}^{Contribution} = [Y \times S + S \times S] / \sqrt{VAR(P)}$$

that is, from the matrix above, we sum all elements in the row of interest (row 1 for Y, row 2 for S), and normalize it by the standard deviation of the portfolio. This normalization (1) takes into account correlations and (2) ensures that the contributions to risk of all factors add up to the total risk of the portfolio given by[5]

$$Risk_{Curve}^{Contribution} + Risk_{Spreads}^{Contribution} = \sqrt{VAR(P)} = STD(P)$$

The difference between isolated and contribution to risk, due to the interplay of the two sources ($2(Y \times S)$), is allocated equally to each source of risk. In cases when one type of risk on isolated basis is much smaller in magnitude than the other, the ($Y \times S$) term may have an oversized effect. To summarize, isolated risk takes into account only the individual behavior of each source of risk, while the contribution to correlated risk looks at the joint behavior of various risk sources.

5. In this example, we focus only on the systematic component of risk. Later, the normalization is with respect to the total risk of the portfolio, including idiosyncratic risk.

The generic analysis we just performed constitutes the first step into the description of the risk associated with a portfolio. The analysis refers to categories of risk factors (such as "curve" or "spreads"). However, a factor-based risk model allows for a significantly deeper analysis of the imbalances the portfolio may have. Each of the risk categories referred to above can be described with a rich set of detailed risk factors. Typically in a fixed income factor model, each asset class has a specific set of risk factors, in addition to the potential set of factors common to all (e.g., curve factors). These asset-specific risk factors are designed to capture the particular sources of risk the asset class is exposed to. In the following section, we go through a risk report built in such a way, emphasizing risk factors that are common or particular to the different asset classes. Along the way, we demonstrate how the report offers insights from both a risk management and a portfolio construction perspective.

A Detailed Risk Report

In this section, we continue the analysis of the portfolio introduced previously, a 100-bond portfolio benchmarked against the Barclays Capital U.S. Aggregate Index. The report package we present was generated using POINT, Barclays Capital cross-asset portfolio analysis and construction tool, and gives a detailed picture of the risk embedded in the portfolio.[6] The package is divided into four types of reports: summary reports, factor exposure reports, issue/issuer level reports, and scenario analysis reports. Some of the information we reviewed earlier can be thought of as summary reports.

Summary Report

Exhibit 47–6 illustrates a typical risk summary statistics report. It shows that the portfolio has 100 positions, but from only 48 issuers. This number implies limited ability to diversify idiosyncratic risk, as we will see below. The report confirms that the portfolio is long interest-rate duration (5.36 years for the portfolio versus 4.98 years for the benchmark) and has higher yield (4.55% for the portfolio versus 2.97% for the benchmark) and coupon (5.07% for the portfolio versus 4.24% for the benchmark).

The exhibit also reports that the total volatility of the portfolio (127.7 bp/month) is higher than that of the benchmark (121.2 bp/month). This is not surprising: longer interest-rate duration, higher spread, and less diversification all tend to

6. The Barclays Capital Global Risk Model is available through POINT, Barclays Capital portfolio management tool. It is a multicurrency cross-asset model that covers many different asset classes across the fixed income and equity markets, including derivatives in these markets. At the heart of the model is a covariance matrix of risk factors. The model has several hundreds of factors, many specific to a particular asset class. The asset class models are periodically reviewed. Structure is imposed to increase the robustness of the estimation of such large covariance matrix. The model is estimated from historical data. It is calibrated using extensive security-level historical data and is updated on a monthly basis.

EXHIBIT 47–6

Summary Statistics Report

	Portfolio	Benchmark	
A. Parameter			
Positions	100	7,999	
Issuers	48	834	
Currencies	1	1	
Market Value ($MM)	100	15,133	
Notional ($MM)	97	14,260	
B. Analytics			**Difference**
Coupon	5.07	4.24	0.83
Average Life	7.71	7.04	0.67
Yield to Worst	4.55	2.97	1.59
Spread	204	56	148
Interest-Rate Duration	5.36	4.98	0.38
Vega	–0.03	–0.03	0.00
Spread Duration	5.20	4.91	0.29
Convexity	0.14	–0.04	0.18
C. Volatility			**TEV**
Systematic	127.3	121.1	10.4
Idiosyncratic	10.5	4.7	9.6
Total	127.7	121.2	14.2
D. Portfolio Beta			1.05

Source: Barclays Capital POINT

increase the volatility of a portfolio. Because of its higher volatility, we refer to the portfolio as riskier than the benchmark. Looking into the different components of the portfolio volatility, the exhibit reports that the idiosyncratic volatility of the portfolio is significantly smaller than that of the systematic one (10.5 bp/month versus 127.3 bp/month), which is what we expect from a medium-sized portfolio of investment-grade bonds.

Given the fact that the systematic and idiosyncratic components of risk are independent by construction, we can calculate the total volatility of the portfolio as

$$\text{TEV}_{Portfolio} = \sqrt{127.3^2 + 10.5^2} = 127.7$$

There are two interesting observations regarding this number:

1. The total volatility is smaller than the sum of the volatilities of the two components.
2. The total volatility is very close to the systematic one.

The first observation is the diversification benefit that comes from combining independent sources of risk. The second observation may suggest that the idiosyncratic risk is irrelevant. That is an erroneous and dangerous conclusion, as we will see later. In particular, when managing against a benchmark, the focus should be on the net exposures and risk, not on their absolute counterparts.

In Exhibit 47–6, the total TEV is reported as 14.2 bp/month. This means that the model forecasts the portfolio return to be typically around 14 bp/month higher than or lower than the return of the benchmark. This number is in line with the risk budget of the manager. The exhibit also reports idiosyncratic TEV of 9.6 bp/month, which is close in magnitude to the systematic TEV (10.4). Therefore, when measured against the benchmark, half of the risk is idiosyncratic, contrary to the conclusion one could draw by looking only at the portfolio's volatility. The TEV of the portfolio is also greater than the difference between the volatilities of the portfolio and benchmark. It would be equal to the difference only if the portfolio and benchmark were perfectly correlated.

Finally, the report shows that the portfolio has a beta of 1.05 to the benchmark. This statistic measures the co-movement between the portfolio and the benchmark. We can read it as follows: the model forecasts that a movement of 100 bp in the benchmark leads to a movement of 105 bp in the portfolio in the same direction. Note that a beta of less than one does not mean that the portfolio is less risky than the benchmark; it just means that the portfolio is less sensitive to movements in the benchmark. To see this more clearly, consider the limit case when the portfolio and benchmark are uncorrelated. The portfolio beta in this case is zero but obviously that does not mean that the portfolio has zero risk. Finally, one can compute many different "betas" for the portfolio or subcomponents of it.[7] A simple and widely used one is the "interest-rate duration beta," given by the ratio of the portfolio interest-rate duration to that of the benchmark. In our case this ratio is 5.36/4.98 = 1.08. This implies that the portfolio has a return from yield-curve movements around 1.08 times larger than that of the benchmark. This beta is larger than the portfolio beta (1.05), meaning that net exposures to other factors (e.g., spreads) "hedge" the portfolio's net curve risk.

7. For example, see Exhibit 47–13 later in this chapter.

This first summary report (Exhibit 47–6) allows the manager to get a glimpse into the risk of the portfolio. However, the manager wants to know in more detail what the sources of this risk are. Risk can be broken down along various dimensions, two of which we briefly looked at above: security groups (asset classes) and risk factors. The next two summary reports present the detailed risk breakdown along these two dimensions. In the first, risk is partitioned across different groups of risk factors. In the second, the partition is across groups of securities.

Exhibit 47–7 shows four different statistics associated with each set of risk factors. The first two were partly explored in Exhibits 47–4 and Exhibit 47–5.[8] The exhibit reports in the first column the isolated TEV, that is, the risk associated with that particular set of risk factors only. We see that in an isolated analysis, the systematic risk and idiosyncratic risk are balanced at 10.4 and 9.6 respectively.

The report also shows the isolated risk associated with the major components of systematic risk. As discussed before, all components of systematic risk have nontrivial isolated risk, but only curve and credit-spreads are relevant when we look into the CTEV. If we look across factors, the major contributors are idiosyncratic risk, curve, and credit-spreads. Other systematic exposures are relatively small.

Another look into the correlation comes when we analyze the liquidation effect reported in Exhibit 47–7. This number represents the change in TEV when we completely hedge that particular group of risk factors. For instance, if we

EXHIBIT 47–7

Factor Partition—Risk Analysis

Risk Factor Group	Isolated TEV(bp)	Contribution to TEV (CTEV)(bp)	Liquidation Effect on TEV(bp)	TEV Elasticity (%)
Total	**14.2**	**14.2**	**–14.2**	**100.0**
Systematic Risk	10.4	7.6	–4.5	53.8
Curve	11.3	5.6	–1.1	39.2
Volatility	0.2	0.0	0.0	0.1
Government-Related Spreads	3.2	0.0	0.4	0.1
Corporate Spreads	6.9	2.1	–0.5	15.1
Securitized Spreads	2.9	–0.1	0.4	–0.7
Idiosyncratic Risk	9.6	6.6	–3.8	46.2

Source: Barclays Capital POINT

8. Note that the contribution numbers are different than those from Exhibit 47–5, because there we were looking at the contribution to systematic—not total—risk.

hedge the curve component of the portfolio, the TEV drops by 1.1 bp/month—from 14.1 to 13.0. One may think that the drop is rather small given the magnitude of isolated risk the curve represents. However, if we hedge the curve, we also eliminate the risk reduction effect of the negative correlation between curve and spreads. Therefore, there is a more limited impact when hedging the curve risk than what is expected based on previous numbers. In fact, for this portfolio we see that hedging any particular set of risk factors has a limited effect on the overall risk.

The TEV elasticity reported in the last column gives another perspective into how the TEV changes when risk loadings change. Specifically, it tells the manager what the percentage impact on TEV is if the exposure to that particular set of factors is changed. For example, if the manager reduces the exposure to corporate spreads by 10%, the TEV would decrease by 10% × 15.1% = 1.51% and therefore it would become 14.2 bp × (1 – 1.51%) = 14.0 bp.

We perform a similar analysis in Exhibit 47–8, but apply it to a security partition. That is, instead of looking at individual sources of risk (e.g., curve) across all securities, we now aggregate all sources of risk within a security and report analytics for different groups of these securities (e.g., subportfolios). Exhibit 47–8 reports results when securities are grouped by asset class. It shows that the majority of risk (7.8 bp/month) comes from the Treasury component of the portfolio. Most of this risk is systematic, which is what we expect given the typically low idiosyncratic risk of the sector and the significant interest-rate duration mismatch. Corporates are also a major contributor to the portfolio's risk, mostly coming from idiosyncratic risk. This reflects the portfolio's large net

EXHIBIT 47–8

Security Partition—Risk Analysis I

		Contribution to TEV		
Security Partition Bucket	**NMW (%)**	**Systematic**	**Idiosyncratic**	**Total**
Total	**0.00**	**7.6**	**6.6**	**14.2**
Treasuries	–3.00	7.7	0.1	**7.8**
Government Agencies	–4.81	1.5	0.3	**1.8**
Government Nonagencies	–1.23	–1.3	0.1	**–1.2**
Corporates	11.18	–0.4	4.6	**4.3**
Agency MBS	–3.82	0.3	0.8	**1.1**
ABS	–0.27	0.0	0.0	**0.0**
CMBS	1.96	–0.2	0.6	**0.4**

Source: Barclays Capital POINT

market weight (NMW) to this sector. The lack of systematic risk contribution by the corporate sector comes from the hedging effect of spreads to the overall curve risk in the portfolio. Note that because the analysis is at the portfolio level, the interplay between net curve risk of Treasuries and spread risk of corporates is partly reflected in the total risk attributed to corporates. The same story applies to other spread sectors, all of which contribute little to systematic risk. Both agency MBS and CMBS contribute non-trivially to idiosyncratic risk. Since the portfolio manager's goal is the replication of a very large benchmark with only 100 positions, the manager has to be comfortable with the issuers selected. This report highlights the significant name risk to which the portfolio is exposed.

Exhibit 47–9 completes the analysis, reporting other important risk statistics about the different asset classes within the portfolio. These statistics mimic the analysis done in terms of risk factor partitions in Exhibit 47–7, so we will not repeat their definitions and focus on the results. Looking at isolated TEV, we see that Corporates have risk of 16.7 bp/month, which is higher than the total risk of the portfolio. This means that the exposures to the other asset classes, on average, hedge the Corporates portfolio. The same can be said about Treasuries. We can even take the analysis a bit further: the next column shows through the liquidation effect that if we eliminate the imbalance the portfolio has on Corporates, we actually would increase the total risk of the portfolio by 4.6 bp/month. In short, we would be eliminating the hedge this asset class provides to the global portfolio, therefore increasing its risk. Because a similar analysis holds for Treasuries, we can conclude that the exposures to Treasuries and Corporates were built to balance each other in the portfolio. Finally, Exhibit 47–9 also reports the TEV elasticity of the different components of the portfolio. This number represents how

EXHIBIT 47–9

Security Partition—Risk Analysis II

Security Partition Bucket	Isolated TEV	Liquidation Effect on TEV	TEV Elasticity (%)
Total	**14.2**	**–14.2**	**100.0**
Treasuries	18.8	4.1	53.2
Government Agencies	5.1	–0.9	12.2
Government Nonagencies	3.4	1.4	–7.5
Corporates	16.8	4.6	32.1
Agency MBS	4.3	–0.5	7.6
ABS	0.6	0.1	–0.3
CMBS	3.5	0.0	2.7

Source: Barclays Capital POINT

much a relative change in NMW translates into a relative change on TEV, so we need to read the numbers with an opposite sign if the NMW is negative. In particular, if we decrease the weight of the agency portfolio (making it more negative, or "more short") by 10%, we would actually increase the TEV by 10% × 12.2 % = 1.22% making it equal to 14.2 bp × (1 + 1.22%) = 14.4 bp. This result shows that the position in agencies provides hedging "on average," but further increasing the exposure to this sector would actually increase the risk of the portfolio. In other words, the hedging went beyond its optimal value.

This set of summary reports gives us a clear picture of the major sources of risk and how they relate to each other. In what follows, we focus on the more detailed analysis of the individual systematic sources of risk.

Factor Exposure Reports

At the heart of a multifactor risk model is the definition of the set of systematic factors that drive risk across the portfolio. As described in Chapter 46, there are many different types of risk sources a fixed income portfolio is exposed to. In what follows we focus on the three major types: curve, credit, and prepayment risk. To illustrate credit and prepayment risk, we use the Corporates component and the agency MBS component of the portfolio, respectively. Moreover, to keep the example simple, we show only a partial view of all relevant factors for these sources of risk.

Curve Risk Exhibit 47–10 details the risk in the portfolio associated with the U.S. Treasury curve. It starts by describing all risk factors the portfolio or benchmark load on. In particular, we use six key-rate (KR) points on the curve plus the convexity term as the risk factors associated with U.S. Treasury risk. They are described in the first column of panel A in the exhibit and measure the risk associated with moves of that particular point on the curve. Exposure to these risk factors is measured by the key-rate durations (KRD) for each of the six points. The description of the loading is in the exhibit's second column, while its value for the portfolio, benchmark, and the difference is displayed in the next columns. Key-rate durations are also called partial durations, as they add up to the interest-rate duration of the portfolio. For instance, for the portfolio, the sum of the key-rate durations is 0.13 + 0.47 + 1.74 + 0.93 + 1.00 + 1.09 = 5.36, the total interest-rate duration of the portfolio. Their loadings are constructed by aggregating partial durations across all the securities.

Looking at the exhibit, we see significant mismatches in the duration profiles between the portfolio and its benchmark, namely at the 10-year and 30-year points on the curve. Specifically, we are short 0.44 years at the 10-year point and long 0.41 years at the 30-year point. Moreover, we are also significantly long at the 5-year and 20-year points. How serious is this mismatch? Looking at the factor volatility column, it can be seen that these points on the curve have been fairly volatile at around 30 bp/month. If we interpret this volatility as a typical move, the first two columns of panel B show us the potential impact of such a movement in

EXHIBIT 47–10

Treasury Curve Risk

A. Exposures and Factor Volatility

Factor Name	Units	Exposure			Factor Volatility
		Portfolio	Benchmark	Net	
USD 6M key rate	KRD (Yr)	0.13	0.12	0.01	23.4
USD 2Y key rate	KRD (Yr)	0.47	0.67	–0.19	22.6
USD 5Y key rate	KRD (Yr)	1.74	1.40	0.34	30.9
USD 10Y key rate	KRD (Yr)	0.93	1.37	–0.44	32.2
USD 20Y key rate	KRD (Yr)	1.00	0.76	0.24	29.1
USD 30Y key rate	KRD (Yr)	1.09	0.67	0.41	28.3
USD Convexity	OAC	0.14	–0.04	0.18	4.9

B. Other Risk Statistics

Factor Name	Return Impact of a Typical Move (%)		Marginal CTEV	TEV Elasticity
	Isolated	Correlated		
USD 6M key rate	–0.2	–2.0	3.2	0.2
USD 2Y key rate	4.4	–2.8	4.5	–6.0
USD 5Y key rate	–10.6	–3.9	8.4	20.0
USD 10Y key rate	14.2	–5.5	12.4	–37.9
USD 20Y key rate	–7.1	–6.1	12.3	20.9
USD 30Y key rate	–11.7	–6.5	12.8	36.7
USD Convexity	0.9	1.2	0.4	0.5

Source: Barclays Capital POINT

the return of the portfolio, net of benchmark. For instance, a typical move up (+32.2 bp/month) in the 10-year point of the Treasury curve, when considered in isolation, will deliver a positive net return of +14.2 bp.[9] In isolation, the positive impact is expected because we are short that point of the curve. More interesting may be the correlated number on the exhibit. It states the return impact but in a correlated fashion. In the scenario under analysis, a movement in the 10-year point will almost surely involve a movement of the neighboring points on the curve. So contrary to the positive isolated effect documented above, the correlated impact of a change up in the 10-year point is actually negative, at –5.5 bp. This result is in line with the overall positive interest-rate duration exposure the portfolio has: general (correlated) movements up in the curve have a negative impact on the portfolio's performance.[10] As another expression of the high correlation among curve points, we can see that correlated changes on various points on the curve have a similar impact on the final portfolio, even though their associated exposures vary greatly. Finally, and broadly speaking, the ratio of the correlated impact to the factor volatility gives us the model-implied partial empirical interest-rate duration of the portfolio. For instance, if we focus on the 10-year point, we get 5.5/32.2 = 0.17. This smaller empirical interest-rate duration is typical in portfolios with spread exposure. This spread exposure tends to empirically hedge some of the curve exposure, given the negative correlation between these two sources of risk. In addition, Exhibit 47–10 shows the risk associated with convexity. We can see that the portfolio is long convexity while the benchmark is short, so higher order changes in the yield-curve have an opposite impact on the portfolio than on the benchmark.

There are many other statistics of interest one can analyze regarding the Treasury curve risk of the portfolio. The portfolio manager may ask questions such as: If I want to reduce the risk of my portfolio by manipulating my Treasury curve exposure, what could I change? What is the most effective move? By how much would my risk actually change? The statistics reported in columns "Marginal Contribution to TEV" and "TEV Elasticity (%)" of panel B are typically used to answer these questions. Regarding the marginal contributions, the 30-year point has the largest value, showing us that an increase (reduction) of one unit of exposure (in this case one year of duration) to the 30-year point leads to an increase (reduction) of 12.8 bp in the TEV.[11] In other

9. This number is obtained by simply multiplying the net exposure by the factor volatility. The sign of the move depends on the interpretation of the factor. In the case of the yield-curve movements, we know that $R = -KRD \times \Delta KR$, where KRD is the duration associated with the KR point. In our example – (–0.44) × 32.2 bp = +14.2 bp.
10. This reversal is clearly related to the fact that the 10-year point on the curve is usually highly correlated to the 5-, 20-, and 30-year ones. In our case, our short position on the 10-year point is more than compensated by the positive exposure to the other points in the curve. Netting out, the positive exposure effect (long duration) dominates when all changes are taken in a correlated fashion.
11. The marginal contribution is the derivative of the TEV with respect to the loading of each factor, so its interpretation holds only for small moves. Therefore, a more realistic reading may be that if we reduce the exposure to the 30-year by 0.1 years, the TEV would be reduced by around 1.3 bp.

words, if we want to reduce risk by manipulating the exposure to the yield-curve, the 30-year point seems to present the fastest track. In addition, the exhibit shows that all Treasury risk factors are associated with positive marginal contributions. This means that an increase in the exposure to any of these factors increases the risk (TEV) of the portfolio. This conclusion holds even for factors for which we have negative exposure (e.g., the 10-year key-rate) because increasing exposure to it means decreasing the negative exposure. To put it differently, the result is a consequence of the portfolio's overall long interest-rate duration exposure. Adding more duration exposure, regardless of the specific point where the manger does it, will result in an increase in portfolio risk.[12] This result holds because we take into consideration the correlations between the different points in the Treasury curve.

Exhibit 47–10 also reports the TEV elasticity of each of the risk factors, a concept introduced earlier. The interpretation is similar to the marginal contribution, but with normalized changes (percentage changes). This normalization makes the numbers more comparable across risk factors of very different nature. It is also useful when considering leveraging the entire portfolio proportionally. In our case, if we increase the exposure to the 10-year key-rate point by 10%, from –0.44 to –0.484 (effectively reducing the long interest-rate duration exposure), the TEV would be reduced by 3.79% (from 14.2 to 13.7 bp/month).

We now turn the analysis to the other component of the curve risk described above: the risk embedded into the portfolio exposure to swap spreads, that is, the differences between the swap and Treasury curves. Many securities trade against the swap curve, making it the natural choice as the base risk curve for those markets. To unify the analysis with markets that use Treasuries as the base curve, we break the swap curve into the Treasury curve (analyzed in Exhibit 47–10) and excess over the Treasury—the swap spread.[13]

All the securities that typically trade against the swap curve (e.g., corporates and securitized bonds) are exposed, in our methodology, to both Treasury and swap spread (SS) risk. The analysis of the latter follows very closely that of the Treasury curve, so we only highlight the major risk characteristics of the portfolio along this dimension. Exhibit 47–11 shows that in general the exposure to swap spreads is smaller than of the exposure to the Treasury curve. Remember that Treasuries do not load on this set of risk factors, so the market-weighted exposures are consequently smaller. Comparing the swap spread volatilities with those from the Treasury curve (see Exhibit 47–10), we can observe significant differences. Looking at the profile of factor volatilities, one can see that its term structure of volatilities is U-shaped, with the short-end being quite volatile and the 5-year point having the lowest volatility. This is typically the case during periods when liquidity risk is high. Regarding net exposures, the exhibit shows that the largest

12. This is a rationale similar to the one used before, where we see all correlated impact with the same sign.

13. For a more detailed discussion, see Chapter 46.

EXHIBIT 47–11

Swap Spread Risk

Factor Name	Exposure (SS-KRD)			Factor Volatility	Return Impact Correlated	Marginal Contribution to TEV
	Portfolio	Benchmark	Net			
6M SS	0.13	0.09	0.04	20.4	–0.8	–2.2
2Y SS	0.47	0.41	0.06	11.5	–0.7	–1.8
5Y SS	0.67	0.85	–0.18	6.8	1.2	–1.0
10Y SS	0.58	0.93	–0.35	8.9	3.1	1.9
20Y SS	0.51	0.57	–0.06	10.4	0.6	1.0
30Y SS	0.47	0.28	0.19	13.3	–2.5	0.5

Source: Barclays Capital POINT

EXHIBIT 47–12

Credit-Spread Risk

Factor Name	Exposure (DTS)			Factor Volatility	Return Impact Correlated	Marginal Contribution to TEV
	Portfolio	Benchmark	Net			
IND Chemicals	0.12	0.03	0.09	9.5	–0.8	–1.6
IND Metals	0.00	0.05	–0.05	12.5	0.6	–1.4
IND Paper	0.00	0.01	–0.01	10.5	0.1	–1.6
IND Capital Goods	0.00	0.05	–0.05	9.5	0.4	–2.0
IND Div. Manufacturing	0.20	0.03	0.18	8.6	–1.5	–2.1
IND Auto	0.00	0.01	–0.01	14.1	0.1	–2.0
IND Consumer Cyclical	0.06	0.04	0.02	10.5	–0.2	–2.0
IND Retail	0.38	0.05	0.33	11.0	–3.6	–2.0
IND Consumer Noncyclical	0.06	0.11	–0.05	8.9	0.4	–2.0
IND Health Care	0.22	0.02	0.20	8.7	–1.7	–1.7
IND Pharmaceuticals	0.07	0.05	0.01	9.2	–0.1	–2.0
IND Energy	0.00	0.15	–0.15	10.6	1.6	–1.7
IND Technology	0.00	0.06	–0.06	9.8	0.6	–1.9

(Continued)

mismatch is at the 10-year point, where the portfolio is short by 0.35 years. Interestingly, this is not the most expensive mismatch in terms of risk: when looking at the last column, we see that we would be able to change risk the most by manipulating the short end of the exposure to the swap spread curve, namely the 6-month point.

The previous exhibits allow us to understand the portfolio exposures to the different types of curve risk and their impact both on the return and risk of portfolios. They also guide us regarding what changes we can introduce to modify the risk profile of the portfolio. We continue our analysis with sources of risk that are more specific to particular asset classes.

Credit Risk Credit risk may be analyzed along various dimensions such as geography, industry, debt seniority, credit rating, or spread level. As discussed in Chapter 46, a powerful determinant of credit risk of a bond for relatively short horizons is given by its *duration times its spread*, or DTS. Under this setting, the spread return of the security is given by the product of its DTS and the percentage change in its spread.[14]

Assuming that the percentage change in spread has similar statistical properties across a group of bonds, we can select this common component as one driver of systematic spread changes, giving rise to the *DTS systematic risk factor*. Apart from DTS, many other characteristics may explain systematic changes in spreads. Examples would be systematic differences along debt seniority or credit rating. However, these differences are typically well captured by the DTS levels of each security. Therefore, they do not justify risk factors in addition to the DTS. On the other hand, there are bonds with similar DTS that may behave very differently, depending on their geography or industries membership, for instance. This difference is relevant enough to grant the typical use of different risk factors across these dimensions. In the framework under analysis here, this is achieved by introducing several DTS factors, one for each combination of region and industry considered in the risk model.

The results of such an approach to the analysis of the portfolio in our example are displayed in Exhibit 47–12, which shows the typical industry risk factors associated with credit risk. The portfolio has exposure to a single region (U.S.) and has net positions in 27 industries, spanning all three major sectors: industrials (IND), Utilities (UTI), and Financials (FIN). We saw before that the portfolio has significant net exposure to Financials in terms of market weights (3.7%, see Exhibit 47–1). In terms of risk exposure, Exhibit 47–12 shows that the net DTS attached to the Banking industry is 0.62[15] clearly the highest across

14. More specifically Spread Return = $-SD \times \Delta S = -SD \times S \times (\Delta S/S) = -DTS \times \%\Delta S$, where SD stands for spread duration, S for spread, and Δ for change.

15. The DTS units used in the report are based on an OAS duration (OASD) stated in years and an OAS in percentage points. Therefore, a bond with an OASD = 5 and an OAS = 200 bp would have a DTS of 5 × 2 =10. The DTS industry exposures are the market-value weighted sum of the DTS of each security in that industry.

EXHIBIT 47–12

Credit-Spread Risk (*Continued*)

Factor Name	Exposure (DTS)			Factor Volatility	Return Impact Correlated	Marginal Contribution to TEV
	Portfolio	Benchmark	Net			
IND Transportation	0.06	0.04	0.02	9.4	–0.2	–1.9
IND Media Cable	0.07	0.06	0.02	10.7	–0.2	–2.0
IND Media Noncable	0.00	0.04	–0.04	10.5	0.4	–2.1
IND Wirelines	0.16	0.14	0.02	10.5	–0.2	–1.8
IND Wireless	0.00	0.02	–0.02	10.6	0.2	–1.5
UTI Electric	0.27	0.17	0.10	9.9	–1.0	–1.7
UTI Gas	0.00	0.08	–0.08	11.5	0.9	–1.5
FIN Banking	1.07	0.44	0.62	13.6	–8.5	–2.3
FIN Brokerage	0.00	0.01	–0.01	11.2	0.2	–2.8
FIN Finance Companies	0.03	0.08	–0.05	16.5	0.8	–2.5
FIN Life & Health Insurance	0.00	0.09	–0.09	14.8	1.3	–2.3
FIN P&C Insurance	0.11	0.05	0.06	8.7	–0.5	–3.2
FIN Reits	0.00	0.03	–0.03	13.2	0.4	–2.3
Non Corporate	0.19	0.26	–0.07	16.7	1.2	–1.2

Source: Barclays Capital POINT

all sectors. However, the marginal contribution to TEV that comes from that industry is comparable to almost all other industries, even with ones that have an almost zero net exposures, such as Brokerage. This observation suggests that all these industries are close substitutes to each other in the context of the current portfolio.

Another interesting point is highlighted by the fact that the marginal contribution is negative for all industries, even though some (such as Retail and Healthcare) are significantly over-weighted. The analysis suggests that if we increase the risk exposure to them, the risk would actually decrease. This result is again driven by the strong negative correlation between spreads in these industries and the yield-curve. For example, the exposure in banking is partially hedging out the significant long interest-rate duration position. This kind of analysis is only possible by accounting for the correlations across factors, underscoring the importance of the quality of the correlation estimates used by the model.

Although the risk factors used to measure risk are predetermined in a given factor model, there is flexibility on the way the risk numbers can be aggregated and reported.[16] For example, the credit risk model used to generate the risk report presented in Exhibit 47–12 does not use credit ratings as drivers of systematic credit risk. Instead, it uses the DTS concept. However, once generated, the risk numbers can be reported using any portfolio partition.

As an example, Exhibit 47–13 shows the risk breakdown by rating. As reported in this exhibit, the majority of risk is coming from the AAA exposure (11.3 bp/month), the bucket with the biggest mismatch in terms of net weight (–12.1%). This bucket includes Treasury and government-related securities, sectors that are underweighted in the portfolio, leading to significant risk. This is even clearer when we look into the isolated TEV numbers. If the manager had mismatches only on AAA's, the portfolio risk would be 22.8 bp/month, instead of the actual 14.2: the other exposures hedge the risk from AAA's. This report also identifies the systematic betas associated with each of the rating sub-portfolios. These betas add up to the portfolio beta, when we use the portfolio weights (not NMW) as weights in the summation. For example, the exhibit allows us to infer that a movement of 10 bp in the benchmark leads to a 12.6 bp return in the AAA sub-component of the portfolio. On the other hand, the beta of 0.22 for the BAA2 component of the portfolio does not signal low volatility for this sub-portfolio. It indicates mainly low correlation with the benchmark, possibly a result of the significant role of idiosyncratic risk for this set of bonds. Systematic betas of zero identify buckets for which the portfolio has (close to) no holdings.

Prepayment Risk Most securitized bonds, such as MBS or asset-backed securities (ABS), have uncertain cash-flows due to the borrower's option to prepay the

16. For a detailed methodology on how to performed this customized analysis, see Antonio Silva, "Risk Attribution with Custom-Defined Risk Factors," Barclays Capital Publication, August 2009.

EXHIBIT 47–13

Risk per Rating

Rating	NMW (%)	TEV				Systematic Beta
		CTEV	Isolated	Liquidation	Elasticity (%)	
Total	**0.0**	**14.2**	**14.2**	**–14.2**	**100.0**	**1.05**
AAA	–12.1	**11.3**	22.8	5.8	76.9	1.26
AA1	–0.3	**–0.3**	0.8	0.3	–2.2	0.00
AA2	–1.4	**–0.5**	2.0	0.6	–3.5	3.27
AA3	–1.1	**0.8**	4.7	–0.1	6.2	3.42
A1	–1.5	**–0.9**	2.5	1.1	–6.1	1.73
A2	2.5	**1.1**	5.1	–0.1	7.3	1.13
A3	1.6	**0.7**	7.5	1.2	4.5	0.25
BAA1	–2.0	**–1.9**	5.3	2.7	–13.3	0.69
BAA2	6.8	**2.0**	9.6	0.7	16.9	0.22
BAA3	7.5	**1.9**	9.6	1.2	13.3	0.35

Source: Barclays Capital POINT

bond at any time. Interest rates strongly drive this prepayment behavior, as explained in Chapter 46, thus adding an extra channel of exposure to interest-rate risk that is absent from other bonds (e.g., corporate bonds with no optionality). Typically, interest and prepayment models can accommodate this feature only imperfectly. Moreover, there are other factors influencing prepayment risk. To accommodate these limitations, risk models incorporate other major characteristics that can be associated with prepayment risk. Examples are the program/term of the deal, if the bond is priced at discount or premium (i.e., if the coupon on the bond is bigger than the current mortgage rates) and how seasoned the bond is.

Exhibit 47–14 shows a potential set of risk factors that capture these characteristics. Programs identified as having different prepayment characteristics are the Conventional (FannieMae and FreddieMac) 30-year bonds (the base case used for the analysis), the 15-year Conventional bonds, as well as the Ginnie Mae 30- and 15-year bonds. The age of bonds is captured by factors distinguishing between new and aged (seasoned) deals. Finally, each bond is also classified by the price of the security—discount, current or premium. In this example there are no seasoned discounted bonds, suggesting that the market rates at the time of the analysis are at historical lows. In terms of risk exposures, the exhibit shows that

EXHIBIT 47–14

Agency MBS (Spread) Prepayment Risk

Factor Name	Exposure (OASD)			Factor Volatility	Return Impact Correlated	Marginal Contribution to TEV
	Portfolio	Benchmark	Net			
New Discount	0.002	0.012	–0.010	26.0	–2.1	3.8
New Current	0.269	0.219	0.050	16.6	0.5	–0.6
New Premium	0.260	0.615	–0.355	20.2	1.1	–1.5
Seasoned Current	0.018	0.003	0.015	19.4	–0.7	0.9
Seasoned Premium	0.810	0.531	0.279	21.2	1.4	–2.0
Ginnie Mae 30Y	0.237	0.291	–0.054	5.4	0.1	0.0
Conventional 15Y	0.000	0.128	–0.128	10.1	–1.0	0.7
Ginnie Mae 15Y	0.000	0.006	–0.006	8.5	0.0	0.0

Source: Barclays Capital POINT

the manager is underweighting 15-year and over-weighting 30-year Conventional bonds (the base case).

Interaction between Sources of Risk So far we analyzed the major sources of spread risk: credit and prepayment. To do this, we conveniently used two asset classes—Corporates and Agency MBS, respectively—where one can argue that these sources of risk appear relatively isolated. However, recent developments have made clear that these sources of risk appear simultaneously in other major asset classes, including nonagency MBS, home equity loans, and CMBS.[17] When designing a risk model for a particular asset class, one should be able to anticipate the nature of the risks the asset class exhibits currently or may encounter in the future. The design and ability to segregate between different kinds of risk depends also on the multitude of the bond indicatives and analytics available to the researcher. For this last point, it is imperative that the portfolio manager understand the pricing model and assumptions made to generate the analytics typically used as inputs in a risk model. This allows the portfolio manager to fully understand the output of the model, as well as its applicability and shortcomings. Other sources of risk—for example, liquidity risk—may be important for particular fixed income portfolios. They were discussed in Chapter 46.

Issue-Level Reports

The previous analysis focused on the systematic sources of risk. We now turn our attention to the idiosyncratic or name-specific risk embedded in the portfolio. This risk measures the volatility the portfolio has because of events specific to the individual issues/issuers it holds. Therefore, idiosyncratic risk is independent across issuers and diversifies away as the number of issuers in the portfolio increases: events with negative impact for some issuers are canceled by events with positive impact for others. Even for medium-sized portfolios, the idiosyncratic risk may be a substantial component of the total risk. Exhibit 47–7 indicates that the idiosyncratic volatility is 10.5 bp/month, more than double the idiosyncratic volatility of the benchmark (4.7 bp/month). When looking at the tracking error volatility net of benchmark, Exhibit 47–6 shows that the idiosyncratic risk is 9.6 bp/month and close to the systematic component (10.4 bp/month). This means that a major component of the monthly net return is typically driven by events affecting only individual issuers. Therefore, monitoring these individual exposures is of particular importance.

The idiosyncratic risk of each bond is a function of two variables: its net market weight and its idiosyncratic volatility. This latter variable depends on the nature of the bond issuer. For instance, a bond from a distressed firm has much higher idiosyncratic volatility than one from a government-related agency.

17. For more discussion on this point, see Radu Gabudean, "US CMBS Risk Model," Barclays Capital Publication, October 2010.

EXHIBIT 47–15

Issue Specific Risk

Identifier	Ticker	Description	Maturity	Spread (bp)	Market Weight (%)		Idiosyncratic TEV
					Portfolio	Net	
912828MA	US/T	US TREASURY NOTES	11/30/2016	3	5.02	4.83	0.6
912828NK	US/T	US TREASURY NOTES	6/30/2017	0	3.86	3.68	0.5
912828MD	US/T	US TREASURY NOTES	12/31/2016	2	3.67	3.48	0.4
126650BK	CVS	CVS CORP-GLOBAL	6/1/2012	915	3.06	3.05	3.5
61945AAA	MOS	MOSAIC CO	12/1/2014	400	3.01	3.00	1.4
489170AB	KMT	KENNAMETAL INC	6/15/2012	503	3.00	3.00	2.6
FNA08000	FNMA	FNMA Conventional Long T. 30yr	3/1/2029	189	2.61	2.61	1.4
313771AA	FHLB	FEDERAL HOME LOAN BANK IL	6/13/2016	224	2.55	2.54	1.1
912828NG	US/T	US TREASURY NOTES	5/31/2017	0	2.29	2.10	0.3
FNA04010	FNMA	FNMA Conventional Long T. 30yr	8/1/2040	28	2.15	1.59	0.4

Source: Barclays Capital POINT

Exhibit 47–15 provides a summary of the idiosyncratic risk for the top 10 positions by market weight in the manager's portfolio. Not surprisingly, seven out of 10 are Treasury or agency MBS securities, in line with the constitution of the index used as benchmark. Moreover, these positions have significant market weights, given that the portfolio contains only 100 positions. Even though we see large concentrations, the idiosyncratic TEV for these holdings is small, as they are not exposed to significant issuer risk. The last column of the exhibit shows that within this group the bonds with the highest idiosyncratic risk are corporate bonds, one issued by CVS Corporation (CVS) and another issued by Kennametal Inc. (KMT). This is not surprising, as these are the type of securities with larger event risk. Even within corporates, idiosyncratic risk can be quite diverse: in particular, it usually depends on the industry, spread duration, and level of distress of the issuer (usually proxied by rating, or by the spread of the bond). For instance, the net position for both the CVS and KMT bonds is similar (3.06% and 3.00% respectively), and even though their maturity is similar, the CVS bond spread is higher, resulting in higher idiosyncratic risk (3.5 versus 2.6 bp/month). To manage the idiosyncratic risk in the portfolio the portfolio manager should pay close attention to mismatches between the portfolio and benchmark for bonds with large spreads or long spread durations. These would tend to affect disproportionally the idiosyncratic risk of the portfolio.

Although important, the information in Exhibit 47–15 is not enough to fully assess the idiosyncratic risk embedded in the portfolio. For instance, a portfolio manager could buy credit protection on CVS through a credit default swap (CDS), thereby significantly reducing the exposure to this issuer's bond. The position reported in this exhibit would still look significant because the CDS protection would not be reflected in it.

A better way is to look at idiosyncratic risk at the issuer rather than at the issue level. While idiosyncratic risk is usually independent across issuers, one may not assume that the idiosyncratic risk of securities of the same issuer is uncorrelated because they are all subject to the same company-specific events. A good risk model should account for such correlation and try to quantify it for different issuer and security types. For example, all types of securities (bonds, equities, convertibles, etc.) of an issuer in financial distress tend to move in a correlated fashion because they all represent claims to the same distressed assets. Adding more securities from such an issuer to a portfolio does not generally deliver additional diversification. On the other hand, securities from issuers in strong financial health can move quite differently from each other, driven primarily by liquidity or capital structure effects rather than credit. In this case, a portfolio manager can achieve some diversification of idiosyncratic risk (although limited) even when adding issues from that same issuer into the portfolio.

In order to understand the net effect of all such interactions, it is useful to review the contributions of individual issuers to the portfolio's total idiosyncratic risk. When aggregating risk from the issue (as shown in Exhibit 47–15) to the issuer level, the correlations referred to above should be fully taken into account.

Exhibit 47–16 shows the results of this exercise for the 10 issuers with the highest isolated idiosyncratic TEV. The riskiest issuer exposure in the portfolio comes from Mellon Capital, with isolated idiosyncratic risk of 4.0 bp/month. Note that no single security from this issuer appears as a top holding in the portfolio (see Exhibit 47–15). This highlights the importance of aggregating idiosyncratic risk at the issuer level. We can also observe that idiosyncratic TEV is not monotonic in the NMW: Mellon Capital and Ameren Corp have similar NMW, but the former is significantly riskier (4.0 versus 1.3 bp/month). It is also possible to have important idiosyncratic risk even for issuers the portfolio does not hold, namely for bonds from issuers that have significant market weight in the benchmark.

Finally, note that because the idiosyncratic risk across issuers is independent, the cumulative risk of several issuers can be easily calculated. For example, the total idiosyncratic risk of the top two issuers in Exhibit 47–16 is given by:

$$\text{TEV}_{idio}^{BK+GS} = \sqrt{4.0^2 + 3.5^2} = 5.3$$

As is the case in most portfolios tracking a benchmark, most issuers present in the portfolio are over-weighted relative to the benchmark. This is a natural

EXHIBIT 47–16

Issuer Specific Risk

Ticker	Name	Sector	NMW (%)	Idiosyncratic TEV
BK	MELLON CAPITAL IV	BANKING	1.50	4.0
GS	GOLDMAN SACHS CAPITAL II	BANKING	0.75	3.5
CVS	CVS CORP-GLOBAL	RETAILERS	3.00	3.5
KMT	KENNAMETAL INC	DIVERSIFIED MANUFACTURING	3.00	2.6
KFW	KREDIT FUER WIEDERAUFBAU	NON-U.S. AGENCIES	–0.03	1.4
MOS	MOSAIC CO	CHEMICALS	3.00	1.4
WFC	WELLS FARGO CAPITAL XIII	BANKING	0.76	1.3
AEE	AMEREN CORP	ELECTRIC	1.27	1.3
PNC	NATIONAL CITY PRE CAP TR I	BANKING	0.78	1.1
JNJ	JOHNSON & JOHNSON	PHARMACEUTICALS	0.54	1.0

Source: Barclays Capital POINT

consequence of the fact that, in practice, portfolios hold far fewer positions than the benchmark. It may be difficult for the manager to hold positive views in all issuers selected in the portfolio. In fact, some of these positions may be selected to build exposure to specific systematic factors, such as a particular industry or asset class, and not to a particular issuer. However, it is important that the manager hold positive views for the issuers with the largest contribution to idiosyncratic risk. If this is not the case, then the manager is assuming a significant unintended name risk that should be promptly taken out of the portfolio, in favor of another issuer with similar characteristics for which the manager does have a positive view. This interactive exercise can easily be performed with a good and flexible portfolio construction tool and the help of an optimizer.

Scenario Analysis Report

Scenario analysis provides an additional perspective on the portfolio's risk. This exercise can be performed in several ways. For instance, a manager may want to reprice the whole portfolio under a particular scenario on risk factors, such as interest rates or spreads, and look at the hypothetical return under that scenario. Alternatively, a portfolio manager may wish to evaluate how the portfolio would have performed under particular historical scenarios (e.g., the 1987 equity crash or the Asian crisis in 1997). One particular problem with this approach is the fact that, given the dynamic nature of the securities, the current portfolio with its current characteristics did not exist during such historical episodes. Some of the portfolio securities may have not even been issued during such periods. A solution might be to price the current securities with the market variables at the time. While a valid solution, it is difficult to implement because pricing models require inputs possibly not available during that historical period.

EXHIBIT 47–17

Historical Systematic Simulated Returns (basis points)

Source: Barclays Capital POINT

An alternative is to represent the current portfolio as the set of loadings to all systematic risk factors in a linear factor risk model. We can then multiply these loadings by the historical realizations of the risk factors. The result is a set of historical systematic simulated returns. Exhibit 47–17 presents monthly returns for the period between December 2003 and December 2010. The dark line represents the absolute portfolio returns and the lighter line represents the portfolio's return net of the benchmark. Note that this analysis uses only one set of static portfolio loadings. Therefore, these simulated returns can be interpreted as the hypothetical returns a portfolio with these characteristics would have, if submitted to the historical episodes. As expected, the largest volatility was realized during the crisis of 2007–2009, when the portfolio registered returns between –300 and 400 bp. The largest underperformance against the benchmark occurred in November 2007 at about –25 bp, followed by other months during the crisis such as February and September 2008. The largest outperformance (about +30 bp) was registered at the end of 2008, when the portfolio—being long interest-rate duration—benefited from the sharp drop in interest rates registered during that period.

This analysis has some limitations, especially for the portfolio under analysis, where idiosyncratic exposure is a major source of risk. This kind of risk is always hard to capture and obviously less relevant from an historical perspective, as the issuers in the current portfolio may have not witnessed any particular major idiosyncratic event in the past. However, these and other types of historical scenario analyses are important, because they give managers some indication of the magnitude of historical returns the portfolio might have encountered. They are usually the starting point for any scenario analysis. The manager should always complement them with other non-historical scenarios relevant for the particular portfolio under analysis. In particular, the risk model can be used to express such scenarios, as discussed in Chapter 46.

KEY POINTS

- A good risk model provides detailed information about the exposures of a portfolio. Risk analysis starts with weight imbalances in the portfolio, when compared to the benchmark. For fixed income portfolios, the analysis of market weights has to be complemented with other analytics for a better description of the portfolio's exposure to the different sources of risk.
- The relevance of a risk source is given by the product of its volatility—how risky it is—and the portfolio's exposure to it. To get an aggregated description of risk, we have to bring into the analysis correlations between the different risk sources the portfolio is exposed to. The combination of these elements results in the overall risk of a portfolio versus a benchmark, or it's tracking error volatility.

- There are many different ways to analyze the risk of a portfolio. We can do it by type of risk factor (e.g., interest-rate risk) or by type of security (e.g., corporates). Many different metrics—such as contribution to TEV, liquidation effect on TEV or TEV elasticity—can provide further understanding of the overall risk of the portfolio.
- Risk analysis can be significantly enhanced using scenario analysis. There are several methods to perform it. One method is to look at the historical performance of a theoretical portfolio with constant loadings. This analysis allows a manager to study the potential behavior of a portfolio with such characteristics across major historical events.

CHAPTER
FORTY-EIGHT

HEDGING INTEREST-RATE RISK WITH TERM-STRUCTURE FACTOR MODELS

Lionel Martellini, Ph.D.
Professor of Finance
EDHEC Business School
Scientific Director, EDHEC Risk Institute

Philippe Priaulet, Ph.D.
Head of Fixed Income Sales for Shareholders Networks Natixis
Associate Professor
Mathematics Department
University of Evry Val d'Essonne

Frank J. Fabozzi, Ph.D., CFA, CPA
Professor of Finance
EDHEC Business School

Portfolio managers seek to control or hedge the change in the value of a bond position or a bond portfolio to changes in risk factors. The relevant risk factors can be classified into two types: *term-structure risk factors* and *non-term-structure risk factors*. The former risks include parallel and nonparallel shifts in the term structure. Non-term-structure risk includes sector risk, quality risk, and optionality risk. Multifactor risk models that focus only on hedging exposure to interest-rate risks are referred to as the *term-structure factor model*.

Exposure to changes in interest rates is most often measured in terms of a bond or portfolio's *duration*. This is a one-dimensional measure of the bond's sensitivity to interest-rate movements. There is one complication, however: the value of a bond, or a bond portfolio, is affected by changes in interest rates of all possible maturities (i.e., changes in the term structure of interest rates). In other words, there is more than one risk factor that affects bond returns, and simple methods based on a one-dimensional measure of risk such as duration will not

allow portfolio managers to manage interest-rate risks properly.[1] Hence the need for term-structure factor models.

In this chapter we show how term-structure factor models can be used in interest-rate risk management. These models have been designed to better account for the complex nature of interest-rate risk. Because it is never easy to hedge the risk associated with too many sources of interest-rate uncertainty, it is always desirable to try to reduce the number of term-structure risk factors and identify a limited number of common factors. There are several ways in which this can be done, and it is important to know the exact assumptions one has to make in the process and try to evaluate the robustness of these assumptions with respect to the specific scenario a portfolio manager has in mind.

We first briefly review the traditional duration hedging method, which is still used heavily in practice and has been illustrated in several chapters in this book. The approach is based on a series of very restrictive and simplistic assumptions, including the assumptions of a small and parallel shift in the yield-curve. We then show how to relax these assumptions and implement hedging strategies that are robust with respect to a wider set of possible yield-curve changes. We conclude by analyzing the performance of various hedging techniques in a realistic situation, and we show that satisfying hedging results can be achieved by using a three-factor model for the yield-curve dynamics.

DEFINING INTEREST-RATE RISK(S)

The first fundamental fact about interest-rate risk management can be summarized by the following statement: bond prices move inversely to market yields.[2] More generally, we define as interest-rate risk the potential impact on a bond portfolio value of any given change in the location and shape of the yield-curve.

To further illustrate the notion of interest-rate risk, we consider a simple experiment. A portfolio manager wishes to hedge the value of a bond portfolio that delivers deterministic cash-flows in the future, typically cash-flows from fixed-coupon Treasury securities. Even if these cash-flows are known in advance, bond prices change in time, which leaves an investor exposed to a potentially significant capital loss.

To fix the notation, we consider at date t a bond (or a bond portfolio) that delivers m certain cash-flows CF_i at future dates t_i, for $i = 1, \ldots, m$. The price V

1. This complication is not specific to the fixed income environment. In the world of equity investment, it has actually long been recognized that there may be more than one rewarded risk factor that affects stock returns. A number of more general multifactor models, economically justified either by equilibrium or arbitrage arguments, have been applied for risk management and portfolio performance evaluation.
2. There are some derivative mortgage products that do not possess this property.

of the bond (expressed as a percentage of the face value) can be written as the sum of the future cash-flows discounted with the appropriate zero-coupon rate with maturity corresponding to the maturity of the cash-flows.

$$V_t = \sum_{i=1}^{m} \frac{CF_i}{[1 + R(t, t_i - t)]^{t_i - t}} \tag{48–1}$$

where $R(t, t_i - t)$ is the associated zero-coupon rate, starting at date t for a remaining maturity of $t_i - t$ years.

We see in Eq. (48–1) that the price V_t is a function of m interest-rate variables $R(t, t_i - t)$. This suggests that the value of the bond is subject to a potentially large number m of risk factors. For example, the price of a bond with annual cash-flows up to a 10-year maturity is affected by potential changes in 10 zero-coupon rates (i.e., the term structure of interest rates). To hedge a position in this bond, we need to be hedged against a change of all 10 of these risk factors.

In practice, it is not easy to perform risk management in the presence of many risk factors. In principle, one must design a *global portfolio* in such a way that the portfolio is insensitive to all sources of risk (the m interest-rate variables and the time variable t).[3] A global portfolio is one that contains the original portfolio plus any hedging instruments used to control the original portfolio's interest-rate risk. One suitable way to simplify the problem is to reduce the number of risk factors. Everything we cover in this chapter can be seen as a variation on the theme of reducing the dimensionality of the interest-rate risk-management problem.

We first consider the simplest model for interest-rate risk management, also known as *duration hedging*, which is based on a single risk variable, the yield-to-maturity of this portfolio.

HEDGING WITH DURATION

The intuition behind duration hedging is to bypass the complexity of a multidimensional interest-rate risk by identifying a single risk factor that will serve as a "proxy" for the whole term structure. The proxy measure used is the yield of a bond. In the case of a bond portfolio, it is the average portfolio yield.

3. In this chapter we do not consider the change of value owing to time because it is a deterministic term. We only consider changes in value owing to interest-rate variations. For details about the time value of a bond, see Don M. Chance and James V. Jordan, "Duration, Convexity, and Time as Components of Bond Returns," *Journal of Fixed Income* (September 1996), pp. 88–96.

First Approximation: Using a One-Order Taylor Expansion

The first step consists in writing the price of the portfolio V_t (in percent of the face value) as a function of a single source of interest-rate risk, its yield-to-maturity y_t, as shown below:

$$V_t = V(y_t) = \sum_{i=1}^{m} \frac{CF_i}{(1+y_t)^{t_i - t}} \tag{48–2}$$

In this case, we can see clearly that the interest-rate risk is (imperfectly) summarized by changes of the yield-to-maturity y_t. Of course, this can only be achieved by losing much generality and imposing important, rather arbitrary and simplifying assumptions. The yield-to-maturity is a complex average of the entire term structure, and it can only be assimilated to the term structure if the term structure happens to be flat (i.e., the yield-to-maturity is the same for each maturity).

A second step involves the derivation of a *Taylor expansion* of the value of the portfolio V as an attempt to quantify the magnitude of value changes that are triggered by small changes y in yield. Before showing how this is done, let's briefly review what a Taylor expansion is. A Taylor expansion is a tool used in calculus to approximate the change in the value of a mathematical function owing to a change in a variable. The change can be approximated by a series of "orders," with each order related to the mathematical derivative of the function. When one refers to approximating a mathematical function by a first derivative, this means using a Taylor expansion with only the first order. Adding to the approximation from the second order to the approximation from the first order improves the approximation.

Let us return now to approximating the change in value of a bond when interest rates change. The mathematical function is Eq. (48–2), the value of a bond portfolio. The function depends on the yield. We denote dV as the change in the value of the portfolio triggered by small changes in yield denoted by dy. The approximate *absolute* change in the value of the portfolio triggered by small changes in yield in using a Taylor expansion is

$$dV(y) = V(y+dy) - V(y) = V'(y)dy + o(y) \approx \$\text{dur}[V(y)]dy \tag{48–3}$$

where

$$V'(y) = -\sum_{i=1}^{m} \frac{(t_i - t)F_i}{(1+y_t)^{t_i - t + 1}}$$

which is the derivative of the bond value function with respect to the yield-to-maturity. This value is known as the *dollar duration of the portfolio V*, denoted by \$duration, and $o(y)$ a negligible term.

Dividing Eq. (48–3) by $V(y)$, we obtain an approximation of the *relative* change in value of the portfolio as

$$\frac{dV(y)}{V(y)} = \frac{V'(y)}{V(y)} dy + o_1(y) \approx -MD[V(y)]dy \tag{48–4}$$

where $MD\ [V(y)] = -[V'(y)/V(y)]$ is known as the *modified duration of portfolio V.*

The \$duration and the modified duration enable us to compute the absolute profit and loss for the portfolio (absolute P&L) and relative P&L of portfolio V for a small change Δy of the yield-to-maturity. That is,

$$\text{Absolute P\&L} \approx N_V \times \$\text{dur} \times \Delta y$$
$$\text{Relative P\&L} \approx -MD \times \Delta y$$

where N_V is the face value of the portfolio.

Performing Duration Hedging

We attempt to hedge a bond portfolio with face value N_V, yield-to-maturity y, and price denoted by $V(y)$. The idea is to consider one hedging instrument with face value N_H, yield-to-maturity y_H (*a priori* different from y), whose price is denoted by $H(y_H)$ and build a global portfolio with value V^* invested in the initial portfolio and some quantity ϕ of the hedging instrument.

$$V^* = N_V V(y) + \phi N_H H(y_H)$$

The goal is to make the global portfolio insensitive to small interest-rate variations. Using Eq. (48–3) and assuming that the yield-to-maturity curve is only affected by parallel shifts so that $dy = dy_H$, we obtain

$$dV^* \approx [N_V V'(y) + \phi N_H H'(y_H)]dy = 0$$

which translates into

$$\phi N_H \$\text{dur}[H(y_H)] = -N_V \$\text{dur}[V(y)]$$
$$\phi N_H H(y_1) MD[H(y_H)] = -N_V V(y) MD[V(y)]$$

so that we finally get

$$\phi = -\frac{N_V \$\text{dur}[V(y)]}{N_H \$\text{dur}[H(y_H)]} = -\frac{N_V V(y) MD[V(y)]}{N_H H(y_1) MD[H(y_H)]} \tag{48–5}$$

The optimal amount invested in the hedging instrument is simply equal to the opposite of the ratio of the \$duration of the bond portfolio to hedge by the \$duration of the hedging instrument when they have the same face value.

When the yield-curve is flat, which means $y = y_H$, Eq. (48–5) simplifies to

$$\phi = -\frac{N_V V(y) D[V(y)]}{N_H H(y) D[H(y)]}$$

where the Macaulay duration $D[V(y)]$ is defined as

$$D[V(y)] = -(1+y)MD[V(y)] = \frac{\sum_{i=1}^{m} \frac{(t_i - t)F_i}{(1+y)^{t_i - t}}}{V(y)}$$

In practice, it is preferable to use futures contracts or swaps instead of bonds to hedge a bond portfolio because of significantly lower costs and higher liquidity. For example, using futures as hedging instruments, the hedge ratio ϕ_f is equal to

$$\phi_f = -\frac{N_V \$\text{dur}_V}{N_F \$\text{dur}_{CTD}} \times cf \tag{48–6}$$

where N_F is the size of the futures contract. $\$\text{dur}_{CTD}$ is the \$duration of the cheapest to deliver, and cf is the conversion factor.

Using standard swaps, the hedge ratio ϕ_s is

$$\phi_s = -\frac{N_V \$\text{dur}_V}{N_S \$\text{dur}_S} \tag{48–7}$$

where N_S is the nominal amount of the swap, and $\$\text{dur}_S$ is the \$duration of the fixed-coupon bond forming the fixed leg of the swap contract.[4]

Duration hedging is very simple. However, one should be aware that the method is based on the following, very restrictive assumptions:

- It is explicitly assumed that the value of the portfolio could be approximated by its first-order Taylor expansion. This assumption is all the more disputable that changes of the interest rates are larger. In other words, the method relies on the assumption of small yield-to-maturity changes. This is why the hedging portfolio should be readjusted reasonably often.
- It is also assumed that the yield-curve is only affected by parallel shifts. In other words, interest-rate risk simply is considered as a risk on the general level of interest rates.

In what follows, we attempt to relax both assumptions to account for more realistic changes in the term structure of interest rates.

RELAXING THE ASSUMPTION OF A SMALL SHIFT

We have argued that \$duration provides a convenient way to estimate the impact of a *small* change dy in yield on the value of a bond or a portfolio.

Using a Second-Order Taylor Expansion

Duration hedging only works effectively for small yield changes because the price of a bond as a function of yield is nonlinear. In other words, the \$duration of a bond changes as the yield changes. When a portfolio manager expects a potentially large

4. For examples of hedging with futures, see Chapter 61. For examples of hedging portfolios constructed with futures contracts and swaps, see Lionel Martellini, Philippe Priaulet, and Stephane Priaulet, *Fixed Income Securities: Valuation, Risk Management and Portfolio Strategies* (Chichester, England: Wiley, 2003).

shift in the term structure, a convexity term should be introduced, and the price change approximation can be improved if one can account for such nonlinearity by explicitly introducing the convexity term.

Let us take the following example to illustrate this point. We consider a 10-year maturity and 6% annual coupon bond trading at par. Its modified duration and convexity are equal to 7.36 and 57.95, respectively.[5] We assume that the yield-to-maturity goes suddenly from 6% to 8%, and we reprice the bond after this large change. The new price of the bond, obtained by discounting its future cash-flows, is now equal to \$86.58, and the exact change in value amounts to –\$13.42 (= \$86.58 – \$100). Using a first-order Taylor expansion, the change in value is approximated by –\$14.72 (= –\$100 × 7.36 × 0.02), which overestimates the decrease in price by \$1.30. We conclude that a first-order Taylor expansion does not provide us with a good approximation of the bond price change when the variation of its yield-to-maturity is large.

If a portfolio manager is concerned about the impact of a larger move dy on a bond portfolio value, one needs to use (at least) a second-order version of the Taylor expansion as given below.

$$\begin{aligned} dV(y) &= V'(y)dy + \frac{1}{2}V''(y)(dy)^2 + o[(dy)^2] \\ &\approx \$\mathrm{dur}[V(y)]dy + \frac{1}{2}\$\mathrm{conv}[V(y)](dy)^2 \end{aligned} \tag{48–8}$$

where the quantity V'' also denoted \$conv[$V(y)$] is known as the \$convexity of the bond V.

Dividing Eq. (48–8) by $V(y)$, we obtain an approximation of the relative change in value of the portfolio as

$$\frac{dV(y)}{V(y)} \approx -MD[V(y)]dy + \frac{1}{2}RC[V(y)](dy)^2$$

where $RC[V(y)]$ is called the (relative) *convexity of portfolio V*.

We now reconsider the preceding example and approximate the bond price change by using Eq. (48–8). The bond price change is now approximated by –\$13.56 [= –14.72 + (100 × 57.95 × 0.02²/2)]. We conclude that the second-order approximation is better suited for larger interest-rate deviations.

Performing Duration/Convexity Hedging

Hedging by taking into consideration first and second orders is called *duration/convexity hedging*. To perform a duration/convexity hedge, a portfolio manager needs to introduce two hedging instruments. We denote the value of the two hedging instructions by H_1 and H_2. The goal is to obtain a portfolio that is both

5. Note that convexity can be scaled in various ways.

$duration-neutral and $convexity-neutral. The optimal quantity (ϕ_1, ϕ_2) of these two hedging instruments to hold is then given by the solution to a system of equations at each date, assuming that $dy = dy_1 = dy_2$. The system of equations consists of two equations and two unknowns and can be solved easily algebraically.

More formally, the sytem of equations is

$$\begin{cases} \phi_1 N_{H_1} H_1'(y_1) + \phi_2 N_{H_2} H_2'(y_2) = -N_V V'(y) \\ \phi_1 N_{H_1} H_1''(y_1) + \phi_2 N_{H_2} H_2''(y_2) = -N_V V''(y) \end{cases}$$

which can be rewritten as:

$$\begin{cases} \phi_1 N_{H_1} \$\text{dur}[H_1(y_1)] + \phi_2 N_{H_2} \$\text{dur}[H_2(y_2)] = -N_V \$\text{dur}[V(y)] \\ \phi_1 N_{H_1} \$\text{conv}[H_1(y_1)] + \phi_2 N_{H_2} \$\text{conv}[H_2(y_2)] = -N_V \$\text{conv}[V(y)] \end{cases} \tag{48–9}$$

or

$$\begin{cases} \phi_1 N_{H_1} H_1(y_1) MD[H_1(y_1)] + \phi_2 N_{H_2} H_2(y_2) MD[H_2(y_2)] = -N_V V(y) MD[V(y)] \\ \phi_1 N_{H_1} H_1(y_1) RC[H_1(y_1)] + \phi_2 N_{H_2} H_2(y_2) MD[H_2(y_2)] = -N_V V(y) RC[V(y)] \end{cases}$$

RELAXING THE ASSUMPTION OF A PARALLEL SHIFT

Duration and duration/convexity hedging are based on single-factor models because only one interest rate is being considered. In this section we look at how we can go beyond a single-factor model to a term-structure factor model.[6]

Accounting for the Presence of Multiple Risk Factors

A major shortcoming of single-factor models is that they imply that all possible zero-coupon rates are perfectly correlated, making bonds redundant assets. We know, however, that rates with different maturities do not always change in the same way. In particular, long-term rates tend to be less volatile than short-term rates. An empirical analysis of the dynamics of the interest-rate term structure suggests that two or three factors account for most of the yield-curve changes. They can be interpreted, respectively, as level, slope and curvature factors (see below). This strongly suggests that a term-structure factor model should be used for pricing and hedging fixed income securities.

There are different ways to generalize duration hedging to account for nonparallel deformations of the term structure. The common principle behind all techniques is the following. Going back to Eq. (48–1), let us express the value of the portfolio using the entire curve of zero-coupon rates, where we now

6. See also Lionel Martellini, Philippe Priaulet, and Stephane Priaulet, "Beyond Duration," *Journal of Bond Trading and Management* (October 2002), pp. 103–119.

make explicit the time dependency of the variables. Hence we consider V_t to be a function of the zero-coupon rates $R(t, t_i - t)$. The risk factor is the yield-curve as a whole, *a priori* represented by m components, as opposed to a single variable, the yield-to-maturity y.

The main challenge is then to narrow down this number of factors in the least arbitrary way. The good news is that one can show that a limited number (two or three) of suitably designed risk factors can account for a large fraction of the information in the whole term yield-curve dynamics. There is actually a systematic method that allows us to achieve this very objective through what is known as a *principal components analysis* (PCA) of interest-rate changes, as will now be explained. This arguably has become the state-of-the-art technique for interest-rate risk management.

Regrouping Risk Factors through a Principal Component Analysis

The purpose of PCA is to explain the behavior of observed variables using a smaller set of unobserved, implied variables. From a mathematical standpoint, it consists of transforming a set of m correlated variables into a reduced set of orthogonal variables that reproduce the original information present in the correlation structure. This tool can yield interesting results, especially for the pricing and risk management of correlated positions. Using PCA with historical zero-coupon rate curves in major bond markets, it has been observed that the first three principal components of spot-curve changes, which can be interpreted as level, slope, and curvature factors, explain the main part of the returns variations on fixed income securities over time. More specifically, studies of spot rates in the U.S., German, Italian, French, Swiss, and Belgium government bond markets, found that at least 90% of the variation in returns can be explained by the three factors. The level component was the first factor which explained from 59% to 93% of the return variation. [7]

Using a PCA of the yield-curve, we may now express the change $dR(t, \theta_k) = R(t+1, \theta_k) - R(t, \theta_k)$ of zero-coupon rate $R(t, \theta_k)$ with maturity θ_k at

7. Robert Litterman and Jose Scheinkman, "Common Factors Affecting Bond Returns," *Journal of Fixed Income* (September 1991), pp. 54–61; Alfred Bühler and Heinz Zimmermann, "A Statistical Analysis of the Term Structure of Interest Rates in Switzerland and Germany," *Journal of Fixed Income* (December 1996), pp. 55–67; Joel R. Barber and Mark L. Copper, "Immunization Using Principal Component Analysis," *Journal of Portfolio Management* (Fall 1996), pp. 99–105; Rita L. D'Ecclesia and Stavros Zenios, "Risk Factor Analysis and Portfolio Immunization in the Italian Bond Market," *Journal of Fixed Income* (September 1994), pp. 51–58; Bennett W. Golub and Leo M. Tilman, "Measuring Yield-Curve Risk Using Principal Components Analysis, Value at Risk, and Key Rate Durations," *Journal of Portfolio Management* (Summer 1997), pp. 72–84; Lionel Martellini and Philippe Priaulet, Fixed Income Securities: *Dynamic Methods for Interest Rate Risk Pricing and Hedging* (Chichester, England: Wiley, 2000); Sandrine Lardic, Philippe Priaulet, and Stephane Priaulet, "PCA of Yield-Curve Dynamics: Questions of Methodologies," *Journal of Bond Trading and Management* (April 2003), pp. 327–349.

date t as a function of changes in the principal components (unobserved implicit factors)

$$dR(t,\theta_k) = \sum_{l=1}^{m} c_{lk} C_t^l + \varepsilon_{tk}$$

where c_{lk} is the sensitivity of the kth variable to the lth factor, defined as

$$\frac{\Delta\,[dR(t,\theta_k)]}{\Delta(C_t^l)} = c_{lk}$$

which amounts to individually applying a, say, 1% variation to each factor and computing the absolute sensitivity of each zero-coupon yield-curve with respect to that unit variation.

These sensitivities are commonly called the *principal component $durations*. C_t^l is the value of the lth factor at date t, and ε_{tk} is the residual part of $dR(t,\theta_k)$ that is not explained by the factor model.

One can easily see why this method has become popular. Its main achievement is that it allows for the reduction of the number of risk factors with an optimally small loss of information. Since these three factors (parallel movement, slope oscillation, and curvature), regarded as risk factors, explain most of the variance in interest-rate changes, we may now use not more than three hedging instruments. We now write the changes of value of a fixed income portfolio as

$$dV_t^* \approx \sum_{k=1}^{m}\left[\frac{\partial V_t}{\partial R(t,\theta_k)} + \sum_{j=1}^{3}\phi_t^j\,\frac{\partial H_t^j}{\partial R(t,\theta_k)}\right] dR(t,\theta_k)$$

We then use $dR(t,\theta_k) \approx \Sigma_{l=1}^{3} c_{lk} C_t^l$ to obtain

$$dV_t^* \approx \sum_{k=1}^{m}\left\{\left[\frac{\partial V_t}{\partial R(t,\theta_k)} + \sum_{j=1}^{3}\phi_t^j\,\frac{\partial H_t^j}{\partial R(t,\theta_k)}\right]\sum_{l=1}^{3} c_{lk} C_t^l\right\}$$

or

$$\begin{aligned} dV_t^* \approx & \sum_{k=1}^{m}\left[c_{1k}\,\frac{\partial V_t}{\partial R(t,\theta_k)} + \sum_{j=1}^{3}\phi_t^j c_{1k}\,\frac{\partial H_t^j}{\partial R(t,\theta_k)}\right] C_t^1 \\ & + \sum_{k=1}^{m}\left[c_{2k}\,\frac{\partial V_t}{\partial R(t,\theta_k)} + \sum_{j=1}^{3}\phi_t^j c_{2k}\,\frac{\partial H_t^j}{\partial R(t,\theta_k)}\right] C_t^2 \\ & + \sum_{k=1}^{m}\left[c_{3k}\,\frac{\partial V_t}{\partial R(t,\theta_k)} + \sum_{j=1}^{3}\phi_t^j c_{3k}\,\frac{\partial H_t^j}{\partial R(t,\theta_k)}\right] C_t^3 \end{aligned}$$

The first term in this expression is commonly called the *principal component $duration* of portfolio V^* with respect to factor 1.

If we want to set the (first order) variations of the hedged portfolio V_t^* to zero for any possible change in interest rates $dR(t,\theta_k)$ or, equivalently, for any possible evolution of the C_t^l terms, we may take as a sufficient condition, for $l = 1, 2, 3$,

$$\sum_{k=1}^{m}\left[c_{lk}\frac{\partial V_t}{\partial R(t,\theta_k)}+\sum_{j=1}^{3}\phi_t^j c_{lk}\frac{\partial H_t^j}{\partial R(t,\theta_k)}\right]=0$$

This is a neutral principal component $durations objective.

Finally, on each possible date, we are left with three unknowns ϕ_t^j and three linear equations. Let us introduce the following matrix notation

$$H_t'=\begin{pmatrix}\sum_{k=1}^{m}c_{1k}\frac{\partial H_t^1}{\partial R(t,\theta_k)} & \sum_{k=1}^{m}c_{1k}\frac{\partial H_t^2}{\partial R(t,\theta_k)} & \sum_{k=1}^{m}c_{1k}\frac{\partial H_t^3}{\partial R(t,\theta_k)}\\ \sum_{k=1}^{m}c_{2k}\frac{\partial H_t^1}{\partial R(t,\theta_k)} & \sum_{k=1}^{m}c_{2k}\frac{\partial H_t^2}{\partial R(t,\theta_k)} & \sum_{k=1}^{m}c_{2k}\frac{\partial H_t^3}{\partial R(t,\theta_k)}\\ \sum_{k=1}^{m}c_{3k}\frac{\partial H_t^1}{\partial R(t,\theta_k)} & \sum_{k=1}^{m}c_{3k}\frac{\partial H_t^2}{\partial R(t,\theta_k)} & \sum_{k=1}^{m}c_{3k}\frac{\partial H_t^3}{\partial R(t,\theta_k)}\end{pmatrix}$$

$$\Phi_t=\begin{pmatrix}\phi_t^1\\ \phi_t^2\\ \phi_t^3\end{pmatrix}\qquad V_t'=\begin{pmatrix}-\sum_{k=1}^{m}c_{1k}\frac{\partial V_t}{\partial R(t,\theta_k)}\\ -\sum_{k=1}^{m}c_{2k}\frac{\partial V_t}{\partial R(t,\theta_k)}\\ -\sum_{k=1}^{m}c_{3k}\frac{\partial V_t}{\partial R(t,\theta_k)}\end{pmatrix}$$

We then have the system

$$H_t'\Phi_t = V_t'$$

The solution is given by

$$\Phi_t = (H_t')^{-1}V_t'$$

In practice, one needs to estimate the principal components $durations used at date t. They are derived from a PCA performed on a period prior to t, for example, [t – 3 months, t]. As a result, the output of the method becomes strongly sample-dependent. In an attempt to alleviate this concern over robustness, it is actually more convenient to use a suitable functional specification for the zero-coupon yield-curve, provided that it is consistent with results from a PCA.

Hedging Using a Three-Factors Model of the Yield-Curve

The idea here consists of using a model for the zero-coupon rate function. We detail below the Nelson and Siegel model,[8] as well as the Svensson (or extended Nelson and Siegel) model.[9] One may alternatively use the Vasicek model,[10] the extended Vasicek model, or the Cox-Ingersoll-Ross (CIR) model,[11] among many others.[12]

Nelson-Siegel and Svensson Models

Nelson and Siegel suggested modeling the continuously compounded zero-coupon rates $R^c(0, \theta)$ as

$$R^C(0,\theta) = \beta_0 + \beta_1\left[\frac{1-\exp(-\theta/\tau_1)}{\theta/\tau_1}\right] + \beta_2\left[\frac{1-\exp(-\theta/\tau_1)}{\theta/\tau_1} - \exp(-\theta/\tau_1)\right]$$

a functional form that was later extended by Svensson as

$$R^C(0,\theta) = \beta_0 + \beta_1\left[\frac{1-\exp(-\theta/\tau_1)}{\theta/\tau_1}\right] + \beta_2\left[\frac{1-\exp(-\theta/\tau_1)}{\theta/\tau_1} - \exp(-\theta/\tau_1)\right]$$
$$+\beta_3\left[\frac{1-\exp(-\theta/\tau_2)}{\theta/\tau_2} - \exp(-\theta/\tau_2)\right]$$

where

$R^C(0, \theta)$ = continuously compounded zero-coupon rate at time zero with maturity θ

β_0 = limit of $R^C(0, \theta)$ as θ goes to infinity (In practice, β_0 should be regarded as a long-term interest-rate.)

β_1 = limit of $R^C(0, \theta) - \beta_0$ as θ goes to 0 (In practice, β_1 should be regarded as the short- to long-term spread.)

β_2, β_3 = curvature parameters

τ_1 and τ_2 are scale parameters that measure the rate at which the short- and medium-term components decay to zero.

8. Charles R. Nelson and Andrew F. Siegel, "Parsimonious Modeling of Yield-Curves," *Journal of Business* (October 1987), pp. 473–489.
9. Lars Svensson, "Estimating and Interpreting Forward Interest Rates: Sweden 1992–94," CEPR discussion paper 1051, October 1994.
10. Oldrich A. Vasicek, "An Equilibrium Characterisation of the Term Structure," *Journal of Financial Economics* (November 1977), pp. 177–188.
11. John C. Cox, Jonathan E. Ingersoll, and Stephen A. Ross, "A Theory of the Term Structure of Interest Rates," *Econometrica* (March 1985), pp. 385–407.
12. For details about these models, see Martellini and Priaulet, *Fixed Income Securities: Dynamic Methods for Interest Rate Risk Pricing and Hedging*.

As shown by Svensson, the extended form is a more flexible model for yield-curve estimation, in particular in the short-term end of the curve, because it allows for more complex shapes such as U-shaped and hump-shaped curves. The parameters β_0, β_1, β_2, and β_3 typically are estimated on a daily basis by using an ordinary least squares (OLS) optimization program, which consists, for a basket of bonds, of minimizing the sum of the squared spread between the market price and the theoretical price of the bond as obtained with the model.[13]

We can see that the evolution of the zero-coupon rate $R^C(0,\theta)$ is entirely driven by the evolution of the beta parameters, the scale parameters being fixed.

In an attempt to hedge a bond, for example, one should design a global portfolio with the bond and hedging instrument so that the portfolio achieves a neutral sensitivity to each of the beta parameters. Before the method can be implemented, one therefore needs to compute the sensitivities of any arbitrary portfolio of bonds to each of the beta parameters.

Consider a bond that delivers principal or coupon and principal payments denoted by F_i at dates θ_i, for $i = 1, \ldots, m$. Its price P_0 at date $t = 0$ is given by the following formula:

$$P_0 = \sum_{i=1}^{m} F_i e^{-\theta_i R^C(0,\theta_i)}$$

In the Nelson and Siegel and Svensson models, we can calculate at date $t = 0$ the \$durations $D_i = \partial P_0/\partial \beta_i$ for $i = 0, 1, 2, 3$ of the bond P to the parameters β_0, β_1, β_2, and β_3. They are given by the following formulas:[14,15]

$$\begin{cases} D_0 = -\sum_i \theta_i F_i e^{-\theta_i R^C(0,\theta_i)} \\ D_1 = -\sum_i \theta_i \left[\dfrac{1-\exp(-\theta_i/\tau_1)}{\theta_i/\tau_1}\right] F_i e^{-\theta_i R^C(0,\theta_i)} \\ D_2 = -\sum_i \theta_i \left[\dfrac{1-\exp(-\theta_i/\tau_1)}{\theta_i/\tau_1} - \exp(-\theta_i/\tau_1)\right] F_i e^{-\theta_i R^C(0,\theta_i)} \\ D_3 = -\sum_i \theta_i \left[\dfrac{1-\exp(-\theta_i/\tau_2)}{\theta_i/\tau_2} - \exp(-\theta_i/\tau_2)\right] F_i e^{-\theta_i R^C(0,\theta_i)} \end{cases} \tag{48–10}$$

13. For more details, see Martellini, Priaulet, and Priaulet, *Fixed Income Securities: Valuation, Risk Management and Portfolio Strategies*.
14. Of course, \$duration D_3 is only obtained in the Svensson model.
15. An example of calculation of the level, slope, and curvature \$durations is given in Martellini, Priaulet, and Priaulet, *Fixed Income Securities: Valuation, Risk Management and Portfolio Strategies*. See also Andrea J. Heuson, Thomas F. Gosnell, Jr., and W. Brian Barrett, "Yield-Curve Shifts and the Selection of Immunization Strategies," *Journal of Fixed Income* (September 1995), pp. 53–64; and Ram Willner, "A New Tool for Portfolio Managers: Level, Slope and Curvature Durations," *Journal of Fixed Income* (June 1996), pp. 48–59.

Hedging Method

The next step consists of creating a global portfolio that would be unaffected by (small) changes of parameters β_0, β_1, β_2, and β_3. This portfolio will be made of

- The bond portfolio to be hedged, whose price and face value are denoted by P and N_P
- Four hedging instruments, whose prices and face values are denoted by G_i and N_{Gi}, for $i = 1, 2, 3$, and 4

We therefore look for the quantities q_0, q_1, q_2, and q_3 to invest, respectively, in the four hedging instruments G_0, G_1, G_2, and G_3 so as to satisfy the following linear system:

$$\begin{cases} q_1 N_{G_1} \dfrac{\partial G_1}{\partial \beta_0} + q_2 N_{G_2} \dfrac{\partial G_2}{\partial \beta_0} + q_3 N_{G_3} \dfrac{\partial G_3}{\partial \beta_0} + q_4 N_{G_4} \dfrac{\partial G_4}{\partial \beta_0} = -N_P D_0 \\ q_1 N_{G_1} \dfrac{\partial G_1}{\partial \beta_1} + q_2 N_{G_2} \dfrac{\partial G_2}{\partial \beta_1} + q_3 N_{G_3} \dfrac{\partial G_3}{\partial \beta_1} + q_4 N_{G_4} \dfrac{\partial G_4}{\partial \beta_1} = -N_P D_1 \\ q_1 N_{G_1} \dfrac{\partial G_1}{\partial \beta_2} + q_2 N_{G_2} \dfrac{\partial G_2}{\partial \beta_2} + q_3 N_{G_3} \dfrac{\partial G_3}{\partial \beta_2} + q_4 N_{G_4} \dfrac{\partial G_4}{\partial \beta_2} = -N_P D_2 \\ q_1 N_{G_1} \dfrac{\partial G_1}{\partial \beta_3} + q_2 N_{G_2} \dfrac{\partial G_2}{\partial \beta_3} + q_3 N_{G_3} \dfrac{\partial G_3}{\partial \beta_3} + q_4 N_{G_4} \dfrac{\partial G_4}{\partial \beta_3} = -N_P D_3 \end{cases} \tag{48–11}$$

In the Nelson and Siegel model, we only have three hedging instruments because there are only three parameters.

COMPARATIVE ANALYSIS OF VARIOUS HEDGING TECHNIQUES

We now analyze the hedging performance of three methods in the context of a specific bond portfolio. The methods we consider in this horse race are the duration hedge, the duration/convexity hedge, and the Nelson-Siegel $durations hedge.

Let us assume that at the initial date $t = 0$ the continuously compounded zero-coupon yield-curve is described by the following set of parameters of the Nelson and Siegel model[16]: $\beta_0 = 8\%$, $\beta_1 = -3\%$, $\beta_2 = -1\%$, and $\tau = 3$.

This corresponds to a standard upward-sloping yield-curve. We consider a bond portfolio whose features are summarized in Exhibit 48–1. The price is

16. Note that we can obtain the annualized compounded zero-coupon yield-curve by using the following equation:

$$R(t,\theta) = \exp[R^C(t,\theta)] - 1$$

where $R^C(t,\theta)$ is the continuously compounded zero-coupon rate at date t with maturity θ, and $R(t,\theta)$ is its annualized compounded equivalent.

EXHIBIT 48–1

Characteristics of the Bond Portfolio to Be Hedged

Price	YTM	$duration	$convexity	Level	Slope	Curvature
972.376	7.169%	–5,709.59	79,662.17	–6,118.91	–1,820.02	–1,243.28

expressed in percentage of the face value, which is equal to $100 million. We compute the yield-to-maturity (YTM), the $duration, the $convexity, and the level, slope, and curvature $durations of the bond portfolio, as given by Eq. (48–10).

To hedge the bond portfolio, we use three-plain vanilla six-month LIBOR swaps whose features are summarized in Exhibit 48–2. $duration, $convexity, level, slope, and curvature are those of the fixed-coupon bond contained in the swap. The principal amount of the swaps is $1 million. They all have an initial price of zero.

We consider that the bond portfolio and the swap instruments present the same default risk, so we are not concerned with this additional source of uncertainty, and we can use the same yield-curve to price them. This curve is the one described earlier with the Nelson and Siegel parameters.

To measure the performance of the three hedging methods, we assume 10 different possible changes in the yield-curve. These 10 scenarios are obtained by assuming the following changes in the beta parameters in the Nelson and Siegel model:

- Small parallel shifts with $\beta_0 = +0.1\%$ and $\beta_0 = -0.1\%$
- Large parallel shifts with $\beta_0 = +1\%$ and $\beta_0 = -1\%$
- Decrease and increase of the short- to long-term spread with $\beta_1 = +1\%$ and $\beta_1 = -1\%$
- Curvature moves with $\beta_2 = +0.6\%$ and $\beta_2 = -0.6\%$
- Flattening and steepening moves of the yield-curve with ($\beta_0 = -0.4\%$, $\beta_1 = +1.2\%$) and ($\beta_0 = +0.4\%$, $\beta_1 = -1.2\%$)

EXHIBIT 48–2

Characteristics of the Swap Instruments

Maturity	Swap Rate	$duration	$convexity	Level	Slope	Curvature
2 years	5.7451%	–184.00	517.09	–194.55	–142.66	–41.66
7 years	6.6717%	–545.15	3,809.39	–579.80	–242.66	–166.22
15 years	7.2309%	–897.66	11,002.57	–948.31	–254.58	–206.69

EXHIBIT 48–3

New Yield-Curve after an Increase ($\beta_1 = +1\%$) and a Decrease ($\beta_1 = -1\%$) of the Slope Factor

The six last scenarios, which represent nonparallel shifts, are displayed in Exhibits 48–3, 48–4, and 48–5.

Duration hedging is performed with the 7-year maturity swap using Eq. (48–7), leading us to enter 1,047 payer swaps. Duration/convexity is performed with the 7-year and 15-year maturity swaps using Eq. (48–9), leading us to enter 337 7-year maturity payer swaps and to enter 841 15-year maturity receiver swaps. Nelson

EXHIBIT 48–4

New Yield-Curve after an Increase and a Decrease of the Curvature Factor ($\beta_2 = +0.6\%$) and ($\beta_2 = -0.6\%$)

EXHIBIT 48–5

New Yield-Curve after a Flattening Movement ($\beta_0 = -0.4\%$, $\beta_1 = +1.2\%$) and a Steepening Movement ($\beta_0 = +0.4\%$, $\beta_1 = -1.2\%$)

and Siegel $durations hedge is performed with the three swaps using Eq. (48–11), leading us to enter 407 2-year maturity payer swaps, to enter 219 7-year maturity receiver swaps, and to enter 696 15-year maturity payer swaps. Results are given in Exhibit 48–6, where we display the change in value of the global portfolio (which aggregates the change in value on the bond portfolio and the hedging

EXHIBIT 48–6

Hedging Errors in Dollars of the Three Different Methods: Duration, Duration/Convexity, and Nelson and Siegel $durations

Yield-Curve Scenario	No Hedge	Duration	Duration/ Convexity	Nelson-Siegel $durations
$\beta_0 = +0.1\%$	–6,076,494	–25,627	–97,826	8,573
$\beta_0 = -0.1\%$	6,161,872	71,692	97,435	2,013
$\beta_0 = +1\%$	–57,176,627	1,605,853	–1,050,770	475,891
$\beta_0 = -1\%$	65,743,922	3,028,609	1,026,043	599,622
$\beta_1 = +1\%$	–17,982,901	7,103,063	–4,934,261	15,557
$\beta_1 = -1\%$	18,421,236	–7,311,245	5,001,463	–4,959
$\beta_2 = +0.6\%$	–7,410,125	2,972,451	–400,339	1,131
$\beta_2 = -0.6\%$	7,509,714	–2,991,594	381,400	–9,038
$\beta_0 = +0.4\%$, $\beta_1 = -1.2\%$	–2,438,405	–8,665,316	5,661,669	90,991
$\beta_0 = -0.4\%$, $\beta_1 = +1.2\%$	2,839,537	9,024,298	–5,474,877	94,636

instruments), assuming that the yield-curve scenario occurs instantaneously. This change in value can be regarded as the hedging error for the strategy. It would be exactly zero for a perfect hedge.

The value of the bond portfolio is equal to $972,375,756.[17] With no hedge, we see clearly that the loss in portfolio value can be significant in all adverse scenarios.

As expected, duration hedging appears to be effective only for small parallel shifts of the yield-curve. The hedging error is positive for large parallel shifts because of the positive convexity of the portfolio. For nonparallel shifts, the loss incurred by the global portfolio can be very significant. For example, the portfolio value drops by $7,311,245 in the pure-slope scenario when $\beta_1 = -1\%$ and $8,665,316 in the steepening scenario. As also expected, duration/convexity hedging is better than duration hedging when large parallel shifts occur. On the other hand, it appears to be ineffective for all other scenarios, even if the hedging errors are still better (smaller) than those obtained with duration hedging. Finally, we see that the Nelson and Siegel $durations hedging scheme is a very reliable method for all kinds of yield-curve scenarios. In all cases, the hedging error appears to be negligible when compared with the initial value of the bond portfolio.

KEY POINTS

- A decline (rise) in interest rates will cause a rise (decline) in bond prices.
- Just as the risk on a stock portfolio is usually proxied by its beta, which is a measure of the stock sensitivity to market movements, bond price risk is most often measured in terms of the bond interest-rate sensitivity, or duration. This is a convenient one-dimensional measure of the bond's sensitivity to interest-rate movements.
- Duration provides a portfolio manager with a convenient hedging strategy: to offset the risks related to a small change in the level of the yield-curve, a portfolio manager should optimally invest in a hedging asset a proportion equal to the opposite of the ratio of the (dollar) duration of the bond portfolio to be hedged by the (dollar) duration of the hedging instrument.
- Duration hedging is convenient because it is very simple. However, it is based on the following very restrictive assumptions: (1) changes in the yield curve will be small, and (2) the yield curve is only affected by parallel shifts.
- An empirical analysis of major government bond markets suggests, however, that large variations can affect the yield-to-maturity curve and that three main factors (level, slope, and curvature) have been found to

17. Opposite results in terms of hedging errors would be obtained if the investor were to short the bond portfolio.

drive the dynamics of the yield-curve. This strongly suggests that duration hedging is inefficient in many circumstances.

- By relaxing the two assumptions for duration hedging, better methodologies for hedging can be developed.
- Relaxing the assumption of a small change in the yield-curve can be performed though the introduction of a convexity adjustment in the procedure. Convexity is a measure of the sensitivity of dollar duration with respect to yield changes.
- Accounting for general, nonparallel deformations of the term structure is not easy because it increases the dimensionality of the problem.
- Because it is never easy to hedge the risk associated with too many sources of uncertainty, it is always desirable to try to reduce the number of risk factors and identify a limited number of common factors. This can be done in a systematic way by using an appropriate statistical analysis of the yield-curve dynamics. Alternatively, one may choose to use a model for the discount-rate function.

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PART

EIGHT

BOND PORTFOLIO MANAGEMENT

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CHAPTER
FORTY-NINE

INTRODUCTION TO BOND PORTFOLIO MANAGEMENT

KENNETH E. VOLPERT, CFA
Head of the Taxable Bond Group
The Vanguard Group, Inc.

Traditional bond management can be likened to a sailing regatta. The index is the lead boat, since it doesn't have to contend with expenses and transaction costs, and all managers (including index fund managers) are the other boats, trying to make up the distance and pass the index boat—or at least keep pace with it. Strategies that may be used to make up the difference and pass the index lead boat comprise a wide spectrum of styles and approaches. Exhibit 49–1 displays the major elements of these approaches.

In this chapter, we'll examine this spectrum, investigating the pros and cons of matching—and mismatching—bond indexes, and comparing ways of constructing bond portfolios. We'll look closely at the factors to consider when matching a bond index's risk factors, as well as the methods that may provide an edge over an index.

OVERVIEW OF TRADITIONAL BOND MANAGEMENT

Although bond portfolio management can be complicated, choosing an investment approach starts with a fairly simple question: How much risk would you like to take?

Pure Bond Index Matching

Pure bond indexing offers the lowest risk (and lowest expected return) approach to bond management versus a specific benchmark. This approach essentially guarantees that returns will lag behind the index by the cost difference (expenses plus transaction costs). Pure bond index matching attempts to fully replicate the index by owning all of the bonds in the index in the same proportion as the index. In the bond market, however, this approach is difficult to accomplish and costly to implement. Many bonds in the index were issued years ago, and are illiquid. Also, many bonds were issued at a time when interest rates were significantly

EXHIBIT 49–1

Traditional Bond Management Risk Sprectrum

different from current rates. Today's bond holders may be unwilling to incur a gain or loss by selling their bonds to an index fund.

On December 31, 2010, the Barclays Capital Aggregate Bond Index contained more than 8,200 different issues, including more than 190 Treasury issues, 940 federal agency issues, 4,200 credit (corporate and non-U.S. government) issues, 120 asset-backed issues, 1,550 commercial mortgage-backed securities, and 1,200 broadly categorized mortgage issues (essentially hundreds of thousands of mortgage pools). In the Treasury market, matching an index, security by security, is feasible, although not desirable (for reasons we'll cover later). However, full replication cannot be reasonably implemented in the agency, mortgage, or corporate bond markets. Thousands of agency and corporate issues are locked away in long-term bond portfolios and must be purchased from the investors who own them—often at a large premium. For this reason, full replication of a broad bond index is inefficient, if not impossible. And, as you'll see, it's also unnecessary.

Enhanced Indexing: Matching Primary Risk Factors

This approach involves investing in a large sample of bonds so that the portfolio's risk factors match the index's risk factors. The result is a portfolio that will have higher average monthly tracking differences (standard deviation of tracking differences) than the full-replication approach. But, it can be implemented and maintained at a much lower cost. This lower cost results in *net* investment performance that is much closer to the index. Returning to the regatta analogy, the

portfolio boat stays on the same "tack" as the index boat, but "trims its sails" to run more efficiently. Staying on the same tack means that the sails are set to take the portfolio boat in the same direction as the index boat, and are exposed to the same winds and elements. By trimming the sails, the little details of the portfolio boat's sail position and shape result in better performance and more efficient execution than the index boat. The risk factors that need to be matched are duration, cash-flow distribution, sector, quality, and call exposure (more on this later). This approach is considered a form of enhanced indexing because the return is enhanced relative to the full replication indexing approach (more on this later as well).

Enhanced Indexing: Minor Risk Factor Mismatches

This approach allows for minor mismatches in the risk factors (except duration) to tilt the portfolio in favor of particular areas of relative value, such as certain sectors, credit ratings, term structure, call risk, or other factors. Because the mismatches (and impact on tracking) are very small, this is still considered enhanced indexing. These additional enhancements are essentially sail-trimming strategies.

Active Management: Larger Risk Factor Mismatches

This is a conservative approach to active management. The manager will make larger mismatches in the risk factors in an attempt to add greater value. This approach may also make small duration bets. In most cases, the management fee and transaction costs are significantly higher than for pure or enhanced indexing, yet the net investment return is usually lower. These additional costs are the reason a typical index portfolio often outperforms the average active manager in performance universes. Typically, the manager will moderately change tack to seek greater "winds" (for example, longer than benchmark duration to add value from expected lower interest rates) to overcome the strategy's higher cost. As a result, manager risk increases the likelihood that the portfolio will deviate from the market return and structure.

Active Management: Full-Blown Active

This is an aggressive active style in which large duration and sector bets are made, and significant variation from the index can occur. Above-average performance consistency is difficult to find among the managers that employ this approach. As a result, investors who choose this management style need to look deeper than recent performance to distinguish the good from the bad. This approach may involve a significant changing of course relative to the index boat, and may risk significant tracking and portfolio structure variations. Of course, the goal of this riskier strategy is to provide a return that is higher than that of the index.

OVERVIEW OF THE CORE/SATELLITE APPROACH

Although these traditional approaches are alive and well, many investment managers have moved a few steps beyond this conventional model and are building portfolios with a conservative, low-cost (often index-based) core, and satellites that may encompass a variety of active strategies. As shown in Exhibit 49–2, a core portfolio is typically managed against a broad, liquid benchmark within a tight risk budget, generally under 40 basis points ex-ante tracking standard deviation versus the benchmark. As we'll see, there are several ways to build the core and the satellite portions of such portfolios.

Risk-Factor Matching

In this strategy, the manager creates a broadly diversified portfolio that closely replicates primary index risk factors such as portfolio duration, key rate durations, sectors, quality, and callability. The ex-ante tracking error is expected to be below 20 basis points. Since this high-quality, liquid bond market is assumed to be efficiently priced, the expected opportunity to outperform the index is very limited. Therefore, the objective is to match and replicate the risks, and generate the returns, of the target benchmark at the lowest possible cost (management fee and transaction costs).

Minor Mismatching

Here, the manager is given a larger risk budget (20 to 40 basis points) to mismatch relative to a broad liquid benchmark's characteristics such as key rate durations, sector and quality weightings, and even overall portfolio duration, to a

EXHIBIT 49–2

Core/Satellite Risk Spectrum

limited extent. The expectation is that the manager will add value relative to that broad benchmark. As a result of this expected added value, the manager would also have a higher fee structure.

The Satellite Investments

The satellite portion focuses on the less-liquid sectors that have lower correlations with the broad liquid core. This manager is given a smaller pool of assets and a much larger risk budget relative to the narrow benchmark. This bigger risk budget provides an opportunity for the manager to take meaningful selection, sector, and quality risk relative to the benchmark, with the expectation of adding considerable value.

Examples of such narrow, less-liquid markets include high-yield and emerging market bonds. In the high-yield market, issuer and sector selection are the primary determinants of added value versus the benchmark. Within the emerging bond market, country selection is a driving force in adding value. In many cases, the mortgage-backed market (agency and particularly nonagency) is viewed as a satellite market because of the many structural complexities based on interest-rate volatility risk and credit risk in the nonagency market. Securities exposed to non-U.S. currencies may be considered satellites, as could inflation-protected securities.

A key requirement of the satellite component is that it acts as a diversifier and that it has a higher expected return due to its illiquidity and lower credit quality.

WHY CHOOSE INDEXING?

As we've demonstrated, indexing plays a major role in bond management. Some managers may use indexing for part of a portfolio; for other managers, it may serve as the approach for an entire portfolio. So why is indexing an effective method of bond investing? Put simply, bond indexing, which has proven its mettle over the past two decades, offers broad diversification and low costs. Low costs are vital to bond indexing because lower costs mean tighter tracking of an index. This, in turn, means that an index portfolio will provide competitive performance that is consistent with the market—or market segment—that it tracks. And it means that nonindex (that is, higher-cost) portfolios will have difficulty beating the index portfolio. Finally, indexing provides a major psychological benefit: It allows investors to focus on asset allocation—or, in the case of the core/satellite approach, on selecting the best investment managers.

Broad Diversification

Broad bond index portfolios provide excellent diversification. The Barclays Capital Aggregate Bond Index, which is designed to capture the entire U.S. investment-grade bond market, had over 8,200 issues and more than $15 trillion in market value

as of December 31, 2010. A large bond index portfolio designed to replicate this Index may have 1,000 to 3,000 or more issues, resulting in significant issuer diversification benefits. Most active portfolios have much heavier specific issuer concentrations, resulting in significant exposure to issuer event (credit) risk.

In addition, an index portfolio designed to match the Barclays Capital Aggregate Bond Index will have exposure to not only Treasury and agency sectors, but also to mortgages, industrials, electric and telephone utilities, finance, dollar-denominated non-U.S., and asset-backed sectors. Such a portfolio will also have broad exposure to the yield-curve with holdings from one year to more than 30 years to maturity. These sources of diversification result in a portfolio with lower risk for a given level of return than is available from less diversified portfolios.

Low Cost

As we've mentioned, the primary reason for an index fund's competitive performance is lower cost. This lower cost takes two forms: (1) lower management fees, and (2) lower transaction costs associated with lower portfolio turnover rates. This lower cost advantage is durable and predictable—year after year. Morningstar president Don Phillips summarizes the impact of higher costs this way: "If you pay the executive at Sara Lee more, it doesn't make the cheesecake less good. But with mutual funds (investment management), it comes directly out of the batter." It sure does!

Competitive Performance

Since index portfolios have lower management fees and lower transaction costs (resulting from significantly lower portfolio turnover), it's not surprising that they usually outperform the average active portfolio in most universes. After all, a broad index, by design, is a representation of the whole pie of investment alternatives. As a result, the sum of all active managers should equal the index in composition. Also, the sum of the investment performance of all active managers (grossed up for the higher management fees and transaction costs) should also equal the index in performance. In the mutual fund market, where the bond index expense ratio advantage is about 0.8% per year, the Barclays Capital Aggregate Bond Index (adjusted for an estimated 20 basis point expense ratio) outperformed more than 49% of its Lipper Group over three years, 60% over five years, and 71% over ten years ended December 31, 2010.

Consistent Relative Performance

Exhibit 49–3 shows the performance for the Barclays Aggregate Bond Index (adjusted for an estimated 20 basis point expense ratio) against its Lipper universe (Intermediate Investment-Grade) for calendar years starting in 1994.

EXHIBIT 49–3

Annual Performance Relative Consistency Analysis—versus Lipper Intermediate Investment-Grade

	Index Return*	Percent Outperformed
1994	–3.12	64%
1995	18.27	80%
1996	3.43	70%
1997	9.45	86%
1998	8.49	80%
1999	–1.02	68%
2000	11.43	80%
2001	8.24	82%
2002	10.06	90%
2003	3.90	42%
2004	4.34	71%
2005	2.43	84%
2006	4.33	72%
2007	6.97	90%
2008	5.24	92%
2009	5.93	9%
2010	6.54	24%
(Periods ended 12/31/2010)		
3 Years	6.90	49%
5 Years	5.80	60%
10 Years	5.84	71%

*Barclays Capital Aggregate Bond Index return-0.2%

The only years that this portfolio outperformed less than 50% of the universe were 2003, 2009, and 2010. The 2003 "underperformance" was due primarily to the poor performance of the mortgage-backed securities sector, which suffered at the hands of heavy refinancing activity. In 2009 and 2010, Lipper funds were overweighted to credit amid a significant credit rebound following the 2008 credit crisis and recession. In the other years, the portfolio outperformed between 64% and 92% of the competition in its maturity and quality categories. Over the full ten years, the average was a remarkable 71%. The primary reason for this consistent outperformance was the index portfolio's significantly lower expenses and transaction costs.

Market Performance Predictability

A properly managed broad bond index portfolio can be assured of performing in line with the market as a whole. Regardless of the market's direction, the investor can be assured the performance of a diversified broad bond index portfolio will follow along.

A Time-Tested Track Record

Bond index portfolios have been successfully managed (that is, close tracking to the benchmark) since the early 1980s—through rising and falling interest rate cycles, as well as periods when credit-spreads widened and narrowed. Through all these market changes, bond indexing has proven to provide a more-than-competitive return with low to moderate risk.

Perhaps the most significant benefit of indexing is that it enables investors to concentrate on more important decisions—namely, the proper allocation of assets. Often, time and effort are wasted in the hope of adding 20 to 40 basis points to the very efficiently priced bond portion of a portfolio, while existing misallocation of assets to stocks or international investments results in hundreds of basis points of underperformance for the entire portfolio. Indexing the core portion of the portfolio that represents the highly liquid markets helps facilitate more effective use of limited decision-making resources available to most investors. For those using a core/satellite approach, indexing provides an opportunity to focus on selecting the best managers for the satellites.

WHICH INDEX SHOULD BE USED?

Once you've decided on an indexing approach to bond management, you should focus on the next important question: Which index? A bond index is defined by a set of rules (that is, characteristics) that are then applied to all issues in the marketplace. The rules include maturity, size, sector, and quality characteristics. The issues that fit the rules are then combined, as if in a portfolio, with each issue's weight determined by its relative market value outstanding.

Generally, the broader the index, the better the benchmark. An index we've discussed, the Barclays Capital Aggregate Bond Index, is the broadest U.S. bond index. (It's essentially identical to the Citigroup Broad Investment-Grade Index and the Merrill Lynch Domestic Master Index.) As we've mentioned, on December 31, 2010 the Barclays Capital Aggregate Bond Index consisted of more than 8,200 issues, representing a market value of more than $15 trillion. The composition of the Index, illustrated in Exhibit 49–4, was 41% government (U.S. Treasury and agency) bonds, 23% credit-related (corporate and non-U.S. government) bonds, 3% asset-backed bonds and commercial mortgage-backed bonds, and 33% mortgage-backed securities. The option-adjusted duration—a number that reflects the possibility of bonds being called by the issuer—was in the intermediate duration range, at 5.0, with an average maturity of 7.1 years, making it the broadest domestic intermediate investment-grade index available. Sub-indices of the Barclays Capital Aggregate Bond Index can be created to capture that result in different risk/return profiles. For example, a credit index may appeal to those who seek higher yields from the spread sectors, or a 1-to-5-year government/credit index would better serve those who are seeking a short-duration portfolio.

EXHIBIT 49–4

Barclays Capital Aggregate Bond Index Composition (as of 12/31/2010)

Sector	Percent of Market Value
Government	41
ABS/CMBS	3
MBS	33
Credit Related	23

Maturity	Percent of Market Value
MBS	33
ABS/CMBS	3
1-5 Gov/Credit	34
5-10 Gov/Credit	19
10+ Gov/Credit	11

An important part of choosing an index is understanding the risks that are involved in the bond market's various segments. Chief among these risks are market value risk and income risk, although the degree to which they apply to a given part of the bond market can vary widely.

Market Value Risk

Generally, the longer a bond portfolio's maturity, the higher is its yield. (This assumes a normally sloped yield-curve.) The total return of a bond is made up of the coupon (or income) component and the principal (or price change) component. Since the yield-curve, which impacts the principal component of total return, is likely to shift, the longer-term bond portfolio will not necessarily have a higher total return. Exhibit 49–5 shows the one-year total return of different maturity securities in both high-rate and low-rate environments. Clearly, as the maturity or duration of the portfolio lengthens, market value risk rises. In addition, the lower the interest-rate environment, the greater the market value risk, especially for the intermediate-term and long-term portfolios. This is the result of two factors: the portfolio's duration increases as interest rates decrease, and the portfolio's lower yield-to-maturity provides less of a cushion to offset principal losses. Therefore, for investors who are risk-averse in terms of their principal, the short-term or intermediate-term index may be more appropriate than the long-term index.

Income Risk

Many investors invest for income. They spend only the income that their investment distributes, and they avoid dipping into their principal. Foundations and retirees invest for a stable—and hopefully growing—income stream that they can

EXHIBIT 49–5

Market Value Risk: One-Year Rates of Return in High and Low Interest Rate Environments

High-Interest-Rate Environment				*One-Year Return (Income + Price Return)*	
Coupon	**Maturity**	**Price**	**Duration**	**Rates Rise 1%**	**Rates Fall 1%**
12%	3 Year	100	2.5	9.6%	14.5%
12%	7 Year	100	4.6	7.5%	16.8%
12%	20 Year	100	7.5	4.9%	20.0%
Low-Interest-Rate Environment				*One-Year Return (Income + Price Return)*	
Coupon	**Maturity**	**Price**	**Duration**	**Rates Rise 1%**	**Rates Fall 1%**
4%	3 Year	100	2.8	2.1%	5.9%
4%	7 Year	100	6.2	–1.1%	9.4%
4%	20 Year	100	14.3	–8.2%	18.4%

depend on for current and future consumption. Exhibit 49–6 shows the income stream from a hypothetical $10,000 investment in short-term (three-year), intermediate-term (seven-year), and long-term (20-year) mutual funds during the 25 years of declining interest rates from 1980 to the mid-2000s, assuming equivalent growth rates for the portfolios. It's obvious that if stability and durability of

EXHIBIT 49–6

Income Risk

income are the primary concerns, the long-term portfolio is the least risky, and the short-term portfolio the most risky.

Liability Framework Risk

Pension funds and financial institutions invest to finance future liabilities. Long-term liabilities require investments in long-term assets to minimize risk, resulting in both a portfolio and a liability stream that are equally sensitive to interest-rate changes. A portfolio that invests in short-term bonds may look less risky on an absolute-return basis, but it is actually much riskier when the portfolio market value is compared to the present value of the pension liability. (The difference is the surplus or deficit.) This is because of the short-term portfolio's mismatch with its long-term liabilities. The surplus risk will be minimized on a fully funded plan when the duration of the portfolio is matched (or immunized) to the duration of the liability.

Exhibit 49–7 contains a summary comparison showing that the investment with the lowest market value risk has the highest income or liability risk. Likewise, the investment with the highest market value risk has the lowest income or liability risk. Clearly, the risk framework chosen depends on whether the investment objective is principal preservation or income durability.

PRIMARY BOND INDEXING RISK FACTORS

As effective as indexing is as a bond management tool, it doesn't eliminate the risks of bond investing by any means. Successful indexing requires matching the primary risk factors of the benchmark index in a credit-diversified portfolio. This doesn't mean an index manager must fully replicate an index. Rather, it means

EXHIBIT 49–7

Bond Market Risk Summary

NAV Type	Market-Value Risk	Income or Liability Risk	Average Maturity	Current Duration	Portfolios
Stable-dollar NAV	Lowest	Highest	30–90 Days	0.1	Money market portfolios
Variable NAV	Low	High	2–4 Years	2.5	Short-term portfolios
	Medium	Medium	7–10 Years	5.0	Intermediate-term portfolios
	High	Low	15–25 Years	10.0	Long-term portfolios

EXHIBIT 49–8

Primary Bond Index Matching Factors

	Government	Corporate	MBS
Modified adjusted duration	x	x	
Present value of cash-flows	x	x	
Percent in sector and quality		x	
Duration contribution of sector		x	
Sector/coupon/maturity cell weights		x	x
Issuer exposure control		x	

that the manager must understand the risk factors and how they're measured. Exhibit 49–8 lists the primary risk factors that apply to the government, corporate, and mortgage sectors; the following paragraphs explain each primary risk factor.

Portfolio Modified Adjusted Duration

The modified adjusted duration (or option-adjusted modified duration) is a simple, single measure of the portfolio's interest-rate risk (see Exhibit 49–9). It's a great place to start, but is entirely too rough of a measure to adequately track an index. Duration is the average time to receipt of the present value of the bond cash-flows. The portfolio duration will give the manager a rough approximation of the price change observed if interest rates rise or fall (in a parallel fashion) immediately by 1%. If rates rise by 1%, a five-year duration portfolio will experience a 5% decline in value [(+1% yield change) × (portfolio duration of 5 years) × (−1)]. If the yield-curve does not move in a parallel fashion, the duration is of limited value. For obvious reasons, it's important to match the duration of the portfolio to the duration of the benchmark index.

Key Rate Durations

A more accurate way to capture yield-curve risk is by matching the key rate durations (known as KRDs) of the index. Yield-curve changes are composed of parallel shifts, curve twists (for example, short rates down, intermediate rates unchanged, long rates up), and curve butterfly movements (for example, short and long rates down, intermediate rates up). By breaking down the index (and portfolio) into a stream of future payments and discounting each payment to the present value and summing these values, one calculates the index (and portfolio) market value. By matching the percent of the portfolio's present value that comes due at certain intervals in time (that is, KRDs) with that of the benchmark index, the portfolio will be largely protected from tracking errors (versus the benchmark) associated

EXHIBIT 49–9

Key Rate Duration Distribution Analysis for Barclays Capital Aggregate Bond Index (as of 12/31/2010)

KRD	Contribution	Percent of Duration
6 month	0.13	2.7%
2 year	0.68	14.0%
5 year	1.36	28.3%
10 year	1.33	27.5%
20 year	0.68	14.0%
30 year	0.65	13.4%
Total	4.82	100.0%

Generated using BlackRock Solutions' Aladdin Risk Management model.

with yield-curve changes. Since the portfolio duration is equal to the benchmark index duration, this method will guard against parallel changes in yield. Since all points in time (KRDs) are closely matched in percent, any local term structure movements (non-parallel changes) will not affect tracking because these yield change risks are essentially immunized. For callable securities, the cash-flows need to be distributed to the KRDs in accordance with the probability of call. A 10-year bond that is highly likely to be called in three years should have cash-flows that are allocated primarily to the three-year KRD.

Percent in Sector and Quality

The yield of the index is largely replicated by matching the percentage weight in the various sectors and qualities, assuming that the replicating portfolio fully accounts for all maturity categories. Matching duration contribution of sectors and qualities, without matching the portfolio percentage weight exposed to the sectors and qualities, may expose the portfolio to significant tracking risk during periods of extreme duress. This is due to the default risk that can reduce the value of all of an issuer's bonds by a given magnitude, regardless of the maturity.

Duration Contribution of Sector

An effective way of protecting a portfolio from tracking differences associated with changes in sector spreads (industry risk) is to match the amount of the index duration that comes from the various sectors (see Exhibit 49–10). (This can be done without excessively constraining the process, subject to managing the market weights, as we've described earlier.) If this can be accomplished, a given change in sector spreads will have an equal impact on the portfolio and the index.

EXHIBIT 49–10

Sector and Quality Distribution Analysis for Barclays Capital Bond Index (as of 12/31/2010)

Sector	MV	Duration	Duration Contribution	Percent of Duration
Treasury	33.7	5.4	1.81	37.6
Agency	7.5	3.1	0.23	4.8
Industrial	9.8	7.1	0.70	14.5
Utility	2.1	8.1	0.17	3.5
Finance	6.6	5.5	0.36	7.5
Sovereign	1.1	7.3	0.08	1.7
Non-U.S. Corporate	2.4	6.7	0.16	3.3
Supranational	1.2	3.3	0.04	0.8
GNMA	6.5	4.0	0.26	5.4
FNMA	15.4	3.4	0.53	11.0
FHLMC	10.5	3.4	0.36	7.5
Asset-Backed	0.3	3.6	0.01	0.2
CMBS	2.9	3.8	0.11	2.3
Total	100.0		4.82	100.0

Quality	MV	Duration	Duration Contribution	Percent of Duration
AAA	77.9	4.3	3.36	69.7
AA	4.4	6.1	0.27	5.5
A	9.7	6.5	0.63	13.2
BBB	8.0	6.9	0.56	11.6
Total	100.0		4.82	100.0

Duration Contribution of Quality

Similarly, the most effective way to protect a portfolio from tracking differences related to changes in quality spreads (leverage/economic risk) is to match the amount of the index duration that comes from the various quality categories. This is particularly important in the lower-rated categories, which are characterized by larger spread changes.

Sector/Coupon/Maturity Cell Weights

The call exposure of an index is difficult to replicate. By itself, the convexity value (convexity measures how a bond's duration changes as yield levels change) is inadequate since it measures expected changes in duration over a small change in yield levels. In addition, the change in convexity can be very different as yield levels change. Managers who attempt to match only the index convexity value often find

themselves having to buy or sell highly illiquid callable securities to stay matched and, in the process, generating excessive transaction costs. A better method of matching the call exposure is to match the sector, coupon, and maturity weights of the callable sectors. By matching these weights, the convexity of the index should be matched. In addition, as rates change, the changes in call exposure (convexity) of the portfolio will be matched to the index, requiring little or no rebalancing.

In the mortgage market, call (prepayment) risk is significant. The volatility in the option-adjusted duration of the Barclays Capital Mortgage Index, which measures the extent of the call exposure of the mortgage market, between 1991 and 2010 is shown in Exhibit 49–11. The graph also shows, over the same 20-year period, the Mortgage Bankers Refinancing Index (inverted), which measures the extent of mortgage refinancing occurring in the market. Clearly, the greater the refinancing activity, the shorter the index duration due to the greater likelihood that the higher coupons (issues priced above par) will be refinanced with lower coupon securities. For this reason, matching the coupon distribution of the mortgage index is critical. The best risk management is accomplished by matching the index weights in a multidimensional matrix of the maturity (balloon, 15-year, 30-year), sector (FNMA, FHLMC, GNMA), coupon (0.5% increments), and seasoning (new, moderate, and seasoned). This level of detail is easily accomplished in a large portfolio (more than $1 billion in assets), but more difficult in smaller portfolios.

The FNMA and FHLMC's government-sponsored enterprises (GSE) disclosures of additional pool detail, such as FICO scores and average loan balances, result in further division of mortgage pricing of specified pools from "to be announced" (TBA) mortgage pricing.

EXHIBIT 49–11

Mortgage Call Exposure Analysis

Issuer Exposure

If the major risk factors described above are matched but with a limited number of issuers, one significant risk remains, but it can still be diversified away. Event risk—a risk widely watched during periods of significant corporate leveraging events (leveraged buyouts, LBOs) or during periods of significant economic stress—needs to be measured and controlled. Issuer exposure, like exposure to sector and quality, must first be measured in percentage terms versus the issuer weight in the index, because periods of serious economic distress can cause bond prices, regardless of maturity, to drop precipitously. However, setting market value limits without regard to issuer duration risk and issuer index weights is not adequate. Spreads widen immediately after a negative credit event. Therefore, an additional measure of the issuer event risk impact on a portfolio is the impact on portfolio market value of that spread widening. This can be measured by calculating how much of the portfolio duration (duration contribution) comes from the holdings in each issuer. This calculation should also be figured for the index. The basis-point impact on tracking of a spread-widening event will be the spread change (of the issuer) multiplied by the difference in duration contribution (portfolio − index) multiplied by (−1). Exhibit 49–12 provides an example of this analysis. Issuer XXX Corp has an equal percent weight to the index, but its duration contribution is 0.16 greater. If an event occurred that would widen XXX Corp spreads by 100 basis points, the portfolio would suffer an unfavorable tracking difference of 16 basis points versus the index (100 basis point spread change x 0.16 duration contribution overweight × −1). If the same 100-basis-point widening were to occur to XYZ Corp bonds, the tracking difference would be a favorable 8 basis points even though the percent weight is matched to the index. For effective index fund management, duration contribution exposure limits (versus the index) need to be set at the issuer level.

ENHANCING BOND INDEXING

In sailing, speed comes from paying close attention to the details, not simply from watching the wind. And in bond management, the return versus the benchmark is a function of more than just interest-rate maneuvering. Portfolio managers can trim their portfolio sails to compete more efficiently in the investment management race. Some trimming strategies include lower costs, issue selection, yield-curve positioning, sector and quality positioning, and call-exposure positioning.

Why Enhancements Are Necessary

Since the index does not incur expenses or transaction costs, enhancements are needed just to provide a net return equal to the index. Operating expenses provide a significant headwind, but transaction costs associated with portfolio growth are a major contributor to return shortfalls.

Exhibit 49–13 shows the transaction costs and resulting tracking error associated with single contribution growth and compares it with multiple contribution

EXHIBIT 49–12

Issuer Exposure Comparison (Percent of Market Value versus Duration Contribution)

	Portfolio			*Index*			*Portfolio – Index*	
	Percent of Market Value	Duration	Duration Contribution	Percent of Market Value	Duration	Duration Contribution	Percent Difference	Contribution Difference
XXX Corp	4%	8	0.32	4%	4	0.16	0%	0.16
ZZZ Corp	4%	4	0.16	4%	4	0.16	0%	0.00
XYZ Corp	4%	2	0.08	4%	4	0%	0%	–0.08

EXHIBIT 49–13

Single Contribution versus Multiple Contributions

	Portfolio Market Value	Contribution	Trans. Cost ($ at 18 bp)	Now Portfolio Value	Tracking Error from Trans Cost (bp)	(bp)
Single contribution	$ —	$250,000,000	$450,000	$249,550,000	18.0	18.0
Multiple contributions	$ —	$ 50,000,000	$ 90,000	$ 49,910,000	18.0	18.0
	$ 49,910,000	$ 50,000,000	$ 90,000	$ 99,820,000	9.0	27.0
	$ 99,820,000	$ 50,000,000	$ 90,000	$149,730,000	6.0	33.1
	$149,730,000	$ 50,000,000	$ 90,000	$199,640,000	4.5	37.6
	$199,640,000	$ 50,000,000	$ 90,000	$249,550,000	3.6	41.2
		$250,000,000	$450,000			

EXHIBIT 49–14

Why Enhancements Are Necessary: Return Impact of Transaction Costs over One Year

growth. In this example, the single contribution portfolio has a tracking error of 18 basis points associated with investing net cash-flow. In the multiple-contribution portfolio, the tracking error is significantly higher, at 41 basis points, even though the amount of transaction costs ($450,000) is identical. Therefore, portfolios with high growth rates will suffer additional negative tracking errors. So, enhancements are necessary simply to stay equal to a no-growth or slow-growth portfolio. Exhibit 49–14 shows, in graphical form, the cumulative adverse tracking impact resulting from portfolio growth for Treasury, government/corporate, and corporate portfolios. The greater the growth rate—and/or the less liquid the market—the greater the adverse impact on tracking error.

Lower-Cost Enhancements

One of the simplest, yet most overlooked, forms of enhancement is keeping costs low. Expenses/management fees and transaction costs have a significant impact on portfolio performance.

Active managers work hard—and usually unsuccessfully—to add an incremental 25 to 50 basis points per year to portfolio gross returns. Yet in the mutual fund arena, the average bond fund expense ratio is 50 to 80 basis points greater than that of the lowest-cost index portfolio. As a result, net returns of the high-expense-ratio funds are significantly lower. Even in the indexing arena, expenses vary by large margins. An investor can enhance returns simply by shopping around for the index fund with the lowest expenses, provided the net return is competitive with other index funds. For a plan sponsor with external index fund

managers, having the current fund manager and one or two other reputable index fund managers rebid the business every few years will help ensure expenses are as low as possible.

Transaction costs are the other major cost factor. Since bond index funds have low annual turnover (about 40%) versus active portfolios (generally greater than 100%), transaction costs are significantly lower for index portfolios. In addition, electronic trading platforms, which enable managers to increase price competition among dealers, further reduce the transaction-cost impact. It's imperative to include a number of brokers in the bidding process. For rapidly growing portfolios, where most of the transactions are offerings, an effective competitive trading process is essential. An efficient system of comparing the relative value of real-time offerings of target issuers and issues from many different brokers will yield significant transaction cost savings and, as a result, further enhance returns.

Issue Selection Enhancements

For U.S. Treasury securities, the primary tool for selecting cheap bonds is comparing actual bond prices to the theoretical "fitted" price. The theoretical curve minimizes the pricing errors of all Treasury issues in the market, subject to various curve-smoothing rules. Each actual bond's yield is then compared to the bond's fitted yield, which is calculated using the theoretical curve. Bonds yielding more than the fitted yield are cheap; those yielding less are rich. Also useful is an analysis of the recent history of the bond yield versus the fitted yield. This analysis will indicate whether a cheap bond has been getting cheaper or richer.

Corporate issue selection enhancements come primarily from staying clear of deteriorating credits and owning improving credits. The greater the manager's confidence in the ability of the firm's credit analyst to add value via issuer selection, the larger the maximum issuer exposure limit. (See "Primary Bond Indexing Risk Factors—Issuer Exposure" in this chapter.) If the manager does not believe the firm's credit analysts can add value through issuer selection, the diversification among issuers must be greater.

Yield-Curve Enhancements

Various maturities along the term structure are consistently overvalued or undervalued. For example, the 10-year and 30-year Treasury regions tend to be consistently overvalued, due to the liquidity preference of those regions. Strategies that overweight the undervalued maturities and underweight the overvalued maturities, while keeping the same general term structure exposure, have tended to outperform the index. This is similar to looking for the maturities that have the more favorable "rolldown" characteristics—that is, the near-term passage of time may result in the bond rolling down the yield-curve. As a result, the security trades at a lower yield and has more opportunity for price appreciation. Cheap

parts of the curve tend to have favorable roll down, while rich parts of the curve (for example, the 30-year area) tend to have little or no roll-down opportunities.

Sector/Quality Enhancements

Sector and quality enhancements take two primary forms: (1) ongoing yield tilt toward short duration corporates, and (2) periodic, minor overweighting or underweighting of sectors or qualities.

The yield-tilt enhancement (also called "corporate substitution") strategy recognizes that the best yield spread per unit of duration risk is available in short-term (under 5-year) corporates. A strategy that underweights 1–5-year government bonds and overweights 1–5-year corporates has tended to increase the yield of the portfolio with a less-than-commensurate increase in risk—except during periods of severe economic stress. Exhibit 49–15 shows the rolling 12-month return difference between the Barclays Capital 1–5 Year Corporate Index and the Barclays Capital 1–5 Year Treasury Index.

The persistent return enhancement is obvious for all periods over the last 15 years except for the brief spread-widening periods of 1990, 1998, 2000, and 2002, and a very significant widening in 2008. An economic downturn that results in significant downgrades from investment-grade to high-yield or leads to significant defaults would prove disastrous to this strategy.

EXHIBIT 49–15

Barclays 1–5 Year Corporate versus Barclays 1–5 Year Treasury Index: Rolling 12-Month Total Return Difference

EXHIBIT 49–16

Break-Even Spread Widening Analysis: Corporates versus Treasuries (Assumes One-year Holding Period)

Maturity	Wide Spreads	Break-Even Add'l Widening	Moderate Spreads	Break-Even Add'l Widening	Narrow Spreads	Break-Even Add'l Widening
2 years	120	155	80	105	40	55
3 years	130	81	90	59	50	37
5 years	140	46	100	34	60	23
10 years	150	25	110	19	70	13
30 years	200	18	150	14	100	10

The strategy has proven effective primarily because the yield advantage of a broadly diversified portfolio of short-term corporates requires a significant corporate spread-widening move over a one-year period for short-term corporates to perform as poorly as short-term Treasuries. Exhibit 49–16 shows the spread increases that would be required to break-even with equal-risk Treasury securities over a one-year holding period. With the passage of time, the duration of corporate bonds shortens, and the yield spread over comparable Treasury securities generally narrows. These risk- reducing and return-enhancing forces, when combined with the yield-spread advantage, provide compelling reasons to overweight short corporates using a broadly diversified credit portfolio. Even at narrow spreads, significant protection is available in maturities under five years. Over the next year, a diversified two-year corporate portfolio with a yield spread of 40 basis points can widen by another 55 basis points versus a comparable duration Treasury portfolio security before it performs as poorly as the comparable Treasury portfolio. Clearly, as the maturities increase, the spread-widening protection decreases.

The risks involved in the strategy are recessionary spread widening risk and issuer default risk. The recessionary spread widening risk tends to be short-lived and quickly overcome by the increased yield advantage of the strategy. The issuer default risk can be minimized by broad issuer diversification (50 or more issuers), by limiting the strategy to A-rated and higher issuers, and by experienced credit analyst oversight.

The periodic overweighting or underweighting of sectors and qualities is a scaled-back version of active "sector rotation." This can be implemented on a cost-effective basis by allowing new cash-flow (net new portfolio growth) to facilitate the mismatching. For example, if spreads are narrow going into the fourth quarter and the manager expects some widening, new money may be invested in Treasury securities to a moderate degree, resulting in a modest reduction in the corporate exposure versus the index. Once the corporate spread widening materializes, Treasury securities (with low transaction costs) can be sold and

corporates overweighted. Expected first quarter asset growth will eventually bring the corporate weighting back in line with the index. A strategy of outright selling of corporates to buy Treasury securities is always difficult to justify because of the higher corporate transaction costs involved, not to mention the yield "penalty" associated with Treasury securities.

Call Exposure Enhancements

The option-adjusted duration of a callable bond is the average of the model duration, if rates rise and fall marginally. These durations under rising and falling rates can be quite different for bonds trading at a price where the bond changes from trading to maturity, to trading to call (or vice versa). The result is a situation where the bond's actual performance could be significantly different than expected given its beginning-of-period option-adjusted duration.

Generally, the greater the expected yield change, the greater is the desire for more call protection. For premium callable bonds (bonds trading to call), the empirical duration (observed price sensitivity) tends to be less than the option-adjusted duration, resulting in underperformance during periods when rates are falling. For discount callable bonds (bonds trading to maturity), the empirical duration tends to be greater than the option-adjusted duration, resulting in underperformance in rising-rate environments. Any large deviations from the index exposure to call risk should recognize the potential significant tracking implications and the market directionality of the bet.

MEASURING SUCCESS

Of course, you can't manage what you can't measure. Managers understand this, but often find themselves without the proper measurement tools. Specifically, they lack accurate ways to gauge the extent of their bets, and the value added or lost from these bets. We've already covered measuring the extent of the bets in this chapter's sections on risk factors and enhancements. In this section, we'll explore how to measure whether any value has been added—and, if so, where the added value came from.

Outperform Adjusted Index Returns

Returning to the sailing theme, it's always critical to understand how the portfolio boat is faring against the index boat. Is the portfolio gaining any ground on the index? To evaluate relative performance, the portfolio returns must be adjusted for pricing, expenses, and transaction costs for growth and rebalancing. Pricing is a key consideration, especially in enhanced indexing, where deviations versus the index are small and pricing errors can hide valuable information. If a Barclays Capital Aggregate Bond Index is used as the benchmark, the portfolio needs to be repriced with Barclays prices. Small differences in either the pricing time or the

pricing matrix may result in significant differences (among pricing services) in periodic returns over short measurement periods. Over longer periods, these pricing differences will wash away. For value-added measurement purposes, though, periodic pricing accuracy is critical.

Since the index does not have transaction costs associated with asset growth, principal reinvestment, or income reinvestment, accurate adjustments to portfolio returns are needed to account for these differences. A simple way is to maintain a trading log with implied transaction costs as a percentage of total portfolio assets. The periodic summation of these implied costs provides a good estimate of tracking error drag associated with growth and income reinvestment.

Finally, an adjustment for expenses is required. As we discussed earlier, keeping expenses low is a simple way to enhance returns. Nevertheless, portfolio returns should be "grossed up" by these expenses to keep the portfolio on an equal footing with the index for measurement purposes.

Exhibit 49–17 shows the monthly *adjusted* tracking of a large bond index mutual fund, which in this example is managed against the Barclays Capital Aggregate Bond Index. If the enhancement sources are many and of a controlled nature, it's expected that the average tracking difference will be small and usually positive. During periods of extreme market stress or spread volatility (for example, the 2008 credit crisis), the enhancement strategies are likely to result in increased tracking differences. As shown in the exhibit, the monthly tracking differences during this experience were small (between +13 basis points and –4 basis points) and mostly positive. Exhibit 49–18 shows a rolling 12-month summation of the monthly *adjusted* tracking differences. An enhanced indexing strategy that has good risk management and diversified enhancements should be able to consistently outperform the index during most periods. Falling below the index return over the 12 months would most likely be the result either of not matching the index risk properly, of enhancement strategies that were not adequately diversified, or of significant market stresses

EXHIBIT 49–17

Consistent Positive Tracking: Bond Index Portfolio versus Barclays Capital Aggregate Index Monthly Adjusted Tracking Difference

EXHIBIT 49–18

Consistent Positive Tracking: Bond Index Portfolio versus Barclays Index Trailing 12-Month Total Adjusted Tracking Difference

(three or more standard deviation events) adversely affecting the enhancement strategies.

Low and Stable Monthly Tracking Differences

The other measure of indexing success is how closely the portfolio is exposed to the same risk factors as the index. This can be measured by evaluating the rolling 12-month standard deviation of *adjusted* tracking differences of the portfolio versus the index. Exhibit 49–19 uses the same bond index mutual fund example used in Exhibit 49–18, managed against the Barclays Capital Aggregate Bond Index. If a portfolio is properly exposed to the index risk factors, the standard deviation will be low and stable over most periods, as we see. Periods of excessive market stress and spread volatility may result in higher standard deviations of tracking differences. However, the increases should be roughly proportional to the spread volatility increase or explainable by idiosyncratic credit risk (sample risk).

EXHIBIT 49–19

Tight Tracking Standard Deviations Bond Index Portfolio versus Barclays Capital Index—Trailing 12-Month Standard Deviation of Adjusted Tracking Difference

Consistent Positive Information Ratios

The information ratio is a good way to evaluate enhanced indexing success. This measures the amount of value added versus the index relative to the risk taken. It can be calculated by dividing the trailing 12-month tracking difference (adjusted for expenses, pricing, and transaction costs of growth) by the annualized trailing 12-month standard deviation of monthly adjusted tracking errors. An effective and diversified enhanced indexing strategy should keep this ratio in the range of 1 to 3 over most periods. Exhibit 49–20 shows a consistent positive information ratio from the same mutual fund example we used in the past few exhibits.

Detailed Performance Attribution

A manager needs excellent performance attribution tools to accurately measure the success of risk factor management and the enhancement strategies. The performance attribution analysis should attribute tracking error to term structure factors, sector bets, quality bets, and issue selection across sectors and qualities.

The term structure attribution should be analyzed at the portfolio level versus the index. The sector and quality attribution (allocation and issue selection) should be analyzed at the sector and subsector levels (detailed sector and maturity categories) with the ability to drill down to issue-level detail. Issue performance should be risk-adjusted (versus Treasury equivalent returns) with subsector, sector, and portfolio returns rolled up from the security level. This level of attribution will provide the manager with the tools to measure, with precision, the risk matching and return enhancing strategies. The result: winning the race against both the index and most managers.

EXHIBIT 49–20

Consistent Positive Information Ratio Bond Index Portfolio versus Barclays Capital Aggregate Index Trailing 12-Month Information Ratio

KEY POINTS

- Full replication of a broad bond index is inefficient, if not impossible.
- Active bond managers intentionally position the portfolio with mismatches in risk factors in an attempt to add value above the index return.
- The core/satellite approach often uses low cost index strategies for the core portfolio and a variety of higher cost active strategies for the satellite strategies.
- The satellite portion of a portfolio focuses on the less liquid sectors which are expected to have lower correlations with the broad liquid core and where issue selection is expected to add value.
- Reasons to index bond include broad diversification, low cost, competitive performance, consistent relative performance, market performance predictability, and a time-tested record of success.
- In selecting an index for a given risk level, generally a broader index (sectors, maturities, issuers, etc.) is better than a narrow index.
- Subindices of a broad index can be created to capture different risk/return profiles (e.g., varying durations, varying credit exposures, etc.).
- For investors who are risk-averse (regarding possible loss of principal), a short-term or intermediate-term index is more appropriate than a long-term index.
- If stability and durability of income are the primary concerns, the long-term portfolio is the least risky, and the short-term portfolio the most risky.
- The primary bond index risk factors are portfolio adjusted duration, portfolio key rate duration exposures, portfolio sector and quality exposures (in percent and contribution to duration), mortgage coupon and maturity exposures, and issuer diversification.
- Since index returns are not adjusted to expenses and transactions costs, enhancements are needed just to provide a net return equal to the index.
- Return enhancements to help offset index portfolio management and transaction costs include lowering management and operating costs, issue selection strategies, yield-curve strategies, sector/quality strategies, and optimal call exposure strategies.
- Measuring success entails evaluating value added relative to a benchmark in the context of risk assumed relative to the benchmark.

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CHAPTER
FIFTY

QUANTITATIVE MANAGEMENT OF BENCHMARKED PORTFOLIOS

LEV DYNKIN, PH.D.
Managing Director
Barclays Capital

JAY HYMAN, PH.D.
Managing Director
Barclays Capital

VADIM KONSTANTINOVSKY, CFA
Director
Barclays Capital

BRUCE D. PHELPS, PH.D., CFA
Managing Director
Barclays Capital

Most fixed income portfolios are managed relative to a benchmark. Depending on the portfolio's investment objective and style, the role of the benchmark varies. At one end of the spectrum are passive indexed portfolios that strive to match benchmark risk exposures, and returns, as closely as possible. At the other end are active portfolios with high risk tolerance that maximize outperformance by investing freely outside the benchmark that serves only as a nonbinding reference point. The majority of fixed income portfolios fall somewhere between these extremes. Typically, a sponsor, an investment committee, a chief investment officer, or some other party that sets the investment objective specifies both the benchmark and the permissible deviations from it. The portfolio manager is then judged by the achieved outperformance versus the benchmark, and the amount of risk taken to generate this outperformance.

For the portfolio manager, the benchmark represents the zero-risk position. Over time, unless the manager deviates substantially from the benchmark, the portfolio's absolute performance will be determined largely by the choice of the benchmark. Consequently, the choice of a portfolio's benchmark is very important.

There is an ever-growing number of bond market indexes published by the leading investment banks and data providers. Often, an appropriate

benchmark can be selected from this wide array of indexes. But there are many cases when none of the ready-made indexes serves the goals of the investor or plan sponsor. To ensure that the benchmark correctly reflects a given investment opportunity set and constraints, an existing index may need to be modified. Sometimes, a new, highly specialized index needs to be constructed. Finally, for some investors, the right benchmark may not even be a traditional total-return market index.

Fixed income markets are extremely diverse, so most indexes tend to include hundreds or thousands of securities. The sources of risk affecting fixed income securities are equally diverse and often difficult to analyze. These conditions turn even relatively straightforward portfolio tasks into complicated endeavors. For most portfolios, a seemingly trivial problem of "buying the benchmark" means selecting a relatively small subset of constituent securities while ensuring somehow that its behavior will be reasonably similar to the broad universe. Understanding portfolio risk versus a benchmark is equally complicated because of the many risk dimensions and intricate interactions among them.

As a result, essentially all functions of the bond portfolio management process are aided greatly by robust quantitative methods. This chapter reviews some major issues facing bond portfolio managers, as well as quantitative approaches for dealing with them: selecting and customizing a benchmark, analyzing portfolio risk and performance, replicating benchmarks, and optimizing portfolio structure to improve its risk-adjusted performance.

SELECTION AND CUSTOMIZATION OF BENCHMARKS

Financial literature lists several desirable qualities for performance benchmarks. A good benchmark is investable, transparent, known in advance, and diversified. However, it is not always possible to achieve all of these goals. While these are all important attributes, first and foremost, the benchmark should be *appropriate*. An appropriate benchmark matches the required strategic allocation of portfolio assets, so that the portfolio's performance will be broadly consistent with the investor's overall objectives. A benchmark should also be investable so that a manager can "buy the benchmark" if and when he so decides. When comparing portfolio performance to the benchmark, it is critical to know when any difference owes to the manager's decisions and not to any in-built mismatches beyond the manager's control. Any constraints that limit the portfolio opportunity set must be reflected in the benchmark as well.

An index may provide an accurate gauge of the performance of a particular segment of the fixed income markets, but that does not necessarily make it an appropriate benchmark. For example, while the Barclays Capital U.S. Aggregate Index is a widely used benchmark for the U.S. investment-grade fixed income market, the average duration of this index (4.59 as of 10/31/10) may make it unsuitable for portfolios funding long-duration liabilities.

Reflecting Investor Opportunity Set and Constraints

When an investment policy requires specific allocations to certain asset classes or imposes other restrictions such as a duration target, a customized index may be a more appropriate benchmark. In the simplest case, a customized index merely changes relative weights of standard components while still including all securities in the standard index. Often, investment policy may impose a minimum credit-rating threshold on the securities that the portfolio can buy. Limitations may be placed on maximum exposure to an industry, country, and so on. Many other bond attributes, such as minimum or maximum maturity, age, coupon, etc., may also be controlled, requiring corresponding changes to the benchmark. In all cases, though, the goal should be to keep the benchmark as broad-based and well-diversified as possible while still meeting all the investment policy requirements. However numerous the modifications to the original market-based index, one important benchmark property always should be preserved: objectivity. The benchmark should be based on a set of rules specified beforehand and kept constant. The rule-based nature of a benchmark also allows for a historical analysis of its past behavior. Such analysis can be quite useful at the stage of selecting a benchmark.

One widely used method to achieve outperformance is to invest outside the benchmark. Such investments (e.g., high-yield credit or emerging market debt) frequently are referred to as "core-plus." Even when the exposure to core-plus assets is constantly present in the portfolio, many managers still prefer to keep such assets out of the benchmark. Their motivation, of course, is to keep this potential source of outperformance at their disposal. However, a case can be made for inclusion of frequently used core-plus assets into the benchmark. First, by including these assets in the benchmark, the manager's relative performance will be more fairly measured if the manager has a persistent allocation to these assets. Second, it is often difficult to "short-sell" core-plus type assets. Yet a manager who has expertise in these markets can benefit from a short position just as much and as frequently as from a long position. The only way to effectively short such assets is to underweight them versus the benchmark. This, of course, is only possible when they are included in the benchmark. Such a benchmark decision should be made only after ensuring that with the inclusion of these asset classes, the benchmark will remain appropriate for the portfolio's investment objective and style.

Targeting Duration/Cash-Flow Profile

Sometimes a customized benchmark is necessary not because of sector, quality, or other allocation constraints but because the portfolio is expected to have a particular term-structure exposure. For example, some portfolios are managed to provide a particular cash-flow stream to fund a set of liabilities. At the simplest level, portfolio duration may be kept equal to the duration of the liability stream. Dedication is another widely used method for ensuring the necessary cash-flows

while (usually) minimizing the portfolio cost. Of course, funding the future liabilities is the main investment objective in such cases. Yet investment policies of liability funding portfolios can be quite liberal, providing an opportunity for outperformance while still ensuring sufficient cash flows.

Such portfolios would benefit from a diversified benchmark with a cash-flow profile that matches the expected liability stream and at the same time fully reflects the manager's opportunity set. Consider, for example, a liability funding portfolio that is free to invest in any security in a credit index. An appropriate benchmark for such a portfolio could match the sector and quality distribution of the index while also matching the cash-flow profile of the liabilities. Such a "liability-based" benchmark retains many of the desirable attributes of a broad market-based index: it is objectively-defined, so the portfolio manager can stay neutral to it, and its returns are calculated using market prices. Because this benchmark consists of marketable securities, its performance can be calculated and published by a third-party index provider.[1]

Even outside the asset/liability context, many fixed income portfolios are managed with a specific duration target. If this target is not close to the duration of any standard (published) index, an appropriate benchmark may be constructed as a blend of two published indexes, one of which is longer and the other shorter than the target. Although the weights needed to achieve a desired duration may have to be adjusted at regular intervals, they typically remain fairly stable for indexes that consist mainly of option-free securities.

Things get more complicated for portfolios containing a large proportion of securities with embedded optionality. Duration of such portfolios is likely to be unstable, changing in response to interest-rate movements. For example, the duration of mortgage-backed securities (MBS) can be quite volatile. If maintaining a stable duration is an important requirement, managers may engage in such techniques as delta hedging to overcome the effect of negative convexity and keep duration relatively constant. Hedging techniques entail various costs, from the more obvious transaction costs to the less obvious but potentially more significant "whipsaw" costs.[2] It is unfair to judge the performance of a manager who must engage in costly delta hedging against a benchmark that does not bear similar costs. Two possible solutions are: to apply delta hedging to the benchmark; or to construct a "constant duration" index that provides a fairer benchmark for a delta-hedged mortgage portfolio.[3] An example of such a benchmark could be a market-weighted

1. For a detailed discussion, see Chapter 10 in Lev Dynkin, Anthony Gould, Jay Hyman, Vadim Konstantinovsky, and Bruce D. Phelps, *Quantitative Management of Bond Portfolios* (Princeton, NJ: Princeton University Press, 2007).
2. Negative convexity causes duration to decline with falling rates. The term *whipsaw* refers to having to add duration after rates have just fallen and prices have gone up and to shed duration after the opposite movement.
3. Lev Dynkin, Jay Hyman, Vadim Konstantinovsky, and Ravi K. Mattu, "Constant Duration Mortgage Index," *Journal of Fixed Income,* 10:1 (2000), pp. 79–96.

MBS index dynamically hedged, according to a set of rules, with a liquid leveraged overlay of Treasuries or futures contracts.

Asset-Swapped Indexes

Some investors can take credit positions but are required to match the interest rate exposure to their funding source (e.g., three-month LIBOR). For example, some bank and insurance investment managers must manage their portfolios to a short duration target for asset/liability management purposes but are free to exercise their credit skills in asset selection. Leveraged investors often concentrate on credit exposure but minimize interest-rate exposure by managing the portfolio duration to the short-term LIBOR funding. In an environment of moderate credit-spreads and low interest rates (and worries about rising rates), traditional total return managers are also likely to keep durations very short while maintaining an overweight to spread sectors. These managers want to exercise their credit skills but avoid term-structure risk.

The most straightforward way to create and maintain such exposures is to turn to the floating-rate note market. However, given limited issuance, this may create an unintended concentration of systematic sector exposures or issuer idiosyncratic risk. Ideally, the manager would want to match systematic spread-sector risks (i.e., credit quality and sector exposures) of a broad credit market index while simultaneously removing exposure to all systematic Treasury key-rate risk factors except, perhaps, the shortest (e.g., three or six-month) key rate. The challenge of designing a benchmark for such a portfolio is to ensure a very short Treasury duration and at the same time match the overall index allocations to the credit sectors.

To exercise their spread-sector timing skills while minimizing interest-rate exposure, investors can buy fixed-rate spread assets on an "asset-swapped" basis. Asset swaps are combinations of a fixed-rate bond (and its credit exposures) and an interest-rate swap that exchanges the fixed-rate coupons for floating-rate coupons. An asset swap gives an investor an opportunity to take spread-sector exposure with little term-structure risk.

There are no formal indexes of asset swap performance. To benchmark an asset-swapped portfolio effectively, the benchmark must represent a "neutral" spread-sector allocation. Then the manager's deviations from neutral may lead to outperformance of the benchmark. Using three-month LIBOR as a benchmark is inadequate because LIBOR reflects only a single type of spread risk (i.e., swap spreads) and does not represent the wide array of spread-sector choices that may be available to the manager. An ideal design for asset-swapped portfolios is a floating-rate benchmark that reflects a diversified set of spread-sector exposures. One approach to constructing such benchmarks[4] starts with the creation, for each asset class, of a "mirror" swap index, which is a portfolio of interest rate swaps that has

4. For a detailed description of this methodology see *Quantitative Management of Bond Portfolios*, Chapter 12.

the same key-rate duration profile as that of the "mirrored" asset class. Then, short positions in these mirror-swap indexes are combined with long positions in the corresponding asset-class indexes, as well as with a long position in a short-term asset (e.g., one-month LIBOR). This creates "asset-swapped indexes" for all asset classes in the benchmark. Finally, individual asset-swapped indexes are merged into the final composite benchmark according to the portfolio's "neutral" allocations.

Book Accounting Based Indexes

Fixed income investors typically measure portfolio performance by calculating returns using market prices at the beginning and end of the performance period. Consequently, the portfolio's market value fluctuates with changing Treasury yields, spreads, and prepayments. Most standard fixed income indexes are market-return based, and many analytical tools make the same assumption about portfolios.

However, there is a large class of investors (e.g., insurance companies and banks) less concerned about short-term market fluctuations. They purchase fixed income assets to match a set of liabilities whose net present value is based not on market prices, but on book, or purchase, prices. Typically, these fixed income portfolios are relatively static. Investors expect the portfolio to earn an adequate spread over the cost of the liabilities, assuming that the assets do not default or prepay at a rate unanticipated at the time of purchase. Given that liabilities are valued using book accounting, these investors (and their regulators) need to measure asset portfolio performance similarly either by the portfolio's "book return," which is book income divided by book value, or the portfolio's "book yield," which is its internal rate of return calculated at time of purchase. However, how can such investors measure their investment skill when most indexes are market-return based?

Book accounting based investors can measure their performance relative to book accounting based indexes, or "BOOKINs," that are, in theory, replicable investment portfolios. For example, suppose that in January 2011, an investor restricted to assets in the Barclays Capital Aggregate Index must fund a newly acquired liability. The investor could passively invest in the January 2011 Aggregate BOOKIN. The composition of this BOOKIN is set to reflect the Aggregate Index as of January 2011, and its book yield and book return are calculated every month. Over the course of the month, the BOOKIN will generate cash-flow (coupon, prepayments, proceeds from maturities), which is reinvested in the February 2011 Aggregate Index. Consequently, by February 2011, the JAN11 Aggregate BOOKIN becomes a conglomeration of the initial investment in the January Aggregate Index plus a smaller investment in the February Aggregate Index. This process is repeated every month. The performance of the JAN11 Aggregate BOOKIN, expressed in book accounting terms, reflects what the investor could have achieved by passively investing in the Aggregate Index starting in January 2011, and thus can be directly compared with the book accounting performance of the investor's actual portfolio.[5]

5. For a detailed description of book accounting based benchmarks, see *Quantitative Management of Bond Portfolios*, Chapter 9.

Strategy-Based Indexes

Finally, some portfolio managers must operate under severe performance constraints such as "over the next three months generate as much return as you can, but don't lose any money!" Many official institutions manage their Treasury portfolios under such constraints. What is an appropriate benchmark for these investors? While a cash benchmark (i.e., zero duration) would not suffer any losses, it would severely limit income. In contrast, a longer duration benchmark would likely generate more income but put the portfolio at risk of losses over the holding period.

The right benchmark would have a duration that maximizes expected returns subject to the risk constraint. But, how to best generate expected returns to determine the benchmark? Using historical Treasury returns data is one approach. An advantage of historical returns is that they are non-subjective estimates of expected returns. However, historical returns are poor predictors of future returns. Another approach is to use expected returns embedded in the current term structure. These estimates are also non-subjective (i.e., "no-view") because they assume only that the yield-curve will remain unchanged. These no-view expectations reflect current market conditions whereas historical returns do not.

A benchmark can be constructed using no-view expected returns and historical volatilities to maximize expected return subject to a risk constraint of not having a return less than zero with a pre-specified probability. The solution to this optimization problem is a Treasury portfolio that would serve as the benchmark. The manager would then be responsible for outperforming it. Alternatively, the manager could simply hold the benchmark if he did not wish to take any risk. This "no-view" Treasury benchmark is an example of how benchmarks can be objectively designed to reflect investment goals and constraints.[6]

DIVERSIFICATION ISSUES IN BENCHMARKS

Issuer-specific risk is an important consideration in credit portfolios. Increasingly, though, benchmarks are also scrutinized for any embedded security-specific risks. Excessive exposure to individual issuers is a concern not just for portfolio managers. Plan sponsors now reexamine benchmark design and pay close attention to large issuer concentrations. This is a serious issue even for the users of very broad market indexes. As Exhibit 50–1 shows, as of October 2010, the top 10 issuers in the Barclays Capital U.S. Corporate Bond Index accounted for 23% of the overall market value. For some plan sponsors, this is too much security-specific risk. An asset manager benchmarked to this index may feel compelled to have exposure to some of these large-cap issuers because they have significant weights in the benchmark. Concerns about the high level of issuer concentration risk in some commonly adopted benchmarks led to a number of developments in benchmark design that attempt to mitigate this risk.

6. For a discussion of no-view optimization and benchmarks, see *Quantitative Management of Bond Portfolios*, Chapter 22.

EXHIBIT 50–1

Market Value Weight of the Top Ten Issuers in the Barclays Capital U.S. Corporate Bond Index, August 1999–October 2010

Source: Barclays Capital

Issuer-Capped Benchmarks

A cap on the market-value weight that an issuer can have in the index limits exposure to the issuer's idiosyncratic risk. When such a cap (e.g., 1%) is imposed, every issuer's capitalization is checked against this ceiling. The market value in excess of the cap is "shaved off" and then distributed to all other issuers in the index in proportion to their market-value weights. Different caps can be chosen for various credit ratings, reflecting the differences in issuer-specific risk between higher and lower credit qualities. While issuer-capped portfolios have existed for quite a while, issuer-capped benchmarks are more recent and emerged in response to the increased levels of issuer-specific risk in credit markets.

Issuer-capped indexes seem very straightforward. However, the cap level and the redistribution rule can have a significant impact on the risk and return characteristics of an index. Some redistribution rules can limit the benefits of issuer capping by inadvertently introducing unfavorable sector-quality risk exposures relative to the uncapped index.[7]

For example, an "index-wide" redistribution rule allocates the "excess" market value across all non-capped issuers in the index in proportion to their weights. However, this may produce an index with very different (and most likely unintentional) sector and quality exposures compared with the uncapped index. For

7. For a discussion of issuer-capped credit benchmarks, see *Quantitative Management of Bond Portfolios*, Chapter 13.

example, the following table covering the period August 1989 through October 2010 shows that the index-wide redistribution rule in a 1% issuer-capped Barclays Capital U.S. Corporate Bond Index produces significant overweights in Baa-rated and industrial issues and a significant underweight to financials compared with the uncapped Corporate Index:

	Aaa-Aa	A	Baa	Industrial	Utility	Financial
Average	–2.62%	–0.39%	3.00%	3.17%	1.31%	–4.48%

This inadvertent introduction of potentially unfavorable sector-quality risk exposures can be avoided by a "quality-sector-neutral" redistribution rule that preserves the sector and quality profiles of the uncapped index.

Another side effect of capping large issuers in an index is the increase in weights of smaller ones. By construction, in a capped index the market-value weights of smaller issuers exceed their actual weights in the marketplace, sometimes dramatically so. This raises a practical concern that the available market supply may not allow the manager to match (if he or she so chooses) the required allocation in the issuer-capped index.

Issuer-capping has also been applied to sovereign indexes. The distribution of sovereign issuers is highly concentrated. For example, based on market value weights, Japan represents almost 32% of the Barclays Capital Global Treasury Index (as of 12/31/2010), and the U.S. almost 26%. Together, Japan and the U.S. comprise almost 60% of the Global Treasury Index. Within geographical regions these country weights are even larger, as Japan Treasuries account for over 90% of Asian Treasury bonds while U.S. Treasuries account for 92% of Treasuries in the Americas. The skewed distribution of sovereign issuers may make issuer-capping attractive to investors. However, as with issuer-capped credit indexes, care must be exercised when redistributing any excess capped market value.

A simple sovereign capping scheme of redistributing any excess market value above a cap level across all smaller sovereign issuers in the index does little to reduce the volatility of the index. This is because the excess capped market value gets proportionally reallocated to other countries that are closely related economically to the capped countries. A more productive sovereign capping scheme is first to cap the market value weight of economic regions, and redistribute excess market value across other regions. Then, cap individual sovereigns within a region and redistribute any excess capped market value within the region. Such a two-tier capping scheme reduces the volatility of the index, compared to the uncapped sovereign index, and does not hurt the index's performance.

An alternative sovereign capping scheme is to adjust index market value weights depending on the relative economic fundamentals across countries. For example, countries whose Debt/GDP levels are below average would have their

index market value weights increased, while those countries with above average debt levels would have their weights lowered.[8] Such "fundamental-based" weighting schemes have become more popular as sovereign creditworthiness has become less certain.

Despite these subtle issues, issuer-capped indexes are now a permanent fixture of the investment management landscape. With good judgment, investors can design issuer-capped indexes that meet their risk-management preferences in dealing with issuer-specific risk.

Swap-Based Benchmarks

A somewhat radical approach to dealing with issuer-specific risk in credit benchmarks is not to have this risk at all. Apart from the naive solution of adopting an all-Treasury benchmark, one popular type of benchmark is based on interest-rate swaps. Swaps offer excellent liquidity, a virtually unlimited market supply, limited idiosyncratic or "headline" risk, and an opportunity to capture some of the long-term spread advantage of investing in non-Treasury product. Swaps have been a key feature of the debt markets since the early 1990s. In fact, in several ways the swaps market is larger and more heavily traded than the U.S. Treasury market.

Swap payments are based on LIBOR, and therefore, the par swap rate curve can be viewed as a generic yield-curve for large, highly rated banks whose interbank lending rates constitute the LIBOR index.[9] Correspondingly, the swap spread (to the Treasury curve) is considered a generic proxy for high-grade credit spreads. (While the swap spread does not reflect counterparty risk, this can be effectively eliminated through collateral management.)

This relationship between interest rate swap spreads and high-grade credit-spreads has prompted some investors to consider swaps as total return benchmarks for their credit portfolios. However, unlike returns on regular fixed income securities, returns on swaps are not directly observable in the marketplace. In addition, while cash fixed income securities have an underlying market value that serves as the base on which to calculate returns, par swaps at initiation have zero market value. While swap yields and spreads are available from many sources, swap returns are not. To create total return indexes for the swaps market, a new index methodology is needed.

The Barclays Capital interest rate swap index methodology[10] relies on the creation of hypothetical constant-maturity swap "securities" from the swap curve. At the start of every month a set of par receive-fixed swaps is identified with swap

8. For a detailed description of one such index, see "Barclays Capital Fiscal Strength Weighted Bond Indices", Barclays Capital, July 2011.
9. A list of the banks that currently participate in the "LIBOR panel" for U.S. dollar LIBOR and other currency deposit rates is available from the British Bankers Association's Web site at www.bbalibor.com.
10. Lev Dynkin, Yuri Greenfield, and Dev Joneja, "The Lehman Brothers Swap Indexes," *Journal of Fixed Income* 12:2 (2002), pp. 28–42.

rates taken from the specific maturity points on the swap curve. To create, say, the 10-year swap index the 10-year par swap is paired with a cash investment in three-month LIBOR equal to the notional amount of the swap. Over the course of the month, the mark-to-market return of the 10-year swap is combined with the mark-to-market of the LIBOR deposit, divided by the initial notional value, to produce a 10-year swap index return. There are as many swap indexes as there are maturity points on the swap curve. There are interest rate swap indexes not only for USD, but for other currencies as well (e.g., EUR, GBP, and JPY).[11]

The individual swap indexes can be combined to produce a swap index with any desired term-structure profile (e.g., to match a particular liability duration target). Recall the earlier discussion on asset-swapped benchmarks where each asset class had an associated swap index (the mirror swap index) with a matched key-rate duration profile. A credit portfolio manager who has a swap index as a benchmark is completely free to hold only those credits which he thinks will outperform and to avoid credits expected to underperform duration-matched swaps. Credits on which the manager is neutral or has no view need not be in the portfolio at all. In contrast, if the manager's benchmark is a market index, he is under pressure to have at least some exposure to the largest issuers in the benchmark. Even when the manager has a negative view on a large issuer in the corporate index, he is unlikely to hold a zero weight because that creates a large active bet against the benchmark.

Downgrade-Tolerant Benchmarks

Even in periods of severe spread volatility, many investors retain a persistent allocation to credit in the belief that given sufficiently long time, credit bonds earn a meaningful spread premium over comparable duration Treasuries. Credit-spread premium refers to any excess return net of realized default losses, not including the impact of spread changes. A buy-and-hold credit investor earns the spread premium to maturity and ignores mark-to-market volatility in the interim.

But do investors indeed capture this credit-spread premium? In theory, they do, as long as they maintain a hold-to-maturity allocation to credit. In reality, however, most investors use a market benchmark to represent their credit allocation. In the case of Barclays Capital investment-grade indexes, for example, the index rules stipulate that a bond downgraded below investment grade be dropped from the index. Accordingly, portfolios benchmarked to the index have to sell these bonds. Usually, this is precisely when the spreads of such bonds are particularly wide, often wider than justified by any subsequent default losses. This bad timing may cause index-benchmarked investors to forfeit, at least partially, the credit-spread premium.

11. In addition, Barclays Capital publishes a set of CDX and iTraxx swap indexes which measure the total return of a funded investment ("selling protection") in these popular credit default swap portfolio indexes.

EXHIBIT 50–2

Estimated Annual Credit-Spread Premium, 1990–2009, % per Year

Source: Barclays Capital

An alternative is to allow managers to hold on to downgraded bonds and choose their own timing in selling such bonds.[12] Such a "downgrade-tolerant" Corporate Index has captured a spread premium almost 80% higher than the standard index. Exhibit 50–2 plots a yearly comparison between the two, for the period from 1990 through 2009. The downgrade-tolerant index delivers a higher premium in every one of these 20 years, with virtually the same risk profile as the standard index.[13]

These results suggest that if managers are allowed to hold on to bonds that the Corporate Index discards, they should be able to harvest a considerably higher spread premium and significantly improve their performance versus the benchmark.

PORTFOLIO ANALYSIS RELATIVE TO A BENCHMARK

The selection of the investment guidelines and appropriate benchmark marks the beginning of the portfolio management process. Once a portfolio is established,

12. The performance varies greatly across fallen angels, so there are no clear decision rules as to the best time to sell them. However, there is an overall improvement in the risk-adjusted forward performance of fallen angels as the permitted holding period is increased.
13. See: Kwok Yuen Ng and Bruce D. Phelps, "Capturing the Credit-Spread Premium," *Financial Analysts Journal*, 67:3 (2011), pp. 63–75.

investors continually monitor its positioning relative to the benchmark. Apart from investing new funds, periodic transactions help to maintain desired exposures and express changes in market outlook.

Certain portfolio monitoring activities are typically performed at regular intervals (say, a calendar month) and in a set sequence. Other analyses are performed as the need arises and not necessarily in a fixed order. Yet, however different the operational details might be, there are certain common functions that portfolio managers must perform and certain types of tools necessary to carry out these duties. Typically, at the start of a performance period, managers will use forward-looking, or *ex-ante,* analytics to create and ascertain the desired portfolio positioning. At the end of the period, managers will use backward-looking, or *ex-post,* analysis to review and explain the realized performance which, in turn, guides portfolio adjustments.

Analyzing Portfolio Risk: A Cell-Based Approach

The most obvious way to analyze portfolio-versus-benchmark risk is a structural comparison of the two by partitioning them into a matrix of cells. Different choices of partition variables put the focus on different aspects of portfolio composition. Corporate portfolios, for example, are likely to be divided by quality and industry category (e.g., basic industry, consumer cyclical, and energy). Segmenting by duration highlights the yield-curve exposure. The amount and quality of information a portfolio manager can derive from such reports depend on the appropriateness of the chosen risk dimensions and on the portfolio and benchmark attributes (beyond market-value percentages) available for comparison.

The fundamental assumption behind the use of structural reports is, of course, that the contribution of a mismatch in a given cell to the overall portfolio-versus-benchmark risk is primarily a function of the magnitude of the mismatch and the weight of the cell. This assumption is not unreasonable. Certainly, a portfolio that matches its benchmark in all cells (along *all* possible dimensions) is risk-neutral to the benchmark.

While the simplicity of such analysis is attractive, there are two major problems with its basic assumption. First, the risk consequences of a particular mismatch depend not only on its apparent magnitude but also on its nature, i.e., the volatility of the underlying exposure. A mismatch in spread duration contribution of 1.0 in Aa financials has a very different risk than the same-size mismatch in Baa telecom. Granted, some experienced portfolio managers may have a feel for the portfolio performance implications from the magnitudes of individual mismatches.

However, the second problem is equally important and, arguably, more difficult to compensate for with experience. The cross-correlation among the multiple sources of risk in a portfolio makes judging overall risk a daunting one without quantitative tools. Two mismatches in two different cells, each entailing significant risk in isolation, may cancel each other if low (or even negative)

correlation between them reduces their joint contribution to risk. Conversely, a few mismatches that could easily be ignored individually may represent a serious risk if the correlations among them are high. Needless to say, when the number of mismatches reaches dozens, as it can even in relatively simple portfolios, finding the common risk denominator by "eyeballing" the structural mismatches is unrealistic.

Analyzing Portfolio Risk: Multifactor Risk Models

One reliable approach to quantifying a portfolio's active risk (i.e., risk versus benchmark) is multifactor risk analysis. Its primary goal is to help managers to structure portfolios with desired risk exposures relative to the benchmark. As such, it is generally used not as an *ex-post* control tool but rather as an *ex-ante* tool for portfolio structuring. One obvious need is to measure the expected risk of return deviation in portfolios that track a benchmark. Another is to form a reliable estimate of risk for active managers with a particular outperformance, or "alpha," target. There is a well-established consensus among investment professionals regarding realistic levels of *information ratio,* or risk-adjusted outperformance, versus the benchmark. A realized information ratio above 0.5 generally is considered to be quite high, with 1.0 often seen as a practical upper limit. As a result, quantifying active risk allows managers to test the feasibility of a specified alpha target. For example, a portfolio with an alpha target of 50 basis points per year should be allowed an active risk somewhere in the range of 50 to 100 basis points per year. If, as a result of policy constraints, the projected risk is estimated to be much lower, the manager should make a case for either relaxing portfolio constraints or revising downward the alpha target.

Active risk has *systematic* and *idiosyncratic* components. The former is a result of the differences between the portfolio and benchmark sensitivities to common market *risk factors* (e.g., movements of the key rates, credit sector spreads, or volatility). The latter, sometimes referred to as "diversifiable risk," reflects unequal exposures (usually overweights in the portfolio) to individual issuers and can be present even when all systematic exposures are eliminated. This type of risk reflects residual spread movements of individual issuers, not explained by anything that happens to their peer group. Apart from the risk of typical idiosyncratic spread movements, there is default risk which is particularly important in lower-quality credit portfolios. For example, in the Barclays Capital risk model, default risk is modeled and reported separately from market risk. Conceptually, default risk contains both systematic and idiosyncratic parts. Correlated defaults across different issuers create a systematic risk component. To the extent that defaults are uncorrelated and reflect unusual events specific only to a particular issuer, the default risk is idiosyncratic risk. Separating the systematic and idiosyncratic components of default risk is quite difficult.

To quantify the systematic component of market risk, multifactor risk models use historical volatilities and correlations of a relatively small set of risk factors. These are processed into a *covariance matrix* that is the cornerstone of the model. The idiosyncratic component of active risk is quantified by measuring the differences between the portfolio and benchmark concentrations in a specific issue or issuer. These weight differentials are then multiplied by idiosyncratic spread volatilities specific to a given issuer or its peer group.

These risk components are combined to produce the key output of such models—*tracking-error volatility* (TEV), defined as the projected standard deviation of the monthly return differential between the portfolio and the benchmark. TEV is an extremely useful measure because it provides a common unit for many different sources of risk, enhancing comparisons of diverse exposures and greatly facilitating portfolio risk management and risk budgeting. Well-developed models not only compute TEV but also provide useful information on its components, for example, detailed analysis of the TEV sources, their relative contribution to the total, and their interdependence.[14]

Of course, the reliance on historical observations exposes the multifactor analysis to criticism that risk-factor correlations are unstable and depend (as do volatilities) on the economic cycle. These concerns, however, are easily addressed.

Different historical periods can be viewed as more or less relevant to the current environment. Some asset classes evolve over time, and their risk characteristics change. For example, the dramatically increased refinancing efficiency in the U.S. residential mortgage market made MBS prepayment history up to the early 1990s largely irrelevant for estimating prepayment risk in subsequent periods. Economic and market conditions also may justify emphasizing a particular historical period while downplaying others. Risk models can accommodate these risk dynamics. One mechanism is to impose time decay on the historical data series to give greater weight to more recent data.

The idiosyncratic component of active risk presents a bigger challenge to history-based risk models. To quantify the issuer-specific risk, a model needs estimates of residual spread volatility in all market segments. These estimates can be derived only from the historical time series of individual securities' residual returns; that is, parts of each bond's return unexplained by all the systematic risk factors. This requires a large body of individual security-level historical data.

As with systematic risk, there is the issue of choosing a relevant historical period for the idiosyncratic risk estimation. Conservatism is usually a good rule of thumb. After a spike in issuer-specific volatility, such as the one that happened in the U.S. credit market in 2008, a risk model needs to "learn" quickly from recent experience. Applying time decay to the historical data accomplishes this and makes the model produce higher estimates of idiosyncratic risk going forward. Sometimes, however, a risk model should pay less

14. *Quantitative Management of Bond Portfolios*, Chapter 26.

attention to recent experience. After a long period of calm, the model should revert to the equal weighting of historical data to avoid underestimating issuer risk.

History-Based Scenario Analysis

In one form or another, scenario analysis is used widely by portfolio managers to study portfolio (and benchmark) behavior in various yield-curve, spread, volatility, prepayment, or exchange-rate environments. Managers focus on what they consider the most likely scenarios, or unlikely but potentially damaging scenarios. Scenario analysis complements multifactor risk analysis. It allows managers to stress-test benchmarked portfolios by subjecting them to extreme conditions ("three-standard-deviation events") not necessarily consistent with the history underlying the risk model. Such analysis may highlight potential sources of return deviations that do not manifest themselves under normal (by historical standards) circumstances.

When using scenario analysis, investors usually make explicit forecasts for specific, observable market dimensions: key interest rates, credit-spreads for certain market sectors, particular exchange rates, and such. It is very difficult, however, to formulate scenarios that are consistent in both direction and magnitude across many different market sectors and to estimate the probability of such scenarios. This is similar to analyzing risk simultaneously along many dimensions. Thus the solution also can be the same as in multifactor risk models. A covariance matrix estimated from historical observations can be used to build "maximum-likelihood scenarios." Such scenarios incorporate a few explicit forecasts provided by the investor and then infer historically-consistent realizations (forecasts) for all other factors in the matrix. Then the full set of stated and derived factor forecasts is translated into expected returns for individual securities.

Explicit forecasts may represent unlikely scenarios. For example, the projection of a one-month yield increase of 50 basis points (or more) represents a 2.3% probability event if the historical yield volatility is only 25 basis points per month (assuming a normal distribution). Similarly, historical correlation patterns would not support an expectation of credit-spread widening at the same time with an increase in Treasury yields because yield and spread changes typically are negatively correlated. A scenario-generation model can be made to assess the likelihood of an explicit forecast in light of the covariances that underlie the analysis and to allow a rescaling of forecasts to meet pre-specified likelihood targets. The views can be relative as well as absolute. A yield-curve slope forecast is an example of a relative forecast because it does not express an opinion on the overall direction of interest rates. Individual forecasts can be accompanied by degrees of confidence in them. For example, investors usually are more confident in their views on credit-spread movements than on currency and

interest-rate changes. A robust scenario analysis framework should be able to incorporate this information.

Attribution of Portfolio Performance Relative to a Benchmark

A comprehensive performance-attribution framework must account for all potential sources of portfolio performance and quantify the contribution from each of these sources. Performance attribution of past returns is perhaps the most important tool that asset managers can use to substantiate their claims on expertise in a given style of investment. If, for example, an investment fund claims to be adept at finding undervalued credits, performance attribution can be used to determine what share of the fund's past outperformance was due to credit picks. Unless there is hard proof that the generated returns came from the advertised source, investors may worry that superior performance might have been luck rather than skill and may, in fact, be a sign of imprudent risk taking.

Asset management companies also benefit from using performance attribution in the internal analysis to help determine their skill in managing different kinds of exposures and the areas that need improvement. Sources of achieved outperformance should be matched with sources of ex-ante risk. Quantitative analysis of return deviations from the benchmark may point out unintended portfolio exposures that need to be corrected. This is particularly important for large funds with decentralized decision making in which separate groups or individuals are responsible for yield-curve positioning, sector and quality allocations, and name selection. Performance attribution can help evaluate individual manager performance in such an organization. Flexibility is critical in this analysis. A performance-attribution framework will only be useful (and used) if it is aligned with the actual decision-making process behind the portfolio investments. This process differs across firms and may vary over time within a single firm.

For multicurrency portfolios, the analysis normally starts at the global level, where outperformance can be traced to two basic sources: exchange-rate exposures and asset allocation exposures to different markets. The ability to implement currency hedges as an overlay using FX futures or forwards empowers managers to separate the asset allocation and currency allocation decisions. The attribution framework should explain the performance due to each.

After multicurrency outperformance is assessed, portfolio positions generally should be segregated by currency, and the performance of each single-currency portfolio evaluated separately (versus appropriate single-currency benchmarks). In a developed fixed income market, such as the United States, local returns can be divided into three main components: Treasury (yield-curve), volatility, and spread.

The Barclays Capital performance-attribution system relies on the key-rate duration[15] methodology to compute outperformance owing to the Treasury curve positioning. Both the portfolio and the benchmark are replaced by hypothetical portfolios of Treasuries with exactly the same yield-curve exposures, that is, with matching key-rate duration profiles. Then the returns of these "Treasury-matched" portfolios are compared. Any difference comes exclusively from their disparate curve exposures. The bonds in the Treasury-matched portfolios usually are not real securities but rather points from the par yield-curve, and contribute no pricing noise (such as owing to the richness of on-the-run issues). The model breaks down this component of outperformance even further to individual key-rate exposures.

A shift in implied volatility affects prices of bonds with embedded optionality. Quantifying outperformance owing to differences in volatility exposure requires a good term-structure model that can estimate the implied volatility of the Treasury curve and the analytics to compute volatility sensitivity (or vega) for all securities in the portfolio and in the benchmark.

Outperformance owing to spread exposure can be broken into an asset allocation part (asset class, sector, industry, quality, etc.) and a security-selection part. The former occurs when the portfolio had larger allocations to winning asset classes (or smaller to losing) than the benchmark. Security-selection outperformance comes from picking names that outperform their peers. Both measures depend strongly on the definition of asset classes or security peer groups.

Performance attribution is one of the most complex elements in a suite of methodologies and tools that modern asset managers need. There are many technical points and subtleties, such as aggregating daily results, accounting for intraday trading, and dealing with pricing and return conventions that differ between the portfolio and the benchmark.

QUANTITATIVE APPROACHES TO BENCHMARK REPLICATION

Besides index funds whose investment mandates explicitly call for tracking benchmarks with the minimum possible deviation, "buying the benchmark" is often a reasonable tactic even for managers who normally pursue active strategies. For example, in times when managers have no definite views on particular segments of the market, matching index returns in those segments is a sensible strategy. Sometimes, when managers have accrued significant outperformance before the year is over, they decide to switch to passive benchmarking for the rest of the year to preserve their gains. Finally, investors sometimes use so-called proxy portfolios that replicate broad market indexes for modeling purposes rather

15. While a single duration number measures price sensitivity to a parallel shift of the entire yield-curve, key-rate durations measure sensitivity to changes in rates at various points (key rates) along the curve, holding the rest of the curve unchanged.

than for direct investment. The main reason usually is to apply the same in-house models (e.g., prepayment models) to both the portfolio and the benchmark, eliminating "model noise" that can be quite significant. Sometimes it is not feasible to include the actual benchmark in the analysis because of constraints on either processing time or data availability. Computer-based analysis gets simpler and faster when applied to a small set of well-priced securities as opposed to potentially thousands of bonds in an index. Hence, the term *proxy portfolios*.

As pointed out earlier, the replication of a diverse market index that has multiple sources of return is not a trivial task and requires complicated techniques and tools. There are two main techniques: replication with actual, or "cash," securities and replication with derivative instruments (e.g., futures and swaps). The replication strategies vary greatly, reflecting diverse characteristics of various fixed income markets, as well as objectives and constraints of different investors. For example, in markets with high idiosyncratic risk, it is relatively more important to match the issuer distribution of the benchmark. Where systematic risks dominate, the replication techniques should pay close attention to matching benchmark allocations along the important risk dimensions. For portfolios experiencing dynamic cash inflows and outflows, replication strategies using derivatives may be preferred because of their liquidity and low costs. Derivatives replication is also popular with investors engaged in "portable alpha" strategies that use liquid derivatives that require little or no cash investment to replicate index returns and then invest the available cash outside the index in overlay strategies to gain alpha.

Of course, the simplest way to replicate an index is to buy most of its securities. However, this method is practical only for the few largest index funds that have had years to accumulate many of the index issues. For smaller and newer portfolios, maintaining the required proportions of a large number of bonds would lead to buying and selling odd lots, with limited availability, and overwhelming transaction costs. Furthermore, this strategy is appropriate only for portfolios that intend to remain neutral versus the benchmark for a long time.

For most investors, cash replication involves buying a small set of index bonds to track the index. The problem of selecting the right subset of index securities is solved by one of two basic approaches: cell matching (stratified sampling) or tracking error minimization using a risk model. The relationship between the two parallels closely that between the cell-based and the risk-model approaches to measuring portfolio risk.

REPLICATION WITH CASH INSTRUMENTS: STRATIFIED SAMPLING

Sampling is the "common sense" approach. To replicate an index, one attempts to match its allocation to each important segment with a few securities. In the simplest case, the market-value weight of holdings in a particular segment of the portfolio is set to match the index weight. More often, holdings are selected and scaled so that, collectively, they match the segment's contribution to the index duration. To improve

tracking further, the manager may target other characteristics of each individual segment, such as convexity or credit quality. Of course, the more securities purchased in each segment, the more closely the portfolio will track the index.

This approach may work quite satisfactorily in homogeneous markets, such as U.S. governments or MBS. One very simple but effective approach to replicate governments requires just six securities. The index is partitioned into three market-specific maturity segments. The choice of these segments may reflect such market characteristics as auction cycles, maturity distribution, or refunding policies. Within each segment, the bonds are divided into two groups: one with durations above the segment's average and one below. One liquid bond is selected from each group. These two bonds are weighted in such a way that the total duration of the pair matches the duration of the segment they represent. The three pairs of bonds are then given appropriate weights to match the contributions of their segments to the index. This simple procedure ensures sufficiently close matching of the term-structure allocation that is the primary source of risk in government markets.

Stratified sampling also works well for the U.S. MBS market that has little idiosyncratic risk. For MBS replication it is usually sufficient to sample the index along just three dimensions: program (GNMA 30-year, conventional 30-year, and all 15-year), seasoning (seasoned, unseasoned), and price (premium, cusp, and discount).[16] Stratified sampling works less well for markets with much idiosyncratic risk (e.g., credit). Matching broad risk dimensions still leaves the proxy portfolio vulnerable to issuer-level risk because, by necessity, the proxy overweights each issuer relative to the benchmark. The important question of how to control the issuer-specific risk of a portfolio is discussed below.

Sometimes stratified sampling is the only available replication method—for example, in markets where multifactor risk models are not available. The actual techniques, while still based conceptually on sampling, may get quite sophisticated. First of all, special rules may be used for selecting individual bonds in each segment (e.g., starting from the largest issuer), as well as for setting the level of diversification in each segment (e.g., based on the segment's historical volatility). The sampling process may be performed within an optimization context. In this case, satisfying constraints is the main goal, with the objective function being a secondary consideration (yield, spread, or liquidity may be maximized, for example). The number of securities that end up in the replicating portfolio can be regulated by tightening or relaxing constraints.

The fundamental issues with replication techniques based on stratified sampling are the same as with the cell-based approach to analyzing risk. Matching some cells may be more critical than matching others because return volatility

16. Partitioning the MBS universe by price is essentially equivalent to partitioning by coupon. The advantage of using price is that the cutoff levels defining the boundaries do not change over time.

associated with these cells is higher. And sampling-based techniques ignore the all-important correlations among cells.

Replication with Cash Instruments: Tracking-Error Minimization

As mentioned earlier, multifactor risk models usually provide more accurate estimates of portfolio risk than sampling techniques that match the index risk parameters "naively," often ignoring historical variances and correlations of risk factors. Besides performing their primary function of measuring risk, multifactor models can be augmented with optimization capabilities. Given a set of securities representing the investable universe, a benchmark, and a set of constraints, an optimizer based on a multifactor model can pick a sample of bonds (a portfolio) with the minimum projected tracking error versus the benchmark. This may be done in one step, with the model being essentially a "black box" cranking out a solution. Or the model may allow the manager to step through the optimization one bond at a time, using his knowledge of relative value to select the best bond to buy from a list of candidates.

Tracking-error minimization has been applied successfully to construct replicating portfolios for broad benchmarks of the U.S. and global government and credit markets. This method also has proved very effective in replicating the Barclays Capital MBS Index.[17]

The realized performance of most actual replicating portfolios has been within the model-projected range. The level of tracking achieved by a replicating portfolio depends, of course, on the number of bonds it contains. As more bonds are added to the portfolio, tracking risk decreases. Exhibit 50–3 illustrates this tradeoff by showing how the projected monthly TEV of a corporate replicating portfolio versus the Barclays Capital U.S. Corporate Bond Index declines with the increase in the number of securities. At first, adding more securities to the portfolio reduces tracking error quickly, but gradually, the rate of decline slows. The explanation lies in the difference between systematic and idiosyncratic risk. As the plot shows, after the 60-bond level the systematic risk ceases to be a concern, reaching the almost negligible 2.6 bp/month for a 100-bond portfolio. Consequently, even relatively small portfolios can match the systematic risk exposures of a broad market index surprisingly well. The dominant type of risk for small portfolios is idiosyncratic. By the time the portfolio size reaches 100 bonds, the idiosyncratic risk contributes almost 100% of the total TEV and declines very slowly as more bonds are added to the proxy portfolio.

Multifactor risk models rely on historical experience over the calibration period. Such models may ignore a significant structural mismatch between the proxy and index that historically did not result in return volatility. There is always

17. Lev Dynkin, Vadim Konstantinovsky, and Bruce D. Phelps, "Tradable Proxy Portfolios for an MBS Index," *Journal of Fixed Income* 11:3 (2001), pp. 70–87.

EXHIBIT 50–3

Tracking Error Volatility versus the Barclays Capital U.S. Corporate Bond Index as a Function of the Number of Bonds in the Portfolio

Source: Barclays Capital

a chance that historical patterns will not hold over the next month, and that a mismatch will prove more consequential than the model thought. This is why stratified sampling analysis may be useful even in the presence of a powerful risk model. It may alert the portfolio manager to structural mismatches ignored by the model. In such cases, managers can use their judgment in deciding whether to rely on historical patterns.

Replication with Derivatives

Derivatives effectively reduce the number of dimensions in the portfolio management problem and simplify asset allocation shifts and deployment of cash inflows. Because of this, derivatives can be particularly useful in replicating the benchmark at the start-up phase, when diversified cash investments in tradable sizes are not easily available. Derivatives can also be used in portable alpha strategies, in which a manager's value-added from one strategy is "transported" into another strategy.

Treasury futures have been widely used as a duration-adjustment tool because of such advantages as no portfolio disruption, ease of establishing and unwinding positions, and low transaction costs. A derivatives version of the cell

matching technique using a mix of four Treasury futures contracts (2-, 5-, 10-, and bond) is effective in replicating the term structure exposure of any fixed-income index.[18] In this approach, an index is divided into four maturity (duration) cells, and the market value allocations and dollar durations of each cell are matched with a combination of cash and the appropriate futures contract. The cash can be invested in Treasury bills or other short-term instruments. For an added benefit, cash may be invested more aggressively into riskier and higher-yielding instruments such as commercial paper or floating rate notes. For investment funds with frequent and significant cash inflows and outflows, replication of benchmark returns with exchange-traded futures is often the preferred strategy. Similarly, a large asset allocation shift may be initiated with futures because of their liquidity and low trading costs. Less liquid cash assets can then be deployed gradually as opportunities arise.

While the term-structure exposure can be matched effectively with Treasury futures alone, spread risk needs to be hedged separately. The next level in derivatives replication techniques introduces Eurodollar futures and swaps to replicate indexes with credit-spread exposure. Replication strategies based on these instruments rely on the positive correlation between credit or MBS/ABS spreads on the one hand, and the Treasury-Eurodollar (TED) and swap spreads on the other. These strategies can successfully replicate credit and mortgage benchmarks.

A further enhancement introduces TBAs to replicate the mortgage component, and portfolio credit default swaps to replicate the credit component. TBAs offer two key advantages over mortgage pools in replication strategies: they are suitable for an unfunded strategy because no cash outlay is required; the back office aspects are much simpler because monthly interest payments and principal paydowns are avoided. Portfolio credit default swaps (CDX and iTraxx) are liquid instruments that investors can use to take a long or short position in credit. Credit yields can be broken down into two parts: the swap yield and a credit-spread to swaps. Accordingly, the exposure to movements in swap yields can be matched by using interest-rate swaps, and the exposure to movements in credit-spreads to swaps by using CDX. For example, such widely traded portfolio products as CDX.NA.IG represent baskets of equally-weighted CDS in 5- and 10-year maturities and can be useful in replicating credit indexes. TBAs and CDX swaps help reduce TEV for derivatives replication of the U.S. Aggregate Index.[19]

Finally, derivatives can be employed to replicate the broadest, multicurrency fixed income benchmarks. A global index presents investors with a portfolio management problem involving multiple yield curves and exchange rates, as

18. Lev Dynkin, Jay Hyman, and Peter Lindner, "Hedging and Replication of Fixed-Income Portfolios," *Journal of Fixed Income* 11:4 (2002), pp. 43–63.

19. Lev Dynkin, Anthony Gould, and Vadim Konstantinovsky, "Replicating Bond Indices with Liquid Derivatives," *Journal of Fixed Income* 15:4 (2006), pp. 7–19.

well as credit and issuer risk in several markets. As a matter of fact, this diversity of exposures makes global indexes particularly good candidates for replication with derivatives.

Typically, the single-market components of a global index are replicated separately and then combined into the resulting tracking portfolio. The greater number of risk dimensions in a global index provides better opportunities for diversification of the TEVs for each subcomponent of the index. For example, the tracking risk associated with replicating the U.S. MBS component is not likely to be highly correlated with the tracking risk in replicating the Euro-credit component. This will reduce the overall portfolio's TEV.

Investors have a wide range of choices for derivatives replication of a cash index. For example, an investor wishing to replicate the Barclays Capital U.S. Aggregate Index can choose among the following strategies: Treasury futures only; a blend of futures and interest rate swaps; futures, swaps and TBAs; futures, swaps, TBAs and CDX; swaps only; etc. In addition, it may, at times, be possible for an investor to find a counterparty with whom to enter into a total return swap on the index itself. With an index TRS, the investor agrees to receive the total return on the index from the counterparty in return for paying LIBOR plus a spread. The choice of a derivatives replication strategy will depend on the investor's sensitivity to monthly tracking errors versus cumulative tracking over time and the cost (both transactions cost and monitoring cost) of maintaining the replication strategy.

Some investors have little time or inclination to manage a large set of derivatives positions. To accommodate these investors a broker-dealer may offer a total return swap based on the total returns of a *basket* of derivatives, automatically rebalanced every month to minimize the expected tracking error to the underlying index. Because the replicating basket contains very liquid derivative instruments (e.g., futures and swaps), such total return bond replicating index swaps are inexpensive and liquid.

CONTROLLING ISSUER-SPECIFIC RISK IN THE PORTFOLIO

Credit crises like the one of 2008 usually compel portfolio managers to adopt a more disciplined approach to diversifying portfolio risk (although a few years of calm often erode this discipline). At the simplest level, managers try to avoid large exposures to single issuers and hold as many different issuers as practical. A more nuanced approach, described below, places stricter diversification requirements on lower-rated bonds, as event risk is more significant in lower credit strata, both in frequency and in loss severity.

Managers who do not pursue alpha via name selection may not buy cash securities at all, choosing alternative ways of getting credit sector exposure. Such "bondless" portfolios assume the net issuer risk of the benchmark. For sufficiently broad market indexes, such risk is usually much smaller than the issuer risk of a typical cash portfolio. Well-developed and liquid swap markets in several currencies provide

a viable means of getting credit exposure without acquiring actual securities and the associated exposure to their issuers. The credit derivatives markets, particularly credit default swaps, provide managers with even more flexibility in controlling credit exposures in their portfolios.

Sufficient Diversification in Credit Portfolios

The need to reduce issuer-specific risk by diversification is obvious to any credit manager. Very often, though, the diversification is pursued in a simplistic way; for example, by setting issuer or security allocation limits without regard for credit quality. On the other hand, diversification should not be viewed as an unqualified benefit because there is a downside to it as well, from increased transaction costs as more bonds are purchased, to the dilution of the value of credit research as bonds with less perceived upside are added solely to increase diversification. This issue has been addressed in a study of optimal diversification levels in credit portfolios.[20] A simple model of downgrade risk was proposed, based on the observed historical underperformance of downgraded bonds and transition probabilities published by rating agencies.

The study answers the following question: for a portfolio of a given number of bonds, how many bonds of each credit quality should be held to achieve the lowest tracking error due to downgrade risk? The optimal allocations are skewed in their diversification levels (i.e., in maximum allowed position sizes) across qualities. For the study period from August 1988 through September 2010, the optimal ratio of position sizes for the three major investment-grade credit categories was found to be roughly 3 : 1.5 : 1. In other words, the optimal position size in Baa-rated bonds, for example, was one third the position size of Aaa/Aa-rated bonds. Compared with earlier periods, this ratio is not very skewed because in the credit crisis of 2008, higher quality bonds, primarily A- and Aa-rated financials, experienced significant turmoil.[21] The ratio reflects only one type of idiosyncratic risk—the risk of a downgrade. Of course, issuer-specific events may be quite significant but not accompanied by a downgrade. Indeed, this type of volatility usually dominates in the higher-quality segment of the market. When one takes into account the spread volatility not caused by rating transitions, the position size ratio becomes less skewed, but still indicates smaller position limits in lower qualities.

Clearly, these ratios should never be used as a literal directive when structuring credit portfolios. They depend heavily on the methodology and the historical period covered by the study. Yet the very clear and enduring lesson is that to lower the overall issuer-specific risk, it is most important to diversify exposures to lower-rated issuers. This conclusion has implications for plan

20. For the original study, see Lev Dynkin, Jay Hyman, and Vadim Konstantinovsky, "Sufficient Diversification in Credit Portfolios," *Journal of Portfolio Management* 29 (2002), pp. 89–114.

21. Over the period of 1988–2002 for example, the ratio was a more dramatic 10 : 3 : 1.

sponsors as well: portfolio guidelines that establish maximum position limits to force diversification should not do so evenly across credit qualities.

To counterbalance the desire to reduce event risk as much as possible, managers should carefully consider the costs associated with increasing the number of issuers in a portfolio. First, transaction costs increase as the portfolio transacts more and in smaller amounts. Second, there is the overhead of monitoring a larger number of issuers. Finally, as managers push to add issuers for diversification's sake, they will be forced to add issuers less highly regarded by their credit analysts. Consequently, the optimal level of diversification is determined by the tradeoff between the reduction of issuer-specific risk and the dilution of outperformance. The development of quantitative models that pinpoint this optimal level is possible but not trivial. Such models need to consider both the marginal cost and the marginal value of credit research, as well as the portfolio's size and many other factors.

Swaps as a Total-Return Investment

Interest rate swaps traditionally are used as a risk-management tool to adjust portfolios' term structure and spread exposures. However, swaps have received attention as a total-return investment.

Changes in the credit risk premium influence both swap and credit-spreads. Expectations of significant changes in the future Treasury supply, for example, as well as "specialness" of individual Treasury securities affect the spreads over Treasuries of both swaps and other spread product. As discussed earlier, Barclays Capital publishes interest rate swap indexes that help investors analyze and use swaps as just another asset class, complete with pricing, returns, and analytics.

As mentioned earlier, among the published swap indexes are so-called mirror indexes that match the term-structure (i.e., key rates) exposure of various popular fixed income benchmarks. Despite monthly tracking volatility, over the long period from August 1992 through October 2010, the cash components of the Barclays Capital Aggregate Index performed roughly in line with their mirror swap indexes, as interest-rate exposures are the key determinant of fixed income asset performance. However, during periods of market stress, swaps tend to outperform. In 2008, for example, every single subindex of the Aggregate Index underperformed its mirror swap index by a wide margin. Although that was a time of extreme market conditions, and there were historical periods when swaps underperformed, it is clear that swaps have a performance potential that investors should consider along with other spread asset classes.

Swap spreads usually are aligned with credit-spreads, although certain factors can cause them to diverge. For example, in a steep yield-curve environment, swapping activity by corporations intensifies, leading to the tightening of swap spreads unaccompanied by the corresponding tightening of credit-spreads. Although such factors weaken the case for swaps as a credit proxy, they promote the role of swaps as a means to diversify systematic risk in total return portfolios.

EXHIBIT 50–4

Correlation Matrix: Excess Returns over Treasuries, July 1992–October 2010

	Aggregate	Credit	Agency	MBS	ABS	5-Yr Swaps
Aggregate	1	0.92	0.71	0.66	0.72	0.48
Credit		1	0.58	0.39	0.71	0.40
Agency			1	0.55	0.34	0.69
MBS				1	0.39	0.43
ABS					1	0.20
5-Yr Swaps						1

Source: Barclays Capital

Exhibit 50–4 shows that for the period from July 1992 through October 2010, five-year swaps had a noticeably lower excess return correlation with the Barclays Capital Aggregate Index than did any of the index's four main spread components. The low excess return correlation implies that adding five-year swaps to a diversified portfolio of agencies, credit, mortgage-backed, and asset-backed securities may reduce risk.

The treatment of swaps as a total-return investment should be considered from a tactical as well as a strategic asset allocation perspective. The outperformance and diversification properties that swaps have demonstrated over the recent years make them a valuable tool for total-return portfolio managers.

Credit Default Swaps as Protection against Issuer Risk

Credit default swaps (CDS) have a place in many portfolios. CDS can be used to hedge existing credit exposures in the portfolio and to create new exposures that could not be created otherwise; for example, taking short positions to express a negative view. A conventional cash corporate bond bundles together exposures to interest rates, swap spread, credit-spread (over swaps), and possibly currency risk as well. CDS allow investors to pick from this bundle of exposures only the desired one. With CDS, investors can separate their views on a particular credit (issuer) from views on the market segment to which that issuer belongs.

Besides their primary function of hedging the default risk of particular issuers, CDS are used in a number of other ways. Some investors place bets on the "CDS-cash basis," that is, the spread between a CDS and corporate debt of the same issuer, or express relative views on two issuers. Finally, CDS are often more liquid than the underlying corporate bonds, providing an easier and cheaper way to get a desired exposure.

QUANTITATIVE METHODS FOR PORTFOLIO OPTIMIZATION

Optimization has been an important part of investment practice since the introduction of mean-variance analysis more than 50 years ago. The asset management problem lends itself quite naturally to optimization techniques. Almost always, it is a multi-variable, multi-constraint task with a well-defined objective. A portfolio of financial assets has two essential characteristics: investment return and risk (i.e., uncertainty about the magnitude of return). Therefore, the countless optimization methods and tools developed over the past decades target one of these two characteristics while controlling the other.

Historically, the usual objective function of portfolio optimization has been to maximize expected return relative to risk. This requires upfront estimates for expected returns of every asset considered in the optimization. As discussed below, historical data, whether long-term or recent, are poor predictors of future performance. Analysts' forecasts are imperfect as well. This section examines two examples of optimization techniques that do not rely on explicit predictions of asset performance.

Optimal Risk Budgeting Based on Skill

The managing of large, multi-asset portfolios is usually a collective effort. Various managers, analysts, or teams form opinions relevant to particular segments of the overall portfolio. Then all these opinions are considered by some central decision-making authority. This may be a committee of the very same portfolio managers responsible for individual portfolio segments, often supervised by a chief investment officer. Multiple recommendations have to be reconciled: "go long duration," "overweight the 10-year segment of the curve," "underweight industrials," "buy current coupon mortgages," etc. How can the decision makers establish the magnitudes of exposures along all these dimensions? They need to consider the interaction among all the intended exposures and the resulting overall portfolio risk. But first and foremost, they estimate (explicitly or implicitly) the degree of confidence in each particular recommendation, which depends on the perceived skill of those who made that recommendation.

The manager's skill is a critical factor that largely determines portfolio performance. While this is obvious, oddly enough, the notion of skill is rarely used formally when allocating portfolio risk or projecting expected outperformance. Even more surprisingly, skill rarely is measured in any disciplined way.

Several studies have examined the role of skill in the historical performance of various investment strategies.[22] These skill-based historical simulations produced an interesting conclusion. The information ratios of very diverse strategies

22. *Quantitative Management of Bond Portfolios*, Chapters 24 and 25.

were very similar for a given skill level. Apparently, when performance is measured on a risk-adjusted basis, the particular nature of an investment strategy plays a minor role. Performance is essentially determined by the skill and dimensionality (the number of independent decisions) of the strategy.

The empirical results confirm the "Fundamental Law of Active Management" defined by Grinold and Kahn.[23] This law states that the information ratio of an investment strategy is determined by two factors: the "information coefficient" based on correlation between predictions and realizations (and closely related to the probability-based skill) and "breadth" or the number of independent decisions made by the strategy.

Because the information ratio is outperformance (alpha) divided by risk (tracking-error volatility), the law can be expressed slightly differently by stating that a strategy's alpha is proportional to risk, skill, and the number of independent decisions.

This idea has fundamental implications for portfolio optimization. Asset managers traditionally have used the mean-variance approach to find the optimal asset allocation that maximizes expected outperformance, or alpha, for a given level of risk (or minimizes risk for a given alpha). The Achilles' heel of this approach is the expected returns of asset classes (or strategies) used in the optimization.

The Barclays Capital proprietary risk-budgeting methodology—*ORBS* (*O*ptimal *R*isk *B*udgeting with *S*kill)—relies on skill levels, breadth, and directional views to allocate the total risk budget among macro strategies to maximize portfolio alpha. Skill at timing a given strategy is defined as a percentage of directionally correct forecasts for this strategy minus the percentage of directionally wrong forecasts. The risk allocated to an individual strategy is then translated into the size of an active position that corresponds to that risk. At the core of this risk-budgeting methodology is a covariance matrix of returns for the asset classes underlying all considered strategies. This framework is very flexible and can be applied to essentially any set of asset classes and investment strategies with any number of different constraints.

Asset Allocation for Buy-and-Hold Investors

A corporate bond provides investors with a relatively small spread over Treasuries during its lifetime in compensation for the risk of a large, albeit unlikely, loss from default. While default risk is issuer-specific and can be reduced via diversification, correlation of defaults among issuers makes it impossible to eliminate it completely. This asymmetric risk/return profile of credit investing corresponds most closely with the considerations of a long-term investor who intends to hold bonds to maturity. In contrast, most total-return investors have a much shorter time frame and perceive a very different, less asymmetric risk/return profile.

23. Richard Grinold and Ronald N. Kahn, *Active Portfolio Management* (New York: McGraw-Hill, 1999).

For a total-return investor, the dominant risks are spread volatility (essentially symmetric) and possible loss of liquidity. At least in investment-grade markets, credit-quality deterioration typically occurs gradually, so the primary risk for a total-return investor is not default but rather downgrade (and the accompanying spread widening).

This difference in perspective has major implications for buy-and-hold investors. The spreads observed in the market result from interactions among all market participants, many of whom are total-return investors. If these investors expect high short-term spread volatility or liquidity risk, they can drive spreads much wider than would be justified by long-term default risk alone. This action can work to the benefit of long-term credit investors unaffected by short-term risks.

The asymmetric nature of the risk/return profile for long-term investors should be reflected in their asset allocation process. The most common approach to asset allocation, mean-variance optimization, generally is not suitable for buy-and-hold investors. In mean-variance optimization, risk is represented by the standard deviation of asset returns, which implies a symmetric distribution. For very asymmetric return profiles, standard deviation is not a particularly helpful measure of risk. In fact, no single measure of risk is universally appropriate for dealing with extreme, or "tail," events. The treatment of this "tail risk" must be customized to the needs and risk tolerance of each investor. One approach to asset allocation focuses on the downside risk, that is, the part of the return distribution that is below a certain minimum required return. This approach, though, requires a fuller description of the return distribution; the mean and standard deviation are not sufficient.

The central problem in the buy-and-hold asset allocation process is the fundamental tradeoff between current credit-spreads and expected horizon defaults. When is credit "cheap" from a buy-and-hold perspective? The answer depends on the level of default risk in the portfolio. To what extent can the default risk be reduced by issuer diversification, that is, how many issuers should a portfolio contain to limit default loss to a certain threshold with a given level of confidence? Or what allocation among different credit qualities will maximize spread within a given limit of the tail risk? Sophisticated quantitative models and techniques have been developed to address these matters.[24] There is an extensive body of research literature dealing with modeling default risk and particularly with default correlation.

TOOLS FOR QUANTITATIVE PORTFOLIO MANAGEMENT

The challenge for building a good quantitative portfolio-level system comes from the simultaneous need for broad asset class coverage and consistency of

24. *Quantitative Management of Bond Portfolios*, Chapter 16.

analytics across all asset classes. Specialized systems usually offer advanced analytics for specific asset classes. The objective for a portfolio system is to treat a wide range of asset classes within a single consistent framework without giving up too much accuracy.

At the foundation of a powerful analytical suite are basic security-level analytics, such as cash-flow projection, spread-to-price conversion, or duration calculation. The word *basic* belies the enormous complexity of this task. The variety of financial assets available to investors is ever-expanding and necessitates powerful underlying yield-curve, mortgage-prepayment, option-pricing, and volatility models.

Built on security pricing models is a broad set of portfolio-level analytics, that is, portfolio management tools that help managers analyze portfolio risk exposures, estimate the effect of various changes to portfolio structure, construct optimal portfolios, and attribute achieved performance. An important part of this analytical suite is a multifactor risk model. When such a model is enhanced with optimization capabilities, it becomes a powerful tool for portfolio construction.

A useful complement for history-based risk modeling is flexible scenario analysis. An advanced scenario analysis engine is able to expand a few user-provided inputs into a complete set of maximum-likelihood scenarios for all relevant risk factors. A flexible performance attribution model is another essential component of the analytical suite. Various portfolio optimization tools, such as the risk-budgeting framework described earlier, complete the picture. Each of these building blocks requires sophisticated financial modeling and computer implementation effort. The added challenge is to ensure consistency among all these various tools. The conclusions a manager derives from the risk model should not contradict those from scenario analysis. The ex-post return analysis should attribute the achieved outperformance to the risk exposures highlighted in the ex-ante risk analysis.

KEY POINTS

- Portfolio management entails two essential functions: forming market views at a macro and/or security level and optimally implementing those views in the portfolio.
- Portfolio managers usually focus on the first task. Success in uncovering relative value by market timing, sector, or name selection requires experience and intuition and is usually equated with portfolio management talent.
- Constructing actual portfolios that reflect the desired views is just as vital for ultimate performance. It is this task that is greatly aided by quantitative methods and benefits from the methodologies, tools, and studies described in this chapter.

- Quantitative approaches can add value at each step of the portfolio management process: selection, customization and replication of benchmarks; construction and optimization of benchmarked portfolios; risk analysis; performance attribution; and empirical support of investment decisions.

CHAPTER
FIFTY-ONE

GLOBAL CREDIT BOND PORTFOLIO MANAGEMENT

JACK MALVEY, CFA
Chief Global Markets Strategist
BNY Mellon Asset Management

Corporate bonds are the most demanding and fascinating subset of the global debt capital markets. The label, *corporate,* understates the scope of this burgeoning asset class. As commonly traded and administered within the context of an overall debt portfolio, the "corporate asset class" actually encompasses much more than pure corporate entities. Instead of the title, *corporate asset class,* this segment of the global bond market really should be classified as the *credit asset class,* including non-agency mortgage-backed securities (MBS), commercial mortgage-backed securities (CMBS), and asset-backed securities (ABS). Sovereigns and government-controlled entities with foreign currency debt issues thought to have more credit risk than the national government also should be included. In keeping with conventional practice in the debt market, however, the application of the term *credit asset class* in this chapter will pertain only to corporate bonds, sovereigns, and government-controlled entities.

From six continents, thousands of organizations (corporations, government agencies, projects, and structured pools of debt securities) with different credit "stories" have sold debt to sustain their operations and to finance their expansion. These borrowers use dozens of different types of debt instruments (first mortgage bonds, debentures, equipment trust certificates, subordinated debentures, medium-term notes, floating-rate notes, private placements, preferred stock) in multiple currencies (dollars, yen, euros, sterling, Swiss francs, reals, renminbi) from maturities ranging from one year to even a thousand years. Sometimes, these debt structures carry embedded options, which may allow for full or partial redemption prior to maturity at the option of either the borrower or the investor. Sometimes, the coupon payment floats with short-term interest rates or resets to a higher rate after a fixed interval or a credit-rating change.

Parts of this chapter are adapted from "Relative-Value Methodologies for Global Credit Bond Portfolio Management," Chapter 5 in Frank J. Fabozzi (ed.), *Fixed Income Readings for the Chartered Financial Analyst Program* (New Hope, PA: Frank J. Fabozzi Associates, 2004).

EXHIBIT 51–1

Rolling 5-year Excess Return of U.S Investment-Grade Credit: 1988–2010

Investors buy credit assets because of the presumption of higher long-term returns despite the assumption of credit risk. Except immediately prior and during recessions, credit products usually outperform local government bond benchmarks like U.S. Treasury securities and other higher-quality "spread sectors" such as U.S. agency securities, mortgage-backed securities, and asset-backed securities. In the 38-year period since the beginning of the Barclays/Lehman indexes (1973–2010), U.S. investment-grade credit outperformed U.S. Treasuries by 29 basis points (bp) per year on average (8.31% versus 8.02%) as shown in Exhibit 51–1.[1] As usual, an average masks the true daily, weekly, monthly, and annual volatility of credit assets relative performance. Looking at the rolling five-year excess returns of U.S. investment-grade credit from 1988 through 2010 in Exhibit 51–1, there have been extended periods of generous (1991–1995) and disappointing returns (2004–2008) for credit assets.

Global credit portfolio management presents a complex challenge. Each day hundreds of credit portfolio managers face thousands of choices in the primary (new issue) and secondary markets. In addition to tracking primary and secondary flows, investors have to keep tabs on ever-varying issuer fundamentals, creditworthiness, acquisitions, earnings, ratings, and prices cast in multiple gauges (bond price, nominal spread, interest-rate swap spread, and credit default swap spread). The task of global credit portfolio management is to process all this rapidly changing information about the credit markets (issuers, issues, dealers, and competing managers) and construct the portfolio with the best return for a

1. Based on absolute returns of key Barclays/Lehman Indexes from 1973.

given risk tolerance. This discipline combines the qualitative tools of equity analysis with the quantitative precision of debt analysis.

Exhibit 51–2 illustrates the magnitude of this information-processing challenge. From a set of 5,000 different issuers, investors can assemble 4 × 10 (55) different combinations of 20-bond portfolios. The number of potential portfolio combinations of 20 bonds expands to the infinity neighborhood with the inclusion of additional variables such as rating (20 choices), issues (100,000), and currencies (at least 20). Incredibly, the number of potential combinations of this 20 bond credit portfolio exceeds the neutrons in the known universe. In turn, this begs the question of whether credit portfolio "optimization" is truly achievable given the current state of technology. Although perfect optimization may prove elusive, the optimization goal remains a worthy pursuit for asset managers.

Despite this apparent limitation on the perfection of credit portfolio optimization, broad demand exists for credit debt. Investors in credit debt consist of individuals in the pursuit of incremental yields above government bonds, central banks aiming to extract a higher yield and return on their considerable holdings of fixed income assets, commercial banks arbitraging the difference between the greater yields on floating-rate notes and their lower cost of funding, mutual funds attempting to maximize both yield and total return, insurers and state pension funds seeking to fund their projected long-term liabilities, "pure" total-return maximizers competing against each other on a monthly, quarterly, and annual basis to satisfy their clients (public or private pension fund plan sponsors) or risk their loss, and hedge funds staking out leveraged long or short positions in credits

EXHIBIT 51–2

U.S. Investment-Grade Credit vs. U.S. Treasury: 1973–2010

EXHIBIT 51–3

Global Credit Sector Asset Allocation Methodology

with short-term potential for major price and spread movements. Portfolio investment choices are driven also by the existing security population of the credit market (sector, issuer, structure, and currency) and often the need to constrain tracking error deviations from broad corporate indices, by the psychology of portfolio managers (overall risk tolerance, shortfall risk aversion, and internal politics of the investment-management institution), and the state of market liquidity.

Borrowers and investors intersect mainly through dealers in both the classic telephone form and increasingly through "e-market techniques" such as websites and e-mails. Each day a few dozen credit bond dealers convey information about secondary positions and new issue offerings from any of the thousands of corporate borrowers to the hundreds of corporate bond portfolio managers. Through their investment banking and syndicate operations, dealers also advise issuers on when and how to sell new debt. Through their debt research, sales, and trading arms, dealers relay investment recommendations to portfolio managers.

As shown in Exhibit 51–3, the task of global credit bond portfolio management is to process rapidly changing information about the credit bond market (cash and derivative prices, industry and issuers' fundamentals, ratings, issuance, demand, dealer market-making, and competing asset managers) and construct a portfolio with the best expected return for a given risk tolerance.

CREDIT RELATIVE-VALUE ANALYSIS

Credit portfolio management represents a major subset of the multi-asset global portfolio management process illustrated in Exhibit 51–4. After setting the currency

EXHIBIT 51–4

Fixed Income Portfolio Management Process

allocation (in this case, dollars were selected for illustration convenience) and distribution among key debt asset classes (Treasuries, agencies, asset-backed securities, commercial mortgage-backed securities, and mortgage-backed securities), bond managers are still left with a lengthy list of questions to construct an optimal credit portfolio. Some examples are:

- What stages are the global and local business cycles (peak, descending to recession, recession, ascending to peak)?
- How are overall capital market liquidity conditions and dealer receptiveness to trading?
- Will structural changes in broad market themes, geopolitical risk, regulation, rating agency philosophy, and portfolio management methodology affect valuations?
- Should U.S. investors add U.S. dollar–denominated bonds of non-U.S. issuers?
- Should global credit market investors in 2011 bank on ultimate fiscal recovery of key European sovereigns (Greece, Ireland, Portugal, Spain, Italy) or wait for more information?
- Should central banks and Sovereign Wealth Funds add high-quality euro-denominated corporate bonds or high-quality emerging market sovereigns to their reserve holdings?
- Should LIBOR-funded London-based portfolio managers buy fixed-rate U.S. industrial paper and swap into floating-rate notes?

- Should Japanese mutual funds own euro-denominated telecommunications debt swapped back into dollars or yen using currency swaps?
- Should U.S. insurers buy perpetual floaters (i.e., floaters without a maturity date) issued by British banks and swap back into fixed-rate coupons in dollars using a currency/interest rate swap?
- When should investors reduce their allocation to the credit sector and increase allocation to governments, pursue a "strategic upgrade trade" (sell Baa/BBBs and buy higher-rated Aa/AA credit debt), rotate from industrials into utilities and/or financial institutions, switch from consumer cyclicals to noncyclicals, overweight airlines and underweight telephones, or deploy a credit derivative (e.g., short the high-yield index or reduce a large exposure to a single issuer by selling an issuer-specific credit default swap) to hedge their portfolios?

To respond to such questions, managers need to begin with an analytical framework (relative-value analysis) and to develop a strategic outlook for the global credit markets.

Relative Value

Economists have long debated the concept and measurement of "value." But fixed income practitioners, perhaps because of the daily pragmatism enforced by the markets, have developed a consensus about the definition of value. In the bond market, *relative value* refers to the ranking of fixed income investments by geographic regions, sectors, structures (i.e., fixed versus floating rate), issuers, and issues in terms of their expected performance over some future period of time (horizon).

For a day trader, relative value may carry a maximum horizon of a few minutes. For a dealer, relative value may extend from a few days to a few months. For a total-return investor, the relative-value horizon typically runs from one to three months. For a large insurer, plan sponsor, and sovereign wealth fund, relative value usually spans a multiyear horizon. Accordingly, *relative-value analysis* refers to the methodologies used to generate such rankings of expected returns.

Classic Relative-Value Analysis

There are two basic approaches to global credit bond portfolio management—*top-down approach* and *bottom-up approach*. The top-down approach focuses on high-level allocations among broadly defined credit asset classes. The goal of top-down research is to form views on large-scale secular economic and industry developments like geopolitical risk, demographics, climate change, energy, global monetary and fiscal policies, global trade and capital flow imbalances, and plan

sponsor investment philosophy. These views then drive asset allocation decisions (overweight certain sectors, underweight others). The bottom-up approach seeks to identify individual issuers and issues that will outperform their peer groups. Managers follow this approach hoping to outperform their benchmark owing to superior security selection while maintaining mainly neutral weightings to the various sectors in the benchmark.

Classic relative-value analysis is a dialectic process combining the best of top-down and bottom-up approaches as shown in Exhibit 51–5. This process blends the macro input of chief investment officers, strategists, economists, and portfolio managers with the micro input of credit analysts, quantitative analysts, and portfolio managers. The goal of this methodology is to pick the sectors with the most potential upside, populate these favored sectors with the best representative issuers, and select the structures of the designated issuers at the yield-curve points that match the investor's overall duration target and perspective on the Treasury benchmark yield-curve.

For many credit investors, the use of classic relative-value analysis usually leads to portfolio management success. Although sector, issuer, and structural analyses remain the core of superior relative-value analysis, the increased availability of information and technology has transformed the analytical process into a complex discipline. Credit portfolio managers have far more data than ever on the total returns of sectors, issuers, and structures; quantity and composition of new-issue flows; investor product demand; aggregate credit-quality movements; multiple sources of fundamental and quantitative credit analyses on individual issuers; and yield-spread data to assist them in their relative-value analysis.

Relative-Value Methodologies

The main methodologies for credit relative-value maximization are

- Total-return analysis
- Primary market analysis
- Liquidity and trading analysis
- Secondary trading rationales and constraints analysis
- Spread analysis
- Structure analysis
- Credit-curve analysis
- Credit analysis
- Asset allocation/sector analysis

In the sections that follow, we discuss each of these methodologies.

EXHIBIT 51–5

Credit-Sector Portfolio Management Process: Classic, Dialectic Relative-Value Analysis

TOTAL-RETURN ANALYSIS

The goal of global credit portfolio management for most investors is to optimize the risk-adjusted total return of their credit portfolio. The best place to start is naturally total-return analysis. Accordingly, credit relative-value analysis begins with a detailed dissection of past returns and a projection of expected returns. For the entire asset class and major contributing subsectors (such as banks, utilities, natural gas pipelines, sovereigns, Baa/BBBs, etc.), how have returns been generated? How much is attributed to credit-spread movements, sharp changes in the fundamental fortunes of key issuers, and yield-curve dynamics? If there are macro determinants of credit returns (the total return of the credit asset class), then credit markets may display regular patterns. For instance, the macroeconomic cycle is the major driver of overall credit-spreads. With the approach of and during recessions, the escalation of default risk widens spreads (which are risk premiums over underlying, presumably default-free government securities—or swaps) and reduces credit returns relative to Treasuries. Conversely, economic prosperity reduces bankruptcies and enhances overall credit fundamentals of most issuers. Economic growth usually leads to tighter credit-spreads and boosts credit returns relative to Treasuries. For brief intervals, noncyclical technical factors can offset fundamentals. For example, the inversion of the U.S. Treasury yield-curve in 2000 actually led to wider credit-spreads and credit underperformance despite solid global economic growth and corporate profitability.

Thanks to the development of total-return indexes for credit debt (databases of prices, spreads, issuer, and structure composition), analyses of monthly, annual, and multiyear total returns have uncovered numerous high-frequency patterns (i.e., large issue versus small issue performance variation, seasonality, election-cycle effects, and government benchmark auction effects) in the global credit market. Although they do not always recur, an awareness and understanding of these regular patterns is essential to optimizing portfolio performance.

PRIMARY MARKET ANALYSIS

The analysis of primary markets centers on new-issue supply and demand. Supply is often a misunderstood factor in tactical relative-value analysis. Prospective new supply induces many traders, analysts, and investors to advocate a defensive stance toward the overall credit market as well as toward individual sectors and issuers. Yet the premise, "supply will hurt spreads," which may apply to an individual issuer, does not generally hold up for the entire credit market. Credit-spreads are governed by many factors; supply, although important, represents one of many determinants of spreads. During most years, increases in issuance (most notably during the first quarter of each year) are associated with market-spread contraction and strong relative returns for credit debt. In contrast, sharp supply declines are accompanied frequently by spread expansion and a major fall in both relative and absolute returns for credit securities. For example,

this counterintuitive effect was most noticeable during August–October 1998 (Russian devaluation/default and Long-Term Capital Management implosion) and August–December 2008 (fall of Lehman Brothers and onset of global financial panic) when new issuance nearly disappeared in the face of a substantial increase in credit-spreads.

In the investment-grade credit market, heavy supply is often associated with spread compression and boosts relative returns for credit assets as new primary valuations validate and enhance secondary valuations. When primary origination declines sharply, secondary traders lose reinforcement from the primary market and tend to reduce their bid spreads. Contrary to the normal supply–price relationship, relative credit returns often perform best during periods of heavy supply. For example, 2009–2010 will be recalled for both the then all-time record for new credit origination and the best relative performance for global credit securities in decades.

The Effect of Market-Structure Dynamics

Given their immediate focus on the deals of the day and week, portfolio managers often overlook short- and long-term market-structure dynamics in making portfolio decisions. Because the pace of change in market structure is often gradual, market dynamics have less effect on short-term tactical investment decision making than on long-term strategy.

The composition of the global credit bond market shifted markedly over the last third of the twentieth century and continues in the twenty-first century. For example, medium-term notes (MTNs) dominated issuance in the front end of the credit yield-curve (1–7 year maturities) since the 1980s. Structured notes and swap products heralded the introduction of derivative instruments into the mainstream of the credit market in the 1990s. The high-yield corporate sector became a widely accepted asset class in the 1980s, with emerging market debt following in the 1990s. Global origination became more popular since the early 1990s for U.S. government agencies, supranationals (e.g., World Bank), sovereigns, and large corporate borrowers.

Although the ascent of derivatives and high-yield instruments stood out during the 1990s, the quickening march toward full credit market globalization was the most important structural trend. The rapid development of the Eurobond market since 1975, the introduction of many non-U.S. issuers into the dollar markets during the 1990s, and the birth of the euro on January 1, 1999 have led to the proliferation of truly transnational credit portfolios. The accelerating expansion of local-currency denominated debt origination, especially from Brazil, Russia, India, and China (the so-called BRICs), likely will be recalled as the most prominent evolutionary feature of early twenty-first century global credit markets.

These long-term structural changes in the composition of the global credit asset class arise owing to the desire of issuers to minimize funding costs under different yield-curves and yield spreads, as well as the needs of both active and

asset/liability bond managers to satisfy their risk and return objectives. Portfolio managers will adapt their portfolios either in anticipation of or in reaction to these structural changes across the global credit markets.

The Effect of Product Structure

Partially offsetting this proliferation of issuers since the mid 1990s, the global credit market has become structurally more homogeneous. Specifically, bullet and intermediate-maturity structures have come to dominate the credit market. A *bullet maturity* means that the issue is not callable, putable, or sinkable prior to its scheduled final maturity. The trend toward bullet securities does not pertain to the high-yield market, in which callables remain the structure of choice. With the hope of credit-quality improvement, many high-yield issuers expect to refinance prior to maturity at lower rates.

There are three strategic portfolio implications for this structural evolution. First, the dominance of bullet structures translates into scarcity value for structures with embedded call and put features. That is, credit securities with embedded options have become rare and therefore demand a premium price. Typically, this premium (price) is not captured by option-valuation models. Yet, this "scarcity value" should be considered by managers in relative-value analysis of credit bonds.

Second, bonds with maturities beyond 20 years are a small share of outstanding credit debt. This shift reduced the effective duration of the credit asset class and cut aggregate sensitivity to interest-rate risk. For asset/liability managers with long-time horizons, this shift of the maturity distribution suggests a rise in the value of long-credit debt and helps to explain the warm reception afforded, initially at least, to the handful of new offerings of issues with 100-year maturities in the early and mid 1990s as well as 2010.

Third, the use of credit derivatives has skyrocketed since the early 1990s. The rapid maturation of the credit derivative market has led investors and issuers to develop new strategies to match desired exposures to credit sectors, issuers, and structures. In particular, many high-frequency traders (dealer desks, hedge funds, and active total return managers) prefer to execute their long and short credit positions in highly liquid portions of the CDS market rather than in conventional cash credit securities.

LIQUIDITY AND TRADING ANALYSIS

Short- and long-term liquidity needs influence portfolio management decisions. Citing lower expected liquidity, some investors are reluctant to purchase certain types of issues such as small-sized issues (less than $1 billion), private placements, MTNs, and nonlocal corporate issuers. Other investors gladly exchange a potential liquidity disadvantage for incremental yield. For investment-grade investors with even a medium-term horizon of more than six months, these liquidity concerns often are exaggerated.

The liquidity of credit debt changes over time. Specifically, liquidity varies with the economic cycle, credit cycle, shape of the yield-curve, supply, and the season. As in all markets, unknown shocks, such as a surprise wave of defaults or an eruption of geopolitical risk as in the immediate wake of 9/11, can reduce credit debt liquidity as investors become unwilling to purchase new issues at any spread and dealers become reluctant to position secondary issues except at very wide spreads. In reality, these transitory bouts of illiquidity mask an underlying trend toward heightened liquidity across the global credit asset class. With a gentle push from regulators, the global credit asset class is well along in converting from its historic "over-the-counter" domain to a fully transparent, equity/U.S. Treasury–style marketplace. In the late 1990s, new technology led to creating ECNs (electronic communication networks), essentially electronic trading exchanges. And in July 2002, the U.S.-based regulatory agency, FINRA, introduced the Trade Reporting and Compliance Engine (TRACE) to track publicly all institutional-sized trades of credit securities. In turn, credit bid/ask spreads generally have shifted lower for very large, well-known credit issues. This powerful combination of technological innovation and competition promises the rapid development of an even more liquid and efficient global credit market during the twenty-first century.

SECONDARY TRADE RATIONALES

Capital market expectations constantly change. Recessions may arrive sooner rather than later. The yield-curve may steepen rather than flatten in anticipation of monetary policy adjustments. The auto and paper cycles may be moving down from their peaks. Higher oil and natural gas prices may enhance the credit quality of the energy sector. An industrial may have announced a large debt-financed acquisition, earning an immediate ratings rebuke from the rating agencies. A major firm may plan to repurchase 15% of its outstanding common stock (great for shareholders but leading to higher financial leverage for debt holders). In response to such daily information flows, portfolio managers amend their holdings. To understand trading flows and the real dynamics of the credit market, investors should consider the most common rationales of whether to trade and not to trade.

Popular Reasons for Trading

There are dozens of rationales to execute secondary trades when pursuing portfolio optimization. Several of the most popular are discussed below.

Yield-Spread Pickup Trades

Yield-spread pickup trades represent the most common secondary transactions across all sectors of the global credit market. Historically, at least half of all secondary swaps reflect investor intentions to add additional yield within the overall

duration and credit-quality constraints of a portfolio. If five-year Aa2/AA+ GE Capital paper trades at 114 basis points, 79 basis points less than three-year A2/A Bank of America, some investors will determine the rating and maturity differential irrelevant and purchase the Bank of America bond and sell the GE Capital (an issue swap) for a spread gain of 79 basis points per annum.

This "yield-first psychology" reflects the institutional yield need of long-term asset/liability managers (plan sponsors and insurers). Despite the passage of more than three decades, this investor bias toward yield maximization also may be a methodological relic left over from the era prior to the introduction and market acceptance of total-return indexes in the early 1970s.

Credit-Upside Trades

Credit-upside trades take place when the debt asset manager expects an upgrade in an issuer's credit quality that is not already reflected in the current market yield spread. In the illustration of the GE Capital and Bank of America trade described above, some investors may swap based on their view of potential credit-quality improvement for Bank of America. Obviously, such trades rely on the credit analysis skills of the investment management team. Moreover, the manager must be able to identify a potential upgrade before the market; otherwise, the spread for the upgrade candidate will already exhibit the benefits of a credit upgrade.

Credit-upside trades are particularly popular in the crossover sector—securities with ratings between Ba2/BB and Baa3/BBB– by two major rating agencies. In this case, the portfolio manager is expressing an expectation that an issue of the highest speculative grade rating (Ba1/BB+) has sufficiently positive credit fundamentals to be upgraded to investment-grade (i.e., Baa3/BBB–). If this upgrade occurs, then not only would the issue's spread narrow based on the credit improvement (with an accompanying increase in total return, all else equal), but the issue also would benefit from improved liquidity because managers prohibited from buying high-yield bonds could then purchase that issue. Further, the manager would expect an improvement in the portfolio's overall risk profile.

Credit-Defense Trades

Credit-defense trades become more popular as geopolitical and economic uncertainty increase. Secular sector changes also often generate uncertainties and induce defensive positioning by investors. In anticipating greater competition in the mid 1990s, some investors reduced their portfolio exposures to sectors such as electric utilities and telecommunications. As some Asian currencies and equities swooned in mid 1997, many portfolio managers cut their allocation to the Asian debt market. Unfortunately, because of yield-maximization needs and a general reluctance to realize losses by some institutions (i.e., insurers), many investors reacted more slowly to credit-defensive positioning.

However, after a record number of "fallen angels" in 2002, which included such major credit bellwether issuers as WorldCom, and the misfortunes of many financial institutions in 2007–2008, investors became quicker to jettison potential problem credits from their portfolios. Ironically, once a credit is downgraded by the rating agencies, internal portfolio guidelines often dictate security liquidation immediately after the loss of single-A or investment-grade status. This is usually the worst possible time to sell a security and maximizes losses incurred by the portfolio.

New-Issue Swaps

New-issue swaps contribute to secondary turnover. Because of perceived superior liquidity, many portfolio managers prefer to rotate their portfolios gradually into more current and usually larger sized on-the-run issues. This disposition, reinforced by the usually superior market behavior of newer issues in the U.S. Treasury market (i.e., the on-the-run issues), has become a self-fulfilling prophecy for many credit issues. In addition, some managers use new-issue swaps to add exposure to a new issuer or a new structure.

Sector-Rotation Trades

Sector-rotation trades, within credit and among fixed income asset classes, have become more popular since the early 1990s. In this strategy, the manager shifts the portfolio from a sector or industry that is expected to underperform to a sector or industry that is believed will outperform on a total-return basis. With the general development of enhanced liquidity and lower trading transaction costs during non-crisis periods across the global bond market in the early twenty-first century, sector-rotation trades have become more prevalent in the credit asset class.

Such intra-asset class trading has played a major role in differentiating performance among credit portfolio managers. For example, as soon as the Fed launched its preemptive strike against inflation in February 1994, some investors correctly exchanged fixed-rate corporates for floating-rate corporates. In 1995, the specter of U.S. economic weakness prompted some investors in high-yield corporates to rotate from consumer-cyclical sectors such as autos and retailing into consumer noncyclical sectors such as food, beverage, and health care. Anticipating slower U.S. economic growth in 1998 induced a defensive tilt by some portfolio managers away from other cyclical groups such as paper and energy. The resurrection of Asian and European economic growth in 1999 stimulated increased portfolio interest in cyclicals, financial institutions, and energy debt. Credit portfolio managers could have avoided a great deal of portfolio performance disappointment in 2002 by underweighting utilities and many industrial sectors and again in 2007 by underweighting financial firms.

Curve-Adjustment Trades

Yield-curve-adjustment trades, or simply, *curve-adjustment trades,* are taken to reposition a portfolio's duration. For most credit investors, their portfolio duration is typically within a range from 20% below to 20% above the duration of the benchmark index. If credit investors could have predicted U.S., euro, and yen yield-curve movements perfectly in 2002 and in 2008, then they would have increased their credit portfolio duration at the beginning of 2002 and 2008 in anticipation of a decrease in interest rates. Although most fixed income investors prefer to alter the duration of their aggregate portfolios in the more-liquid Treasury market, strategic portfolio duration tilts also can be implemented in the credit market.

Such trades also are executed in anticipation of changes in the credit term structure or credit curve. For example, if a portfolio manager believes that credit-spreads will tighten (either overall or in a particular sector), with rates in general remaining relatively stable, then she might shift the portfolio's exposure to longer-spread-duration credit issues in her preferred sectors.

Structure Trades

Within the set of investment-grade, fixed-rate credit securities, *structure trades* have become rarer as the global credit markets have become more homogeneous (intermediate bullets). Structure trades are swaps into structures (e.g., callable structures, bullet structures, and putable structures) that are expected to have better performance given expected movements in volatility and the shape of the yield-curve. Structure trades also encompass swaps from less stringent issue indentures into tighter indentures that may afford bond investors greater protection should the issuer encounter financial difficulties. By expanding the choice set from fixed credit-only debt to include floating rate, preferred, preference, and even convertible securities, structural trades remain very common. The following examples illustrate the portfolio benefits of sound structure trades.

- The plunge in U.S. interest rates and escalation of yield-curve volatility during the second half of 1998 restrained the performance of callable structures compared with bullet structures.
- The upward rebound in U.S. interest rates and the fall in interest-rate volatility during 1999 contributed to the relative outperformance of callable structures versus bullet structures.
- A swap from floating-rate debt to fixed-rate debt would have aided credit portfolios at the beginning of global central bank easing cycles in 2001 and 2007.
- A rotation from conventional investment-grade credit debt into riskier subordinated structures, preferred stock, and convertibles in March 2009 would have markedly boosted portfolio performance.

Basis Trades

Traders and asset managers regularly prowl the global credit asset class for discrepancies, even slight, among bond, nominal spread, OAS, interest-rate swap spread, and credit default swap spread values for the same and similar issues. These discrepancies may give rise to advantageous *basis trade* swaps.

Cash-Flow Reinvestment

Cash-flow reinvestment forces investors into the secondary market on a near-weekly basis. In some years, the sum of all coupon, maturity, and partial redemptions (via tenders, sinking funds, and other issuer prepayments) equals approximately 100% of all new gross issuance across the dollar bond market. Before the allocation of any net new investment in the bond market, investors have sufficient cash-flow reinvestment to absorb nearly all new bond supply. Some portfolio cash inflows occur during interludes in the primary market, or the composition of recent primary supply may not be compatible with portfolio objectives. In these periods, credit portfolio managers must shop the secondary market for investment opportunities to remain fully invested or temporarily replicate the corporate index by using CDS and financial futures. Portfolio managers who incorporate analysis of cash-flow reinvestment into their valuation of the credit market can position their portfolios to take advantage of this cash-flow reinvestment effect on spreads.

Trading Constraints

Portfolio managers also should review their main rationales for not trading. Some of the best investment decisions are not to trade. Conversely, some of the worst investment decisions emanate from stale views based on dated and anachronistic constraints (e.g., avoid investing in bonds rated below Aa/AA). The best portfolio managers retain very open minds, constantly self-critiquing both their successful and unsuccessful methodologies.

Portfolio Constraints

Collectively, portfolio constraints are the single biggest contributor to the persistence of market inefficiency across the global credit market. Here are some examples:

- Because many asset managers are limited to holding securities with investment-grade ratings, they are forced to sell immediately the debt of issuers who are downgraded to speculative ratings (Ba1/BB+ and below). In turn, this selling at the time of downgrade provides an opportunity for investors with more flexible constraints to buy such newly

downgraded securities at a temporary discount (provided, of course, that the issuer's creditworthiness stabilizes after downgrade).

- Some Sovereign Wealth Funds and U.S. state employee pension funds cannot purchase credit securities with ratings below A3/A– owing to administrative and legislative guidelines.
- Some U.S. pension funds also have limitations on their ownership of MTNs and non-U.S. corporate issues.
- Regulators have limited U.S. insurance companies' investment in high-yield corporates.
- Some European investors are restricted to issues rated at least single-A and sometimes Aa3/AA– and above, created originally in annual-pay Eurobond form.
- Some investors are confined to their local currency market—yen, sterling, euro, U.S. dollar. Often the same issuer, such as GE Capital, will trade at different spreads in diverse local markets.
- Globally, many commercial banks must operate exclusively in the floating-rate realm; all fixed-rate securities, unless converted into floating-rate cash-flows via an interest-rate swap, are prohibited.

"Story" Disagreement

"Story" disagreement can work to the advantage or disadvantage of a portfolio manager. Traders, salespersons, sell-side analysts and strategists, and buy-side credit researchers have dozens of potential trade rationales that supposedly will enhance portfolio performance. The proponents of a secondary trade may make a persuasive argument, but the portfolio manager may be unwilling to accept the "shortfall risk" if the investment recommendation does not provide its expected return. For example, in early 1998, analysts and investors alike were divided equally on short-term prospects for better valuations of Asian sovereign debt. After a very disappointing 1997 for Asian debt performance, Asia enthusiasts had little chance to persuade pessimists to buy Asian debt at the beginning of 1998. Technically, such lack of consensus in the credit market signals an investment with great outperformance potential. Indeed, most Asian debt issues recorded exceptional outperformance over the full course of 1998 and 1999. After a difficult 2002, the same "rebound effect" was observed in electric utilities during 2003. Of course, "story" disagreement also can work in the other direction. For example, Enron and Lehman Brothers were long viewed as very solid credits before their sudden bankruptcies in late 2001 and September 2008, respectively. An asset manager wedded to this long-term view might have been reluctant to act on the emergence of less favorable information about Enron in the summer of 2001 and about Lehman during early 2008.

Buy-and-Hold

Although many long-term asset/liability managers claim to have become more total-return-focused in the 1990s, accounting constraints (cannot sell positions at a loss compared with book cost or take too extravagant a gain compared with book cost) often limit the ability of these investors to trade. Effectively, these investors (mainly insurers) remain traditional-buy-and-hold investors. Some active bond managers have converged to quasi-buy-and-hold investment programs at the behest of consultants to curb portfolio turnover. In the aftermath of the "Asian Contagion" in 1997–1998 and the Great Recession–induced financial panic of September 2008–March 2009, this disposition toward lower trading turnover was reinforced by the temporary reduction in market liquidity provided by more wary bond dealers. As shown in 2000–2002 and over 2007–2010, however, a buy-and-hold strategy can gravely damage the performance of a credit portfolio. At the first signs of a system-wide credit event (systemic risk) or credit trouble for an issuer (idiosyncratic risk), many credit portfolios would have improved returns by reducing their exposure to the overall credit asset class or to a deteriorating credit. And in the case of systemic-risk events, subsequent relative portfolio performance would have been greatly aided by adding solid issues temporarily caught up in the credit market's transitory general dislocation.

Seasonality

Lower-quality credits (Baa/BBB's) tend to be more susceptible to underperformance during August–October as dealers and investors become more defensive with the approach of year-end. Conversely, lower-quality credits frequently outperform during the first quarter on optimistic hopes for strong economic, industry, issuer fundamentals for the full calendar year. Secondary trading slows at month end, more so at quarter end, and the most at the conclusion of calendar years. Dealers often prefer to reduce their balance sheets at fiscal year-end (December 31 or March 31 [Japan]). Also, portfolio managers take time to mark their portfolios, prepare reports for their clients, and chart strategy for the next investment period. During these intervals, even the most compelling secondary offerings can languish.

SPREAD ANALYSIS

By custom, some segments of the high-yield and emerging (EMG) debt markets still prefer to measure value by bond price or bond yield rather than spread. But for the rest of the global credit market, nominal spread (the yield difference between corporate and government bonds of similar maturities) has been the basic unit of both price and relative-value analysis for more than two centuries.

Alternative Spread Measures

Many U.S. practitioners prefer to value investment-grade credit securities in terms of option-adjusted spreads (OAS) so that they can be compared more easily to the volatility ("vol") sectors (mortgage-backed securities and U.S. agencies).[2] But given the rapid reduction of credit structures with embedded options since 1990 (see structural discussion above), the use of OAS in primary and secondary pricing has diminished within the investment-grade credit asset class. Moreover, the standard one-factor binomial models[3] do not account for credit-spread volatility. And given the exclusion of default risk in OAS option-valuation models, OAS valuation has seen only limited extension into the higher-risk markets of the quasi-equity, high-yield corporate, and EMG-debt asset classes.

Starting in Europe during the early 1990s and gaining momentum during the late 1990s, interest-rate swap spreads emerged as the common denominator to measure relative value across fixed- and floating-rate note credit structures. The U.S. investment-grade and high-yield markets eventually may rely more heavily on such swap spreads to be consistent with Europe and Asia. But with the exponential growth of the credit-default swap (CDS) market since approximately 2000, CDS spreads have emerged as the standard gauge of relative pricing for large credit issuers.

Other U.S. credit-spread calculations have been proposed from time-to-time, most notably using the U.S. agency benchmark curve. This short-lived suggestion in 2000 sprang from the fallacious assumption of a persistent U.S. budgetary surplus and significant liquidation of outstanding U.S. Treasury securities during the first decade of the twenty-first century. As again demonstrated by 2002, history teaches that long-term fiscal assumptions unfortunately often prove to be faulty. Although some practitioners may choose to derive credit-agency spreads for analytical purposes, this practice had little chance of becoming standard market convention.

Credit-default swap spreads have emerged as the latest valuation tool during the great stresses in the credit markets of 2000–2002 and 2007–2010. Most likely, credit-default swap (CDS) spreads will be used as a companion valuation reference to nominal spreads, OAS, and interest rate-swap spreads. The market, therefore, has an ability to price any credit instrument using multiple spread references. Historically, the basic spread measures used the Treasury yield-curve or Treasury spot-rate curve as the underlying benchmark. Given the potential that

2. These sectors are referred to as "vol" sectors because the value of the securities depends on expected interest rate volatility. These "vol" securities have embedded call options and the value of the options, and hence the value of the securities, depends on expected interest rate volatility.

3. The model is referred to as a "one-factor model" because only the short-term rate is the factor used to construct the tree.

swap spreads will become the new benchmark, these same measures can be performed relative to swaps rather than relative to U.S. Treasuries.

Here is an illustration of how a bond manager can use the interest-rate swap-spread framework. Suppose that a hypothetical Ford Motor 4½s of 2016 traded at a bid price (i.e., the price at which a dealer is willing to buy the issue) of 113 basis point over the five-year U.S. Treasury yield of 2.75%. This equates to a yield-to-maturity of 3.88% (2.75% + 113 basis points). On that date, five-year swap spreads were 83 basis points (to the five-year U.S. Treasury). Recall that swaps are quoted where the fixed-rate payer pays the yield on a Treasury with a maturity equal to the initial term of the swap plus the swap spread. The fixed-rate payer receives LIBOR flat; that is, no increment over LIBOR. Thus, if the bond manager invests in the Ford Motor issue and simultaneously enters into this five-year swap, the following would result:

Receive from Ford Motor (2.75% + 113 basis points)	3.88%
– Pay on swap (2.75% + 83 basis point)	3.58%
+ Receive from swap	LIBOR
Net	LIBOR + 30 basis points

Thus, a bond manager could exchange this Ford Motor bond's fixed coupon flow for LIBOR + 30 basis points. A total-return manager would want to take advantage of this swap by paying fixed and receiving floating if he expects interest rates to increase in the future.

The swaps framework allows managers (as well as issuers) to more easily compare securities across fixed-rate and floating-rate markets. The extension of the swap-spread framework may be less relevant for speculative-grade securities, in which default risk becomes more important. In contrast to professional money managers, individual investors are not comfortable using bond valuation couched in terms of swap spreads. The traditional nominal spread framework is well understood by individual investors, has the advantages of long-term market convention, and works well across the entire credit-quality spectrum from Aaas to Bs. However, this nominal spread framework does not work very well for investors and issuers when comparing the relative attractiveness between the fixed-rate and floating-rate markets.

Spread Tools

Investors also should understand how best to evaluate spread levels in their decision making. Spread valuation includes mean-reversion analysis, quality-spread analysis, and percent yield spread analysis.

Mean-Reversion Analysis

The most common technique for analyzing spreads among individual securities and across industry sectors is *mean-reversion analysis*. The *mean* is the average

value of some variable over a defined interval (usually one economic cycle for the credit market). The term *mean reversion* refers to the tendency for some variable's value to revert (i.e., move toward) its average value. Mean-reversion analysis is a form of relative-value analysis based on the assumption that the spread between two sectors or two issuers will revert back to its historical average. This would lead investors to buy a sector or issuer identified as "cheap" because historically the spread has been tighter and will eventually revert back to that tighter spread. Also, this would lead investors to sell a sector or issuer identified as "rich" because the spread has been wider and is expected to widen in the future.

Mean-reversion analysis involves the use of statistical analysis to assess whether the current deviation from the mean spread is significant. For example, suppose that the mean spread for an issuer is 80 basis points over the past six months and the standard deviation is 12 basis points. Suppose that the current spread of the issuer is 98 basis points. The spread is 18 basis points over the mean spread or, equivalently, 1.5 standard deviations above the mean spread. The manager can use that information to determine whether or not the spread deviation is sufficient to purchase the issue. The same type of analysis can be used to rank a group of issuers in a sector.

Mean-reversion analysis can be instructive as well as misleading. The mean is highly dependent on the interval selected. There is no market consensus on the appropriate interval, and "persistence" frequents the credit market, meaning that cheap securities, mainly a function of credit uncertainty, often tend to become cheaper. Rich securities, usually high-quality issues, tend to remain rich.

Quality-Spread Analysis

Quality-spread analysis examines the spread differentials between low- and high-quality credits. For example, portfolio managers would be well advised to consider the "credit upgrade trade" when quality spreads collapse to cyclical troughs. The incremental yield advantage of lower-quality products may not compensate investors for lower-quality spread expansion under deteriorating economic conditions. Alternatively, credit portfolio managers have long profited from overweighting lower-quality debt at the outset of an upward turn in the economic cycle.

Percent Yield-Spread Analysis

Dating from the early twentieth century, *percent yield-spread analysis* (the ratio of credit yields to government yields for similar-duration securities) is another popular technical tool used by some investors. This methodology has serious drawbacks that undermine its usefulness. Percent yield spread is more a derivative than an explanatory or predictive variable. The usual expansion of credit percent yield spreads during low-rate periods such as 1997, 1998, 2002, and 2008–2010 overstates the risk as well as the comparative attractiveness of credit debt. And the typical contraction of credit percent yield-spreads during upward

shifts of the benchmark yield-curve does not necessarily signal an imminent bout of underperformance for the credit asset class. Effectively, the absolute level of the underlying benchmark yield is merely a single factor among many factors (demand, supply, profitability, defaults, etc.) that determine the relative value of the credit asset class. These other factors can offset or reinforce any insights derived from percent yield-spread analysis.

STRUCTURAL ANALYSIS

As explained earlier in this chapter, there are bullet, callable, putable, and sinking fund structures. *Structural analysis* is simply analyzing the performance of the different structures discussed throughout this chapter. While evaluating bond structures was extremely important in the 1980s, it has become less influential in the credit bond market since the mid 1990s for several reasons. First, the European credit bond market almost exclusively features intermediate bullets. Second, as can be seen in Exhibit 51–6, the U.S. credit and the global bond markets have moved to embrace this structurally homogeneous European bullet standard. Plenty of structural diversity still resides within the U.S. high-yield and EMG debt markets, but portfolio decisions in these speculative-grade sectors understandably hinge more on pure credit differentiation than the structural diversity of the issue-choice set.

Still, structural analysis can enhance risk-adjusted returns of credit portfolios. Leaving credit aside, issue-structure analysis and structural allocation decisions usually hinge on yield-curve and volatility forecasts, as well as interpretation of option-valuation model outputs (see the discussion below). This is also a key input in making relative-value decisions among structured credit issues, mortgage-backed securities, and asset-backed securities. In the short run and assuming no change in the perceived creditworthiness of the issuer, yield-curve and volatility movements largely will influence structural performance. Investors also should take into account long-run market dynamics that affect the composition of the market and, in turn, credit index benchmarks.

EXHIBIT 51–6

Changing Composition of the U.S. Investment-Grade Credit Markets*

	1990 (%)	2003 (%)
Bullets	24	94
Callables	72	3
Sinking funds	32	1
Putables	5	2
Zeros	4	N/A

*Figures in table do not add to 100% given that some structures may have contained multiple options (e.g., a callable corporate bond also may have a sinking fund and put provision).
Source: Lehman Brothers U.S. Investment-Grade Credit Index.

Specifically, callable structures have become rarer in the U.S. investment-grade credit bond market with the exception of the 2000 inversion. This is due to an almost continuously positively sloped U.S. term structure since 1990 and the yield-curve's intermittent declines to approximately multi-decade lows in 1993, 1997, 1998, 2002, and 2008–2010. As a result, the composition of the public U.S. corporate bond market converged toward the intermediate-bullet Eurobond and euro-denominated bond market. To see this, we need only look at the structure composition of Lehman's U.S. Investment-Grade Credit Bond Index. Bullets increased from 24% of this index at the start of 1990 to 96.0% (principal-value basis) by the end of 2010. Over this interval, callables declined at a remarkable rate from 72% to just a 3.5% index share. Sinking-fund structures, once the structural mainstay of natural-gas pipelines and many industrial sectors, are on the "structural endangered species list" with a drop from 32% of the public bond market in 1990 to only 0.1% in 2010. Despite several brief flurries of origination in the mid 1990s and the late 1990s introduction of callable/putable structures, putable structure market share fell from 5% in 1990 to 0.4% by 2010. Pure corporate zeros are in danger of extinction with a fall from 4% market share in 1990 to negligible by 2010.

Bullets

Here is a review of how different types of investors are using bullet structures with different maturities.

Front-end bullets (i.e., bullet structures with one- to five-year maturities) have great appeal for investors who pursue a "barbell strategy." There are "barbellers" who use credit securities at the front or short end of the curve and Treasuries at the long end of the yield-curve. There are non-U.S. institutions who convert short bullets into floating-rate products by using interest-rate swaps. The transactions are referred to as "asset swaps," and the investors who employ this transaction are referred to as "asset swappers."

Intermediate credit bullets (5- to 12-year maturities), especially the 10-year maturity sector, have become the most popular segment of the U.S. and European investment-grade and high-yield credit markets. Fifteen-year maturities, benchmarked off the 10-year bellwether Treasury, are comparatively rare and have been favored by banks that occasionally use them for certain types of swaps. Because new 15-year structures take five years to descend along a positively sloped yield-curve to their underlying 10-year bellwether, 15-year maturities hold less appeal for many investors in search of return through price appreciation emanating from benchmark rolldown. In contrast, rare 20-year structures have been favored by many investors. Spreads for these structures are benched off the 30-year Treasury. With a positively sloped yield-curve, the 20-year structure provides higher yield than a 10- or 15-year security and less vulnerability (lower duration) than a 30-year security.

The 30-year maturity is the most popular form of long-dated security in the global credit market. In 1992, 1993, late 1995, 1997, and 2010, there was

a minor rush to issue 50-year (half-centuries) and 100-year (centuries) securities in the U.S. credit bond market. These longer-dated securities provide investors with extra positive convexity for only a modest increase in effective (or modified-adjusted) duration. In the wake of the "Asian contagion" and especially the "great spread-sector crash" of August 1998 as well as the Great Recession of 2007–2009, the cyclic increases in risk aversion and liquidity premiums greatly reduced both issuer and investor interest in these ultralong maturities.

Callables

Typically after a 5- or 10-year wait (longer for some rare issues), credit structures are callable at the option of the issuer at any time. Call prices usually are set at a premium above par (par + the initial coupon) and decline linearly on an annual basis to par by 5 to 10 years prior to final scheduled maturity. The ability to refinance debt in a potentially lower-interest-rate environment is extremely valuable to issuers. Conversely, the risk of earlier-than-expected retirement of an above-current market coupon is bothersome to investors.

In issuing callables, issuers pay investors an annual spread premium (about 20–40 basis points for high-quality issuers) for being long (from an issuer's perspective) the call option. Like all security valuations, this call premium varies through time with capital market conditions. Given the higher chance of exercise, this call option becomes much more expensive during low-rate and high-volatility periods. Since 1990, this call premium has ranged from approximately 15 to 50 basis points for investment-grade issuers. Callables significantly underperform bullets when interest rates decline because of their negative convexity. When the bond market rallies, callable structures do not fully participate given the upper boundary imposed by call prices. Conversely, callable structures outperform bullets in bear bond markets as the probability of early call diminishes.

Sinking Funds

A sinking-fund structure allows an issuer to execute a series of partial calls (annually or semiannually) prior to maturity. Issuers also usually have an option to retire an additional portion of the issue on the sinking-fund date, typically ranging from one to two times the mandatory sinking-fund obligation. Historically, especially during the early 1980s, total-return investors favored the collection of sinking-fund structures at subpar prices. These discounted sinking funds retained price upside during interest-rate rallies (provided the indicated bond price remained below par), and given the issuers' requirement to retire at least annually some portion of the issue at par, the price of these sinking-fund structures did not fall as much compared with callables and bullets when interest rates rose. It should be noted that astute issuers with strong liability management

skills sometimes can satisfy such annual sinking-fund obligations in whole or in part through prior open-market purchases at prices below par. Nonetheless, this annual sinking-fund purchase obligation by issuers limits bond price depreciation during periods of rising rates.

Putables

Conventional put structures are simpler than callables. Yet, in trading circles, put bond valuations often are the subject of debate. American-option callables grant issuers the right to call an issue at any time at the designated call price after expiration of the noncallable or nonredemption period. Put bonds typically provide investors with a onetime, one-date put option (European option) to demand full repayment at par. Less frequently, put bonds include a second or third put option date. A very limited number of put issues afford investors the privilege to put such structures back to the issuers at par in the case of rating downgrades (typically to below investment-grade status).

Thanks to falling interest rates, issuers shied away from new put structures as the 1990s progressed. Rather than incur the risk of refunding the put bond in 5 or 10 years at a higher cost, many issuers would prefer to pay an extra 10 to 20 basis points in order to issue a longer-term liability.

Put structures provide investors with a partial defense against sharp increases in interest rates. Assuming that the issuer still has the capability to meet its sudden obligation, put structures triggered by a credit event enable investors to escape from a deteriorating credit. Perhaps because of its comparative scarcity, the performance and valuation of put structures have been a challenge for many portfolio managers. Unlike callable structures, put prices have not conformed to expectations formed in a general volatility–valuation framework. Specifically, the implied yield volatility of an option can be computed from the option's price and a valuation model. In the case of a putable bond, the implied volatility can be obtained using a valuation model such as the binomial model. The implied volatility should be the same for both puts and calls, all factors constant. Yet, for putable structures, implied volatility has ranged 4% to 9% since 1990, well below the 10% to 20% volatility range associated with callable structures for the same time period. This divergence in implied volatility between callables (high) and putables (low) suggests that asset managers, often driven by a desire to boost portfolio yield, underpay issuers for the right to put a debt security back to the issuer under specified circumstances. In other words, the typical put bond should trade at a lower yield in the market than is commonly the case.

Unless put origination increases sharply, allowing for greater liquidity and the creation of more standardized trading conventions for this rarer structural issue, this asymmetry in implied volatility between putable and corporate structures will persist. Meanwhile, this structure should be favored as an

outperformance vehicle only by investors with a decidedly bearish outlook for interest rates.

CREDIT-CURVE ANALYSIS

The rapid growth of credit derivatives since the mid 1990s has inspired a groundswell of academic and practitioner interest in the development of more rigorous techniques to analyze the term structure (1–100 years) and credit structure (Aaa/AAA through B2/Bs) of credit-spread curves (higher-risk, higher-yield securities trade on a price rather than a spread basis).

Credit curves, both term structure and credit structure, are almost always positively sloped. In an effort to moderate portfolio risk, many portfolio managers take credit risk in short and intermediate maturities and substitute less-risky government securities in long-duration portfolio buckets. This strategy is called a *credit barbell strategy*. Accordingly, the application of this strategy diminishes demand for longer-dated credit risk debt instruments by many total-return, mutual fund, and bank portfolio bond managers. Fortunately for credit issuers who desire to issue long maturities, insurers, and pension plan sponsors often meet long-term liability needs through the purchase of credit debt with maturities that range beyond 20 years.

Default risk increases nonlinearly as creditworthiness declines. The absolute risk of issuer default in any one year remains quite low through the investment-grade rating categories (Aaa/AAA to Baa3/BBB–). But investors constrained to high-quality investments often treat downgrades like quasi-defaults. In some cases, such as a downgrade from single-A to the Baa/BBB category, investors may be forced to sell securities under rigid portfolio guidelines. In turn, investors justifiably demand a spread premium for the increased likelihood of potential credit difficulty as rating quality descends through the investment-grade categories.

Credit-spreads increase sharply in the high-yield rating categories (Ba1/BB+ through D). Default, especially for weak single-Bs and CCCs, becomes a major possibility. The credit market naturally assigns higher and higher risk premia (spreads) as credit and rating risk escalate. Exhibit 51–7 shows the credit curve for two credit sectors (Baa and single-A industrials) and also illustrates that a higher spread is required as maturity lengthens.

In particular, the investment-grade credit market has a fascination with the slope of issuer credit curves between 10- and 30-year maturities. Like the underlying Treasury benchmark curve, credit-spread curves change shape over the course of economic cycles. Typically, spread curves steepen when the bond market becomes more wary of interest-rate and general credit risk. Spread curves also have displayed a minor propensity to steepen when the underlying benchmark curve flattens or inverts. This loose spread-curve/yield-curve linkage reflects the diminished appetite for investors to assume both curve and credit risk at the long end of the yield-curve when higher total yields may be available in shor and intermediate-credit products.

EXHIBIT 51–7

Illustration of Two Typical U.S. Investment-Grade Credit Curves

Source: Lehman Brothers U.S. Investment-Grade Credit Index, based on average corporate curves 1990–2003.

CREDIT ANALYSIS

In the continuous quest to seek credit upgrades and contraction in issuer/issue spread resulting from possible upgrades and, more important, to avoid credit downgrades resulting in an increase in issuer/issue spread, superior credit analysis has been and will remain the most important determinant of credit bond portfolio relative performance. Credit screening tools tied to equity valuations, relative spread movements, and the Internet (information available tracking all related news on portfolio holdings) can provide helpful supplements to classic credit research and rating agency opinions. But self-characterized credit models, relying exclusively on variables such as interest-rate volatility and binomial processes imported from option-valuation techniques, are not especially helpful in ranking the expected credit performance of individual credits such as IBM, British Gas, Texas Utilities, Pohang Iron & Steel, Sumitomo, and Brazil.

Credit analysis is both nonglamorous and arduous for many top-down portfolio managers and strategists, who focus primarily on macro variables. Genuine credit analysis encompasses actually studying issuers' financial statements and accounting techniques, interviewing issuers' managements, evaluating industry issues, reading indentures and charters, and developing an awareness of (not necessarily concurrence with) the views of the rating agencies about various industries and issuers.

Unfortunately, the advantages of such analytical rigor may clash with the rapid expansion of the universe of issuers of credit bonds. There are approximately 5,000 different credit issuers scattered across the global bond market. With continued privatization of state enterprises, new entrants to the high-yield market, and expected long-term growth of the emerging-debt markets, the global roster of issuers could swell to 7,500 by 2025. The sorting of this expanding roster of global credit issues into outperformers, market performers, and underperformers demands establishing and maintaining a formidable credit-valuation function by asset managers.

ASSET ALLOCATION/SECTOR ROTATION

Sector rotation strategies have long played a key role in equity portfolio management. In the credit bond market, "macro" sector rotations among industrials, utilities, financial institutions, sovereigns, and supranationals also have a long history. During the last quarter of the twentieth century, there were major variations in investor sentiment toward these major credit sectors. Utilities endured market wariness about heavy supply and nuclear exposure in the early to mid 1980s. U.S. and European financial institutions coped with investor concern about asset quality in the late 1980s and early 1990s. Similar investor skittishness affected demand for Asian financial institution debt in the late 1990s. Industrials embodied severe "event risk" in the middle to late 1980s, recession vulnerability during 1990–1992, a return of event risk in the late 1990s amid a general boom in corporate mergers and acquisitions, and a devastating series of accounting and corporate governance blows during 2001–2002. Sovereigns were exposed to periodic market reservations about the implications of independence for Quebec, political risk for various countries (i.e., Russia), the effects of the "Asian contagion" during 1997–1998, and outright defaults such as Argentina (2001).

In contrast, "micro" sector rotation strategies have a briefer history in the credit market. A detailed risk/return breakdown (i.e., average return and standard deviation) of the main credit subsectors (i.e., banks, brokerage, energy, electrics, media, railroads, sovereigns, supranationals, and technology) was not available from credit index providers until 1993 in the United States and until 1999 in Europe. Beginning in the mid 1990s, these "micro" sector rotation strategies in the credit asset class have become much more influential as portfolio managers gain a greater understanding of the relationships among intracredit sectors from these statistics.

Exhibit 51–8 illustrates the main factors bearing on sector rotation and issuer selection strategies. For example, an actual or perceived change in rating agency philosophy toward a sector and a revision in profitability expectations for a particular industry represent just two of many factors that can influence relative sectoral performance.

Common tactics to hopefully enhance credit portfolio performance are also highlighted in Exhibit 51–8. In particular, seasonality again deserves comment.

EXHIBIT 51–8

Some Outperformance Methodologies

The annual rotation toward risk aversion in the bond market during the second half of most years contributes to a "fourth-quarter effect;" that is, there is underperformance of lower-rated credits, Bs in high-yield and Baas in investment-grade, compared with higher-rated credits. A fresh spurt of market optimism greets nearly every new year. Lower-rated credit outperforms higher-quality credit. This is referred to as the "first-quarter effect." This pattern suggests a very simple and popular portfolio strategy: underweight low-quality credits and possibly even credit products altogether until the mid-third quarter of each year and then move to overweight lower-quality credits and all credit products in the fourth quarter of each year.

KEY POINTS

- As prescribed in capital market theory, investors should be rewarded for the assumption of incremental risk. Reality conforms to theory in the global credit market. Over the long run, credit products provide higher long-term returns than presumably risk-free government securities.
- Credit returns and risk are viewed as "asymmetric." On occasion, asset managers may suffer large, transitory relative underperformance to Treasuries with the onset of systemic risk event (i.e., the Financial Panic

in September 2008). And the price of individual credit securities may tumble from the par vicinity to zero in the event of default.

- Credit bond portfolio management requires more work and asset management firm infrastructure than other debt asset classes. There are thousands of credit choices, dozens of security forms, and multiple structures, and the size of the global credit asset class will accelerate during the twenty-first century thanks to the entrance of new emerging market based issuers.
- Global bond management philosophy has evolved rapidly over the past two decades. The arrival of the euro in 1999 curbed the use of currency strategies. Major portfolio-duration bets (more than 10% above or below the duration of an index benchmark) have become less common by asset managers because of frequent duration-timing disappointments. The use of CDS has expanded. New quantitative tools to assist in relative value rankings and asset allocation (i.e., risk budgeting) have proliferated. And particularly at large asset management firms, credit portfolios have truly become globalized.
- In conjunction with the demonstrably higher long-term returns of corporates and an ongoing migration from "government-only index benchmarks" to "government plus corporate and securitized index benchmarks," this reduction in currency and curve timing has propelled investor interest in global credit portfolio optimization as a path to more consistent overall portfolio outperformance in an increasingly competitive asset management industry.

CHAPTER
FIFTY-TWO

ELEMENTS OF MANAGING A HIGH-YIELD BOND PORTFOLIO

MARK R. SHENKMAN
President, Chief Investment Officer
Shenkman Capital Management, Inc.

NICHOLAS R. SARCHESE, CFA
Senior Vice President
Shenkman Capital Management, Inc.

High-yield portfolio management involves the art and science of matching a portfolio's investments to its underlying objectives and overall risk profile. The focus is to balance risk against performance with the goal of achieving superior risk-adjusted returns over an entire credit cycle. From a portfolio management perspective, the high-yield market is a unique asset class due to the fact that high-yield securities exhibit the characteristics of both debt instruments and equities. Given the greater risk associated with highly levered companies, changes in the underlying fundamental credit profile are the primary driver of return over time as default loss is a key concern. However, as part of the fixed income asset class, debt attributes of the security, such as coupon, maturity, covenants, and ratings, also affect prices and performance.

High-yield bonds offer significant incremental return and income as compared with most other fixed income investments. However, it is essential to keep in mind their asymmetrical risk profile. That is, a bond's upside is generally limited to its face value at maturity or early redemption premium, while the downside could include an entire loss of principal in a default. In order to capture the attractive incremental returns and spreads offered by investing in high-yield bonds, minimizing default and credit loss are crucial components to achieving this goal.

Properly assessing and managing risk are critical elements of managing a high-yield portfolio. Risk controls require developing insightful and comprehensive procedures to identify and control risk across the following three key areas:

1. Bottom-up credit/security analysis
2. Top-down high-yield market drivers and macro considerations
3. Portfolio considerations

EXHIBIT 52–1

Elements of Managing a High-Yield Bond Portfolio

Exhibit 52–1 identifies these three areas and highlights the elements to consider. The most successful portfolio managers have the ability to assimilate all three areas as the intersection point is the nexus of the portfolio decision-making process. Each of these areas and their elements are discussed in further detail below.

Over the long term (and through various economic cycles), portfolio managers who have avoided defaults and major trading losses have typically outperformed various high-yield benchmarks.

BOTTOM-UP–CREDIT/SECURITY ANALYSIS[1]

While credit analysis is arguably the most important component of a bottom-up investment process, security structure/terms, covenants, trading liquidity factors and relative value ultimately determine if a "good credit" will make a

[1]This section is adapted from Nicholas Sarchese, Amy Levine, "Credit Analysis and Analyzing a High-Yield Issuance," Chapter 7 in William F. Maxwell, Mark R. Shenkman (ed.), *Leveraged Financial Markets: A Comprehensive Guide to High-Yield Bonds, Loans, and Other Instruments* (New York: McGraw-Hill, Inc., 2010).

EXHIBIT 52–2

Six Steps in Bottom-Up—Credit/Security Analysis

"good investment." Poor relative value and overpaying for a good credit could lead to underperformance. Weak trading liquidity factors can magnify the downside and disrupt the value equation in a negative surprise scenario. In executing a buy-sell decision, a step-by-step process is required to ensure consistency and disciplined decision making. Exhibit 52–2 highlights the six steps in analyzing a high-yield issuance. A checklist of positive and negative attributes should be utilized at each step. It is also important to emphasize that all of the bottom-up steps are significant in their own right. A favorable assessment on many of the steps may not necessarily outweigh an individual risk component that is identified in the process.

Step One: Credit Analysis

Thorough credit analysis is ultimately the foundation for a successful high-yield investment since its primary focus is to avoid defaults. A greater investment risk is getting the credit analysis wrong as opposed to potentially overpaying for a good credit. It is important to keep in perspective that the high-yield asset class involves highly levered companies that have disproportionately less margin for error. The asymmetrical upside/downside return profile of bonds also highlights

the importance of avoiding meaningful downside credit risk. In practice, the underperformance related to overpaying for a good credit pales in comparison to the ultimate downside in holding the bonds of a credit that defaults. Remember that a bond's upside is limited to par (plus perhaps an early takeout premium), while the downside is theoretically zero. If a bond drops from par to 50, it would take 10 bonds to advance five points each in order to recoup the 50-point decline in just one credit! Equity portfolios do not have this similar dynamic because one investment can soar by 500%, thereby offsetting the losses in numerous other transactions. However, the number of bonds in a portfolio that can jump five points or more may be limited.

Credit analysis can be simply defined as determining the borrower's ability to meet its interest and principal obligations when due. It is often identified with financial ratio analysis. However, true credit analysis is much more comprehensive and encompasses greater in-depth review. For example, two credits with identical financial ratios may not represent the same credit risk. As outlined in Exhibit 52–3, credit analysis can be divided into four key areas: business risk, financial risk, management/ownership risk, and covenant risk.

Thorough credit analysis is not complete without a detailed examination of all four risk factors. Weakness in any one of the four areas could offset the strength in the remaining three and result in high credit risk for a particular issuer (Exhibit 52–4).

Investors must focus their analysis on a "forward looking" view of all four risk areas. While historical results are important for perspective, ultimately it is the future credit trend that will dictate performance.

EXHIBIT 52–3

The Four Key Components of Credit Analysis

EXHIBIT 52–4

Credit Analysis Examples

Examples include:

Strong Financial Profile + Strong Management + Strong Covenant Protection

The strengths may not be able to offset a high business risk where the industry structure is unfavorable, and the company is weakly positioned

Strong Business/Industry Fundamentals + Strong Financial Profile + Reasonable Covenant Protection

The strengths may not be able to offset the negative impacts of a weak management team with aggressive financial policy – OR – Bondholder unfriendly private equity sponsor

Strong Business/Industry Fundamentals + Strong Financial Profile + Strong Management

The strengths may not be able to offset the negative impact of a weak covenant package

Strong Business/Industry Fundamentals + Strong Management + Strong Covenant Protection

The strengths may not be able to offset the financial risk of a company that is overlevered

Business Risk

Analyzing the business risk of a particular credit involves an assessment of both the industry risk and company-specific risk from more of a strategic perspective. This analysis should involve not only determining whether the industry structure and fundamentals are favorable, but ascertaining the company's strategic position within its industry. Even the best company in a given industry may not be able to withstand major structural changes.

Industry Analysis. High levels of debt can be manageable and appropriate for certain industries but not others. Some industries are more conducive to leverage because their high operating margins, solid growth rates, and consistency of earnings enable the companies within the sector to service a higher degree of indebtedness. Factors used to assess an industry include: stability of cash-flows, stage in industry lifecycle, capital intensity, cost structure/operating leverage, degree of rapid change, competitive forces, regulation, and pricing power. In addition to providing an enhanced credit profile, industries that possess more favorable outlooks also tend to trade better because of positive macro considerations and investor support.

Company Analysis. It is imperative to dissect a company's specific strengths and weaknesses and determine how it fits into its industry. For example, a company can operate in a growing industry but possess obsolete technology. Conversely,

a company can compete in a declining industry but have a leading market position and generate significant cash-flow. Factors to consider include:

- Size of the company
- Stage in company lifecycle
- Market position
- Diversification
- Potential for event risk

All of the above mentioned factors can impact the creditworthiness of the borrower.

Financial Risk

After assessing an industry and company's business risk, the next step is to consider the overall financial risk and credit profile of the borrower. This consideration should take into account the company's capitalization and degree of leverage. The fundamental operating outlook and credit profile of a company are critical variables that should drive bond performance. Moreover, a thorough analysis must evaluate the past financial results to understand the drivers of the business.

The key variables to financial risk include:

- The stability of cash-flows
- Recent and near term projected performance trends
- Stress testing (how well a company's credit profile can withstand negative surprise)
- Analysis of free cash-flow and the ability to de-lever
- Leverage and coverage statistics
- Cash and available liquidity
- Amortization/maturity schedule
- Quality and salability of assets
- Access to capital markets
- Asset coverage

Management/Ownership Risk

While factors relating to credit analysis are crucial, the senior management of the company are responsible for establishing goals, objectives, and strategic vision for the business. In the end, a great management team can make a significant difference in the performance of a security.

Direct Communications. Portfolio managers or research analysts should have direct contact with senior management (i.e., one-on-one meetings or calls, company visits, etc.). Direct access is the best way to understand and evaluate management and can provide greater insight into the risk parameters for a specific issuer. Moreover, analysts should maintain an ongoing dialogue with company managements. During times of duress, if management is inaccessible, investor confidence in the company could be shaken, and the bonds may underperform.

Quality of Management. The quality of the senior management team is significant in making a good investment. While successful companies must pursue effective strategies, development and execution of those strategies hinge on the management team in control. Although management assessment is somewhat subjective, and improves with experience, the best qualities to look for in a management team include: low turnover, tenure and reputation within the industry, strong track record, timeliness in filing financial statements, forthrightness in responding to questions, strategic vision, a deep bench, and successful completion of stated goals. Great business leaders are able to effectively communicate the company's strategy and vision, articulate the opportunities and risks confronting the company, and act decisively and proactively in times of change.

Private Equity Sponsors/Ownership. Often, a highly levered company may be owned by a private equity sponsor. In these cases, the equity sponsor drives the company's strategic direction and financial policies, while the operating senior management (i.e., CEO, COO, CFO) usually have less influence in the overall direction and financial risk tolerance of the company. It is always important to keep in mind that the interests of the private equity sponsor in many cases may not align with bondholders. For example, sponsors may declare a large cash dividend as quickly as possible to enhance their equity returns, although this action may lead to deterioration in the company's credit quality. If the sponsors have little capital at risk, they could try for a "swing for the fences" type strategy since they have little downside (having taken their invested capital out) but significant upside if the strategy pays off. This "no capital at risk" strategy is not ideal for bond investors, as the company may have little capital cushion, particularly in a faltering economy. The sponsor's investment track record, default history, and record in paying down debt should be carefully examined. Another factor is the percentage of equity owned by the management team. If equity ownership is spread throughout management, they are more likely to be deeply engaged in the success of the overall enterprise.

Financing Philosophy. Investors must consider both the ownership's and management team's intentions regarding the company's balance sheet. Is management comfortable operating with high levels of debt and leverage, or are they more conservative and prefer to have more financial flexibility and lower leverage? Is management comfortable with the current amount of debt or is debt pay down a

key priority? How committed is management to paying down debt? Is management opportunistic in that they would consider making an attractive acquisition even if it involved increasing the financial risk profile of the company? If the management team is comfortable with the current level of debt, they might focus on using cash-flow toward paying dividends, share buybacks, or funding additional acquisitions. If debt pay down is a key priority, and the company generates a large amount of free cash-flow, the issuer's credit metrics are likely to improve. Knowing management's philosophy towards debt is of vital importance in forecasting the company's credit profile as it will serve as a guide toward the application of free cash-flow. It also provides a guidepost from which to judge their success in achieving previously stated goals as well as their credibility. For example, if the management team has stated its intention to de-lever and then initiates a large stock buyback, the bonds are likely to underperform as the "credit story" has not met expectations, and investors may have diminished confidence in senior management.

Covenant Risk

A detailed examination of covenants is a critical part of credit analysis. Although each tranche of debt may contain its own specific debt covenants, collectively they impact the borrower's overall credit risk profile and financial flexibility. Evaluating the collective impact of all of the company's covenants (bank loan as well as bond covenants) is important in understanding the overall credit risk of a company. The presence of a strong covenant package within an issuer's bank loan may have significant influence on bond performance. In certain cases, limited covenant flexibility may improve the overall credit profile of the company because it could create the opportunity for early redemption at a premium or limit increases in financial risk. Conversely, there are cases where limited covenant flexibility may prove to be a significant risk to a borrower's credit profile as it could force a liquidity event at an inopportune time in the credit cycle. Covenants are covered in further detail as part of Step 3, the analysis of an individual security.

Step Two: Security Structure and Terms

A key consideration of a particular bond investment is its terms and structure. Most investors tend to favor bonds that possess terms and structure that are in line with or better than market standard. However, as terms evolve and change with market conditions, portfolio managers must understand the implications and risks associated with alternative structures, and if acceptable, ensure that they are compensated appropriately.

The following factors must be carefully evaluated.

- Issue size
- Ranking/seniority

- Maturity
- Coupon type
- Early redemption features

Issue Size

The issue size of a bond will influence its liquidity and general attractiveness to other constituents in the market. For example, an issue size that is less than $250 million may have a smaller investor base and therefore less trading liquidity. To the extent there is a seller of this security, the downside impact to the market may be greater given the lower trading liquidity and a narrower universe of investors willing to purchase a small, less liquid security. Conversely, mega-issues (greater than $1 billion issue size) may experience greater price volatility. As they tend to be liquid "benchmark" issues in the high-yield market, they may exhibit higher beta during aggressive movements in the overall market, as institutional investors are able to more easily execute trades and express their market sentiment.

Ranking/Seniority

The ranking and seniority of a bond are vital factors in assessing the risk and attractiveness of a security. Ranking and seniority refer to the location of the bond within the issuer's capital structure as well as the priority of claim in the event of bankruptcy. The ranking and seniority range from and include: senior secured, senior secured second-lien, senior unsecured, senior subordinated, subordinated, and structurally subordinated. The more senior securities in the capital structure are generally accompanied by lower relative yields. Additionally, investors must ascertain the level of guarantees provided and where the tranches of debt sit relative to the assets of the company as well as the ranking within the capital structure. Portfolio managers should properly identify the risk associated with the ranking/seniority terms of the specific security so that they can determine the appropriate yield.

Maturity

A bond's maturity involves both technical and credit considerations. From a top-down perspective, an investor may be concerned with a significant rise in interest rates and, therefore, favor a shorter maturity option within a given capital structure. From a bottom-up perspective, an investor may be comfortable with the short-term prospects and liquidity for a given credit, but much less comfortable with the longer-term viability of the company and, therefore, favor a shorter maturity option within a capital structure with multiple maturities. Lastly, uncommon maturity terms may lead to greater price volatility given the potentially smaller investor base interested in a "non-standard" bond. High-yield bonds have historically been structured with final maturities of between 7 and 10 years. More recently, however, issuers have come to market with longer maturities of 11 and 12 years to take advantage of the low interest-rate environment. These uncommon maturities have thus far been met with mixed results.

Coupon Type

While the high-yield market consists primarily of cash-pay bonds, alternative structures also exist, including: zero coupon, pay-in-kind (PIK), or PIK toggle. While the alternative structures tend to offer higher yields as a result of the less investor-friendly repayment terms, they also typically possess greater trading liquidity risk as they tend to appeal to a much smaller investor base within the high-yield universe.

Early Redemption Features

Early redemption features are common within the high-yield market. For example, the most typical bond structures are 8-year, noncall 4, or 10-year, noncall 5. This type of security is not callable for the first half of its life, but then is callable at the company's option and according to a schedule that pays a premium to face value which declines as it nears final maturity. More recently, issuers have come to market with less call protection in exchange for a small, additional premium. Portfolio managers must be careful in evaluating early redemption features that may have a significant impact on returns as they can limit a bond's potential upside.

Step Three: Covenants

Contained within the indenture of all high-yield bond offerings are certain covenants (or agreements) between the issuing company and bondholders. Covenants are essentially restrictions on the borrower/issuer imposed by the lender/bondholder that require the company to do or refrain from doing certain activities. The covenants are primarily designed to protect bondholders against credit deterioration that would hinder the company's ability to service the interest and repay the obligations on a timely basis.

Covenants are often referred to as "tight/strong" or "loose/weak," depending on the specific terms and ultimate financial flexibility they provide the issuer. A weak covenant package can significantly increase the risk of a high-yield bond investment, even though the credit's business and financial risk profiles can be strong. As a result, the covenant package may not protect the bondholders by prohibiting enough actions by the issuer that could be detrimental to its ability to repay the bonds and service the interest.

Covenant analysis is a crucial part of any high-yield bond investment process. While a strong covenant package cannot offset the risk of a weak credit, it may provide significant financial protection to the investor. A weak covenant package may not necessarily preclude investment in a particular issue; however, it may increase the yield an investor demands due to the higher level of risk.

From an investment standpoint, there are four key covenants to analyze, as follows: Limitation on Indebtedness, Restricted Payments, Change of Control, and Limitations on Asset Sales.

Limitation on Indebtedness

The limitation on indebtedness covenant restricts the amount of additional indebtedness that an issuer can incur. Unless it is kept in proportion to operating cash-flow and assets, additional indebtedness can ultimately dilute the claims of the existing bondholders and weaken the credit profile of the company due to the increased debt-service requirements.

Restricted Payments

The restricted payments covenant protects bondholders' interests in the assets of the company by restricting the company's ability to distribute money or assets outside the company, thereby preserving the company's ability to repay its indebtedness. Undesirable distributions and asset transfers that are limited by this covenant include dividends, repurchases of equity, investments in unrestricted third parties, and retiring debt that is subordinate to the bonds before retiring the bonds. It is important to recognize that the restricted payments covenant does not limit acquisitions and capital expenditures, both of which should result in incremental cash-flow and return on investment. The test is ultimately backward looking in that it determines whether the company has earned the right to make a payment to benefit the equity of the company as opposed to the debt.

Change of Control

The change of control covenant requires the issuer to offer to purchase the debt at 101% of principal if a change of control occurs. It is the bondholder's option to accept or decline the offer. In effect, this covenant gives a put option to the bondholder upon certain events. The rationale behind the change of control covenant is that it protects bondholders against a change in controlling interest by an owner who may have a different financial strategy for the issuer that could ultimately lead to deterioration in credit quality.

Limitation on Asset Sales

In contrast to its title, the asset sale covenant does not necessarily limit the ability of the issuer to sell assets. Its true purpose is to define the acceptable use of proceeds from asset sales. The proceeds must be used to permanently repay debt or to reinvest in replacement assets. The rationale is that the assets sold usually generate earnings and cash-flow to service debt and should be replaced with similar assets.

Step Four: Risk Assessment Checklist

One of the key methodologies to optimize a portfolio is to use a checklist of variables that can help to identify hidden risk factors. Similar to a pilot who is required to perform a checklist before any plane takes off, portfolio managers should engage in a similar rigid review. Exhibit 52–5 is a list of 25 factors that

EXHIBIT 52–5

Risk Assessment Checklist

	Yes	No	
1.			PIK/Toggle in Capital Structure
2.			Triple-C Rated on Both Sides
3.			Project Finance
4.			144A For Life
5.			Fallen Angel
6.			2nd or 3rd Tier Underwriter
7.			Deal Size <$250mm
8.			Weak Covenant Package
9.			Recession Prone Industry
10.			Leverage >6× or > 85% of Enterprise Value
11.			Long Duration (>10yrs)
12.			Highly Cyclical Industry
13.			Weak and/or Distrusted Management
14.			High Risk Default Industry or Previously Defaulted Company
15.			Sponsor Has Poor Track Record With Bondholders
16.			Current or Projected Negative Free Cash-Flow
17.			Little or No Hard Assets
18.			Dividend Deal
19.			Middle Market Company
20.			Debt at Holding Company & Structurally Subordinated to Other Debt
21.			Down Quarter and/or Down Year Projected
22.			Lead Underwriter is Also an Equity Holder in the Company
23.			Poor Information Flow or Management Contact
24.			Covenant Violation Forecast in Next 12–24 Months
25.			Significant Refinancing Required in Next 2 Years
			TOTAL

can cause unexpected losses and volatility. The more indicators that flash negative, the greater level of risk associated with the investment. This checklist is by no means a complete listing of *all* potential risk factors. However, it is meant to highlight certain risks that perhaps garner less focus and attention from investors.

Step Five: Trading/Liquidity Factors

While credit analysis is focused on assessing the financial risk of a particular bond issue, the analysis of trading and liquidity risk evaluates the additional volatility that may be experienced by a bond issue. Trading liquidity can hamper the performance of a bond issue that may possess a favorable credit risk profile, but the far more significant risk is that a poor trading liquidity profile could dramatically magnify the downside risk of a weak credit. It may be already difficult to garner investment interest and new buyers in a weak or deteriorating credit; however, it is considerably more challenging to develop new demand in a weak credit that also possesses poor trading liquidity. For example, a disappointing earnings announcement could result in a two-point drop in bond price if the issue possesses favorable trading liquidity, whereas the same announcement could result in a five-point (or greater) drop in price if the bond possesses thin trading liquidity. Portfolio managers should have extremely high conviction level in credits with limited liquidity and require higher returns in those situations.

Liquidity Risk[2]

Liquidity risk involves measuring the ability to sell a particular credit on a timely basis. While equities often trade on an organized stock exchange or electronically and buyers and sellers are matched, high-yield bonds trade over-the-counter. Bond investors are dependent on broker-dealers to make a market. Also, unlike equities, the majority of high-yield bonds do not trade on any given day. An interesting analogy is to think of the high-yield market as being like a lake that is one mile wide, but only inches deep. If a particular high-yield bond has limited liquidity, portfolio managers may be unable to execute their buy/sell decisions.

Portfolio managers should take into consideration the following key elements to assess the liquidity risk of a particular bond.

1. *Public or private company:* Private companies often possess less liquidity than public companies because there is either not enough information about the company in the market or the information is not widely dispersed. For example, a potential purchaser of an unregistered bond (e.g., Rule 144A) issued by a private company can usually get information about the issuer only by

[2]This section is adapted from Mark R. Shenkman, "Principles of Managing High-Yield Assets," Chapter 12 in *Leveraged Financial Markets: A Comprehensive Guide to High-Yield Bonds, Loans, and Other Instruments.*

requesting it from the underwriter or trading desk. New purchasers may be reticent to ask for the information because they may signal to the trading desk their intentions to purchase the bonds, thereby causing the broker-dealer to raise its offered price for the credit.

2. *Number of market makers and number of analysts following the issuer:* The fewer professionals on Wall Street who trade or actively "follow" a bond reduce the available information on a company. Bond issues that have only one market maker and no analyst coverage may be so illiquid that they "trade by appointment" (meaning that a seller has to give an order to a broker-dealer who then tries to sell the bond over a period of time).
3. *Number of tranches of debt in the capital structure:* The more tranches, or issues, of debt that a company has outstanding, the higher the probability that more traders and analysts will follow a given credit. A large number of tranches provides more activity in an issuer because there are paired-trade possibilities, such as shorting senior bonds and purchasing subordinated bonds. The ability to trade across the capital structure in one credit increases the universe of investors interested in the bonds.
4. *Accessibility of management:* Bonds issued by companies with inaccessible management typically inhibit trading activity because investors lack sufficient information to give them comfort or conviction, particularly in volatile markets. If a management team is unwilling to talk when times are good, they are even more unlikely to talk when times are bad!
5. *CDX-listed issuer:* The CDX is a widely traded index of 100 Credit Default Swaps (CDS) that mirrors the broader high-yield market. The CDX, the underlying CDS, and the underlying bonds are all linked by the arbitrage that exists if the CDX becomes too cheap compared with the CDS or the actual bonds. Therefore, underlying bonds of CDS in the CDX tend to trade more frequently because investors may be executing arbitrage trades. Moreover, the price of CDX-listed issues tends to be more volatile because they are the most liquid credits.
6. *Volume of trading activity according to TRACE:* Broker-dealers are required to report high-yield bond trades to a self-regulating organization that makes some trade details of certain high-yield bonds publicly available. This system is called TRACE (Trade Reporting and Compliance Engine). Bonds that have a TRACE history typically have more liquidity because historical patterns and data points can be obtained and measured.
7. *Issuer is a major company within its industry:* Bonds of companies that have a real "presence" in their respective industries tend to have more

liquidity for two reasons. First, if the underlying company is a major part of its industry, it becomes a proxy for the industry and allows investors to obtain exposure to a sector. Second, high-yield traders typically like to own and trade the largest credits in an industry sector.

8. *Size of issue:* The universe of potential buyers of a bond typically increases with the dollar size of the issue. The larger pool of potential purchasers increases the ability of a bondholder to sell a particular issue.
9. *Ratings of issuer and issue:* Higher-rated credits within the high-yield universe tend to trade more frequently because they are perceived as being more stable and have greater demand. Triple-C rated issues generally require more work and conviction to purchase, causing traders to be less willing to hold a bond that investors may need more time to analyze.
10. *Crossover credits:* Bonds that generate demand from both investment-grade and high-yield buyers, such as utilities, offer greater liquidity. High-yield bonds that are considered crossover companies typically generate a new class of investment-grade purchasers who from time-to-time dip down and buy the high-yield bond tranche. With a larger universe of such buyers and sellers, liquidity often improves.

Based on these 10 criteria, each credit should be designated as L1, L2, or L3. L1 credits are traded by multiple market-makers on a daily basis; L2 names are typically traded by two or more market-makers on a weekly basis; and L3 credits trade a few times per month by one or more market-makers, which can result in an inability to execute on a timely basis. In many cases, an L3 bond can become an "orphan" credit if the original underwriter no longer covers or makes a market in the credit.

The percentage of the portfolio represented by L1, L2, or L3 liquidity ratings should be calculated and monitored to determine the appropriate weighting in each category.

Step 6: Relative Value

Relative value is the final step in the bottom-up security analysis process. Once the credit and liquidity risks of an issue have been determined and evaluated, then the overall expected risk premium for the security can be appropriately established. Spread analysis is typically the most appropriate metric in determining if the security's return is commensurate with its overall credit and investment risk.

Risk/Reward

Determining relative value in the high-yield market is more an art than a science. The age-old maxim "Buyer Beware" rings loudly in high-yield as all risk is not created equal! For example, it is much easier to compare and value the

risk of financial leverage across two credits than it is to determine how much incremental return or yield is required to compensate for the potential risk presented by significant covenant flexibility that can be utilized to the detriment of bondholders. Some investors use ratings (usually assigned by Moody's and/or S&P) to determine their credit risk and then evaluate the spreads on that basis. For example, a single-B rated issue yielding 500 basis points over riskless U.S. Treasuries may be considered attractive relative to another single-B rated issue yielding 350 basis points, or versus the current high-yield single-B index average spread of 400 basis points. However, in order to make this assessment, investors must assume that the credit ratings themselves are accurate, and that they are a "leading" indicator of credit risk. More importantly, investors should realize that credit ratings do not contemplate many of the investment risks discussed above, such as bond covenants, size of issue, quality of underwriter(s), number of market makers, Wall Street sponsorship, and information flow, to list a few. Relying on the credit rating alone to determine risk will not give a complete picture and can be a perilous exercise during certain stages of the credit cycle.

Comparables

The basic formula for assessing relative value is to compare the spread of the security being evaluated to the bond spreads of industry peers and other credits of similar risk. Exhibit 52–6 is a typical "comp sheet" that can help assess the relative value of one bond versus another.

Analyzing the credit comparable on the next page, it becomes apparent that Company C is a weaker credit. As compared to the other two companies, Company C has higher leverage, weak interest coverage, negative cash-flow, and significant near-term amortization for which it does not appear to have ample liquidity to address. Given the higher risk credit profile, the spread on Company C's subordinated notes is meaningfully wider than its comparables as one would expect. In contrast, Company A's stronger credit profile has resulted in a meaningfully tighter spread than its comparables. Although it also has substantial debt amortization in the current year, it appears to have ample liquidity (as measured by its cash and availability) to absorb the amortization. Credit comparables should include a snapshot of the trailing 12-month operating results as well as a forward looking credit profile for the next 12 months.

Quadrant Analysis

Many investors use credit ratings to determine risk and evaluate comparable spreads. Given the prevalence of ratings in the marketplace and their acceptance among market participants, portfolio managers should not rely on these ratings as a primary assessment of creditworthiness. Rather, portfolio managers should construct a more comprehensive risk assessment that can be tailored to incorporate factors they deem appropriate.

EXHIBIT 52–6

Sample Credit Comparable Analysis

Sample Credit Comp Sheet

LTM Period	Company A Current	Company B Current	Company C Current
Revenue	**6,000**	**800**	**3,500**
EBITDA	**1,000**	**140**	**430**
Margin	**16.7%**	**17.5%**	**12.3%**
Capital Expenditures (Capex)	350	11	180
Interest	250	80	288
Taxes	50	0	30
Cash-Flow	**350**	**49**	**(68)**
Working Capital Changes	50	(10)	0
Other (including acquistions/dividends)	0	0	0
Free Cash-Flow (FCF)	**400**	**39**	**(68)**
Financial Statistics			
EBITDA/Interest	4.0	1.8	1.5
(EBITDA-Capex)/Interest	2.6	1.6	0.9
Bank Debt/EBITDA	**2.8x**	**3.8x**	**2.6x**
Sr. Notes/EBITDA	**3.0x**	**3.8x**	**6.0x**
Sub. Notes/EBITDA	**3.0x**	**6.3x**	**7.2x**
Total Debt/EBITDA	**3.6x**	**6.3x**	**7.3x**
Net Debt/EBITDA	**2.9x**	**5.9x**	**6.7x**
Free Cash-Flow/Total Debt	11%	4%	–2%
% Total Debt/TEV	46%	—	99%
TEV/EBITDA	**7.9x**	**—**	**7.3x**
Liquidity			
Cash	750	60	250
Availability	650	50	275
Total Liquidity	**1,400**	**110**	**525**
Yr1 Amortization	270	12	15
Yr2 Amortization	70	11	500
Yr3 Amortization	70	11	15
Yr4 Amortization	70	11	400
Yr5 Amortization	70	11	15
Yr6+ Amortization	3,050	824	2,185

(*Continued*)

EXHIBIT 52–6

Sample Credit Comparable Analysis (*Continued*)

Sample Credit Comp Sheet

LTM Period	Company A Current	Company B Current	Company C Current
Capitalization			
Bank Debt	2,800	530	1,120
Sr. Notes	200	0	1,460
Sub Notes	0	350	500
Other Debt	600	0	50
Total Debt	**3,600**	**880**	**3,130**
Preferred	250		
Number of Shares	150	—	75
Stock Price	$37.00	—	$7.00
EquityMarket Cap	5,550	—	525
Total Enterprise Value (TEV)	8,650	—	3,405
LESS: Cash	(750)	(60)	(250)
LESS: Other Value		—	
Adjusted TEV	7,900	—	3,155
Bond Pricing			
Coupon	7.500%	9.500%	11.500%
Maturity	11/15/16	4/15/18	12/1/17
Moody's/S&P Ratings	B1/BB-	B3/B-	Caa1/B-
Price	**98.00**	**91.50**	**77.75**
Yield to Worst (YTW)	**7.91%**	**11.04%**	**16.65%**
Spread to Worst (STW)	458	730	1289
Spread per Unit of Net Leverage	161	125	192

Constructing a risk/return matrix can be helpful in determining a framework. Credits can be divided into four quadrants as shown in Exhibit 52–7 based on their level of risk and potential return. A description of each of these quadrants is as follows:

- *Quadrant I:* Solid credits with strong credit statistics, moderate leverage, and strong free cash-flow. Typical characteristics would include companies with predictable and improving cash-flows; deleveraging companies; and companies that have substantial assets well in excess of debt. Objective: Capital Preservation

EXHIBIT 52–7

Quadrant Matrix

- *Quadrant II:* Good credits with significant leverage that show stability and/or improvement in their credit profile via improved results and lower leverage. Quadrant II companies can appreciate or depreciate depending upon their ability to execute their business plans, and ultimate credit trend. These companies typically possess above average creditworthiness with adequate balance sheets and relatively weak asset value coverage of their total debt. Objective: Total Return
- *Quadrant III:* Weak credits with extremely high leverage and deteriorating or at risk credit trends. These credits have a small margin for error and, therefore, require higher yields to compensate bondholders for the additional risk. Typical characteristics include minimal to negative free cash-flow (best measured relative to total debt) and deteriorating credit statistics. They may also include relatively new companies, companies with large capital requirements, and companies with aggressive capital structures that utilize zero coupon, PIK or

PIK/toggle notes. Asset value coverage of total debt is typically weak. Objective: High Risk/High Return

- *Quadrant IV:* Troubled credits that are stressed or distressed and could be in actual or technical violation of covenants. Bonds are likely to be impaired and therefore should require much higher equity-like returns. Objective: Capital Appreciation

When assigning quadrants to specific credits, they should be evaluated with an emphasis on the prospective, forward-looking view because the markets are more focused on where a credit is going rather than where it has been. Portfolio managers who are better able to correctly forecast credit trends should outperform their peers. Placing too much emphasis on past results could ultimately provide a myopic risk assessment and thereby limit the risk/reward equation and relative value analysis.

Within the quadrant concept, spreads can be analyzed relative to credits within the same quadrant. Given the potentially wide spectrum of credit quality within a specific quadrant, issuers may be further subdivided into lower and upper quadrants for greater segmentation. Once quadrants have been assigned, portfolio managers should compare spreads of companies within the same quadrant that are most similar. When possible, comparisons should be to companies within the same industry and quadrant. Other relative considerations include trading history, stock and bank loan/CDS prices, and duration.

Scenario Analysis

Scenario analysis is another tool to better identify relative value and determine an appropriate investment recommendation. This analysis is particularly useful in circumstances with multiple outcomes or potential event risk.

In Exhibit 52–8, the subject company has just announced a significant acquisition, although financing has not yet been determined. After assessing the amount of flexibility provided by the company's existing covenants as well as taking into account current capital market conditions for debt and equity, the analyst can utilize a scenario analysis to determine a potential trading recommendation.

EXHIBIT 52–8

Scenario Analysis Example

	Probability	Bond Price	Yield-to-Worst	Spread-to-Worst	Leverage Ratio
Current Trading Level		98	8.3%	487bp	5.0x
Scenario A	75%	92	9.4%	596bp	6.3x
Scenario B	25%	99	8.2%	470bp	4.7x

Assumptions:
Scenario A: assumes 100% debt financed acquisition.
Scenario B: assumes acquisition is financed with 60% equity and 40% debt.

Given management's prior comments and long standing financial policy, the analyst has assigned a 75% probability to a debt-financed acquisition as opposed to a more balanced combination of debt and equity. Likely potential trading levels are then assigned to each of the scenarios above based on the pro forma risk profiles. This scenario analysis indicates that there is six points of potential downside on the higher probability outcome as opposed to one point of upside on the less likely outcome. Based on this analysis, the recommendation would likely be to sell or reduce the position if possible, or at least proceed with caution.

Trading History

To the extent an issuer has had bonds outstanding for a period of time, portfolio managers should examine the trading history of those bonds. Exhibit 52–9 provides a list of some key trading history questions.

Stock Prices

Since many lower-rated companies are over-levered, their bond performance oftentimes is highly correlated to their stock prices. In some cases, equity prices may be a leading indicator, and in other cases bond prices may lead the equity markets. In any event, equity prices (if it is public) of the specific credit, or its public peers and competitors, may have a significant impact on bond prices. As equity prices rise or fall, the equity valuation of the company changes, which essentially measures the degree of "equity cushion" on the specific credit. For example, a stock price that has declined 20% may signal that the implied asset value cushion relative to the bonds has also been dramatically reduced, thereby increasing the overall risk of the credit. If a portfolio manager is looking at two similar credits within the same industry and the same leverage ratios, he or she would rather own the company with the higher Enterprise Value-to-EBITDA valuation multiple because it ultimately implies greater asset value coverage and

EXHIBIT 52–9

Key Trading History Questions

What is the issuer's bond price history? If the bond has been volatile, in which case a higher risk premium may be more appropriate?
What is the issuer's bond spread history relative to the current spread? Is it at the tight end or wide end of its historical range? Is it aligned with the credit profile?
What is the issuer's bond spread relative to its industry or the high-yield index? How has this relationship trended over time? Is it at the tight or wide end of its historical range? Where is the price relative to where the current credit profile warrants?
What is the current spread level relative to the spread at issuance? Has it widened or tightened dramatically? Were the moves associated with a change in credit profile as opposed to more technical factors?

EXHIBIT 52–10

Enterprise Value-to-EBITDA vs. Leverage

Ent. Value as % of Total Debt:	200%	148%	135%	104%

thereby less risk (all other things being equal). In Exhibit 52–10, a company's leverage has not changed dramatically over the last four quarters, but due to a severe decline in the stock price, the enterprise valuation of the company has fallen. As a result, the enterprise value coverage of total debt has declined dramatically, and the credit risk has increased. The equity cushion is the lightly shaded area in Exhibit 52–10.

Examples such as this illustration are an important reason why portfolio managers should not take comfort in high implied levels of asset coverage based on the stock price and enterprise value. If equity investors no longer have a favorable view on the company's growth prospects, multiples may contract. Thus, it is important for the credit analysis to include alternate independent methods of asset and enterprise valuation, while monitoring and considering movements in the current public equity value. Although credit metrics may not change dramatically in the near-term, a forward-looking viewpoint of the equity valuation may be important in determining perceived enterprise value coverage and trading outlook. In Exhibit 52–10, the 104% enterprise value-to-total debt coverage in the fourth quarter (Q4) suggests that the bond requires equity-like returns as its implied asset coverage is weak.

Bank Loan Prices/CDS

Portfolio managers should monitor the price of the senior instruments in the capital structure as well as single-name CDS trends. Moreover, the lines between high-yield bonds and bank loans are increasingly blurring as the two markets

and investor bases converge. For example, if the yield on a company's term loan is too tight to the yield on its bonds, it may signify that one or both instruments are mispriced. In order to make an appropriate comparison, portfolio managers must evaluate both yields on an equivalent basis since the bank loan yield is floating rate and based on LIBOR, whereas the bonds are fixed-rate and based on comparably dated U.S. Treasuries. Monitoring CDS trends also provides a window into potential changes in market sentiment towards a particular issue. Given the illiquidity of many high-yield bonds, it is sometimes easier for investors to express their credit opinion on a given issue by trading CDS as opposed to the underlying bond. As such, market sentiment may sometimes be more quickly reflected in CDS price movement before it is evident in the bond. Evaluating and monitoring all securities within the capital structure is essential to good security selection.

Duration

Duration measures the price sensitivity to yield as well as the percentage change in price for a parallel shift in yield. The longer the duration, the more sensitive the price will be to interest rate fluctuations. Overall, bonds of equal maturity with higher yields will have shorter durations than lower yielding issues.

Duration is an important consideration in assessing relative value apart from its sensitivity to changes in underlying Treasuries and determining the appropriate level of additional compensation required for going further out on the curve. First, credit risk will naturally increase with longer dated maturities as there are many factors that can change a company's credit profile over time and have a more profound impact on a levered issuer compared with an investment-grade issuer. Second, to the extent there is near-term potential for a negative surprise, a longer duration bond should have more downside risk. As investors demand incremental yield to compensate for the risk, longer duration bonds should generally experience more downside risk.

TOP-DOWN HIGH-YIELD MARKET DRIVERS AND MACRO CONSIDERATIONS

While the bottom-up component of portfolio management should be the primary driver of security selection, it is important to incorporate a view on key macro top-down factors that will influence the markets as well as individual industries and credits. Understanding these drivers is necessary in evaluating past performance and building individual portfolios. Furthermore, macro considerations are a key component to providing the proper context for individual industry and credit allocations.

The high-yield market has eight primary drivers. The top-down (macro) component of the portfolio management process is further highlighted in Exhibit 52–11 and discussed below.

EXHIBIT 52–11

Top Down—High-Yield Market Drivers and Macro Considerations

Economic Outlook

All top-down macro views require some form of economic analysis. An assessment of current and expected future economic conditions is essential to portfolio management, as the performance of the economy has a significant bearing on the performance and profitability of the companies that make up the high-yield market. An analysis of the general economy usually begins with the business cycle. One determinant of industry allocation decisions is a forecast of whether the macro economy is improving or weakening. A forecast that differs from consensus can have a significant impact on strategy and performance. Economic indicators such as GDP, inflation, consumer sentiment, consumer spending, business investments, unemployment, housing, and ISM provide the necessary data to develop an informed viewpoint and forecast. Ideally, this data should be supplemented with primary research derived from direct management contact. Complementing economic data with primary research can provide a higher level of conviction in formulating an economic forecast. Furthermore, it may highlight risks in the consensus view and provide portfolio managers with an opportunity to add value and enhance returns. Once the economic outlook has been created, it is necessary to establish the impact of that forecast on specific industries as not all sectors are equally sensitive to the business cycle. For example, a negative economic outlook may warrant a higher weighting in defensive industries and conservatively capitalized credits. Conversely, a positive forecast would favor more economically sensitive industries and credits.

Interest-Rate Forecast and Federal Reserve Policy

Rising rates and tightening monetary policy tend to have a negative impact on fixed income investments. While high-yield has historically shown a relatively

low correlation to U.S. Treasuries as compared with many other fixed income asset classes such as investment-grade corporates, formulating an outlook on interest rates provides a framework for the construction of the portfolio. For example, if the interest rate forecast calls for a significant increase in interest rates, it may be appropriate to reduce a portfolio's exposure to low coupon, longer maturities and the most interest-sensitive lower-yielding credits. Additionally, from a credit perspective, certain industries that are highly sensitive to interest rates (such as financials) may face additional risk and technical pressure in a rising rate environment.

Equity Market Trends

Contrary to popular belief, the high-yield market has demonstrated a much higher correlation to the equity markets than to 10-year U.S. Treasuries. For the 20-year period ended February 2011, the high-yield market exhibited a –0.06 correlation to 10-year Treasuries versus a 0.58 correlation to large cap equity according to *StyleAdvisor*. Although high-yield is a fixed income vehicle, the meaningful risk premium over Treasuries absorbs much of the volatility in Treasuries to deliver more equity-like returns. As equity markets fluctuate, so does the ultimate equity cushion for debt investors. Stronger equity markets typically signify stronger outlooks and earnings momentum; however, they also signify stronger equity cushion and asset protection for bondholders. The opposite is true when equity markets are declining. These dynamics are amplified for highly levered companies. In the end, it is generally more difficult for high-yield bonds to perform well when the equity markets are declining. Portfolio managers should keep this dynamic in perspective when managing risk.

Corporate Developments

Just as corporate fundamentals drive returns on an individual issuer, broader trends in overall corporate developments influence the high-yield market as well. To illustrate, a strong equity market may drive many private high-yield companies to go public and use the proceeds to pay down debt (a positive credit event). Conversely, an overabundance of available credit may incentivize private equity sponsors to raise debt in order to fund dividends to the equity holders at the expense of existing bondholders. To the extent corporate development trends are occurring on a broader scale, it may positively or negatively impact the high-yield market as investors anticipate other issuers that are likely to undertake similar positive or negative actions.

Market Yield and Spread (Relative to Historical Averages and vs. Other Asset Classes)

In determining asset allocations for their larger, overall portfolio, investors will ultimately consider the relative yield and spread of high-yield bonds to historical averages as well as to other asset classes and investment alternatives.

This consideration provides an important perspective for high-yield portfolio managers as it is a key influence that drives overall demand in the high-yield market as well as the market technicals. In developing a relative perspective, portfolio managers should consider the following reference points and how they compare to historical ranges and averages:

- High-yield market spread over Treasuries
- High-yield market absolute yield
- High-yield market spread vs. investment-grade corporates
- High-yield market yield vs. dividend yield on the S&P 500

For example, if high-yield spreads are at all time highs, there should be strong technical pressure and ultimate demand to drive yields tighter as new buyers enter the market to take advantage of the opportunity. Additionally, if the incremental high-yield market spread over investment-grade corporates is at all-time historical tights, investors may decide that the incremental yield is insufficient, creating downside technical pressure.

High-Yield Market Supply/Demand

New issue supply and flow of funds play a meaningful role in the performance of the markets. While longer-term returns are more influenced by the overall corporate credit outlook and expected default rate, supply and demand characteristics may be difficult to forecast, but impossible to ignore. A record supply of new issuance can cause technical selling pressure on the secondary market in an otherwise fundamentally strong high-yield credit environment with low default expectations. Conversely, a lack of supply works to strengthen demand for existing issues in the secondary market and drive prices higher in a similar environment.

While new issue supply can easily be measured and monitored through multiple sources, demand is more difficult to ascertain. Although retail mutual fund flows are available on a weekly basis, they provide only a limited picture of the overall high-yield market demand. Retail mutual funds account for less than 15% of the overall high-yield market. Additionally, these funds may not accurately represent the sentiment of the larger institutional investors, which account for the majority of the high-yield market. While retail fund flows provide a window into overall demand, the largest high-yield managers with significant institutional assets can better measure demand through their own level of marketing activity and internal subscriptions/redemptions. Demand can have a significant impact on market returns, particularly in periods where new issue supply is limited.

Market Liquidity

Broker-dealers provide the liquidity needed to sustain active markets in high-yield securities. Over time, broader trends such as bank consolidation and new

foreign entrants have had an impact on market liquidity. More recently, due to the consolidation among broker-dealers which was triggered by the financial crisis, a few smaller firms focused solely on secondary trading have entered the high-yield market to populate the void created in consolidation post the financial crisis. Apart from the broader trends, the amount of capital provided to broker-dealer trading desks is a significant determinant of the ability to effectively trade in the high-yield market. For instance, a broker-dealer's senior management may decide (whether for macro concerns or company-specific circumstances) to "dial down" its risk exposure and hence limit the capital it provides to its high-yield trading desk. In turn, its traders become less willing to commit capital. As a result, investors may experience longer execution times, higher transaction costs, and greater price volatility. Market liquidity is also seasonal based on staffing and the new issue calendar. For example, late summer and periods surrounding holidays exhibit lower liquidity as broker-dealers operate skeleton crews and limit capital. Moreover, traders may be less willing to risk capital as they approach their fiscal year-end and thereby impact their year-to-date profit and loss. It is important for portfolio managers to understand both the secular and shorter-term trends that influence the ability to execute trades in the market.

Default Expectations

Since inception, the high-yield market's most important driver is default rates. In periods where default rate expectations are low, the high-yield market tends to perform well as the lower default expectations influence two important components of high-yield returns: risk premiums and default loss.

$$\text{Expected High-Yield Return} = \text{Risk-Free Rate} + \text{Risk Premium} - \text{Default Loss}$$

In an environment of lower default expectations, risk premiums as measured through credit-spreads should decline as investors are less concerned with default risk and willing to accept less yield, thereby driving bond prices up. Additionally, the lower expected default risk reduces the expected default loss, hence increasing the overall expected high-yield return. Portfolio managers can temper their portfolio risk tolerance based on their overall default expectations. For example, portfolio managers may be willing to assume more risk when the outlook for default rates are trending lower, whereas increasing default rates may warrant a more defensive posture.

PORTFOLIO CONSIDERATIONS

Portfolio considerations are the framework applied by the investment managers to ultimately decide which securities are most appropriate for inclusion in a given portfolio. They act as the filter to screen the potential investment universe

utilizing the bottom-up and top-down considerations discussed in this chapter. These portfolio considerations include:

- Client/portfolio objectives
- Risk tolerance
- Diversification
- Trading strategy
- Portfolio characteristics
- Risk controls
- Performance attribution

Client/Portfolio Objectives

Portfolio objectives are essential to providing the overall direction for portfolio construction and day-to-day investment decisions. A quote from poet Ella Wheeler Wilcox serves as a good analogy for the importance of these objectives. "One ship drives east and another drives west with the selfsame winds that blow. 'Tis the set of sails and not the gales which tells us the way to go." With respect to portfolio management, investment objectives serve as the sails to guide the portfolio in the proper direction. The most vital portfolio objectives are return target and risk tolerance. The client or portfolio manager must decide what the primary investment objective is (i.e., income generation, total return, benchmark "hugger," absolute return, or preservation of capital). Most portfolio managers have one primary objective and a secondary goal; for example, absolute total return as the primary objective and high current income as a secondary goal. The more clearly defined the objectives, the more likely the strategy will be effective and successful.

Risk Tolerance

In the universe of high-yield bonds, preserving capital and controlling risks are paramount factors in generating superior returns over a full credit and economic cycle. Calibrating the portfolio's risk tolerance goes hand-in-hand with the portfolio's investment objective.

For example, a total return strategy will necessitate a higher-risk tolerance, as managers must buy higher-yielding issues with greater risk premiums in order to achieve the high return objective. However, these greater returns and higher risk premiums will likely result in greater volatility of returns as well a higher probability of default loss. Ultimately, portfolio managers must clearly define whether their core risk tolerance is conservative or aggressive and maintain an unwavering style in the face of changing markets. Although it is feasible to beat the benchmark with a conservative strategy in a down market, or with an aggressive style in an up market, the combination of aggressive/conservative style outperforming in both bull and bear markets is extremely challenging and flawed. The lack of trading liquidity

and the unavailability of many issues in the high-yield market inhibits the ability of portfolio managers to shift between styles in a short time frame. While a portfolio manager's core strategy and risk tolerance must remain intact in order to succeed over an entire market or credit cycle, this should not preclude portfolio managers from increasing or decreasing their risk tolerance within their core conservative or aggressive strategy as market conditions change. However, these changes in risk tolerance must remain incremental as opposed to radical. Success is measured by achieving the highest risk-adjusted returns over an entire market or credit cycle.

Diversification

A key factor in reducing risk and helping to achieve return objectives is diversification. Diversification should not simply be measured by the number of investments held in a portfolio, but must be evaluated on many critical levels in order to appropriately manage and lower the overall risk. One of the most common mistakes portfolio managers make is that they "fall in love" with an industry and/or a credit and fail to properly diversify their high-yield portfolios.

There are several key factors to take into account in assessing a portfolio's diversification including:

- Issuer concentration
- Industry concentration
- Risk
- Liquidity
- Duration

Issuer Concentration

Diversification by issuer should be measured on several levels. Number of holdings and average position size are one of the most important diversification measures. Some investors may believe that a more concentrated "best ideas" approach to portfolio management (<35 issuers) will achieve the highest returns; however, it may do so at a much higher level of risk given that the most severe credit losses tend to be the unexpected ones. Conversely, some portfolio managers may believe that a large number of holdings (>200 issuers) provides greater protection against individual loss as well as smaller tracking error versus a given benchmark; however, this is typically more of an index fund approach and it is difficult to argue that a portfolio manager is adding much value in this scenario. Ultimately, a properly diversified portfolio should target position sizes of 1% to 2% on average per name in order to balance the benefits of diversification with the opportunity for greater value added. It is important to remember that larger portfolios will, by necessity, be forced to hold many more issues as their size limits the desired amount of a given issuer that can be held. In addition to the number of holdings and average position size, individual issuer limits and top 10 concentrations should also be considered. In a properly diversified portfolio, most portfolio

managers should maintain diversification percentages with limits of no more than 3% per issuer, and the portfolio's top 10 holdings should not exceed 25% of the portfolio. Portfolio managers must also make certain that their top 10 positions generate the best returns. If the top positions are underperforming, it is extremely difficult to achieve superior results.

Industry Concentration

Industry concentration levels should be held to no more than 15% to 20% and should be reserved for those industries with the strongest technical and fundamental characteristics. Additionally, the portfolio's five largest industry weightings should represent less than 50% of the total assets. Proper diversification should not only reduce a portfolio's volatility, but these weightings should help mitigate the effect of unexpected announcements by an issuer or events that affect an industry in general.

Risk

Managing risk is a critical role of the high-yield portfolio manager. Most investors look to evaluate the ratings (e.g., Moody's/S&P) distribution of the portfolio and monitor concentrations across the ratings categories. However, portfolio managers should maintain their own proprietary framework for evaluating and monitoring credit risk exposure and concentration. Another important risk factor is to identify and monitor the percentage of holdings by the lead underwriter, senior lender, and private equity sponsor. Lead underwriters and senior lenders are important because not all underwriters and lenders are equally committed to the asset class. Some underwriters-brokers are active in high-yield when there is a bull market and abandon their efforts when the market declines, leaving the purchaser holding an orphaned bond. Moreover, broker-dealers possess varying degrees of capital on their trading desks. Private equity sponsors, meanwhile, have track records that cannot be ignored. Some private sponsors are known for frequently taking major dividends out of their LBO companies, thus leaving the entities more leveraged with no benefit to the debt holders. Overconcentration in any of these factors could jeopardize performance over the long term.

Liquidity

Liquidity risk involves measuring the ability to sell a particular credit on a timely basis. If a particular high-yield bond has poor liquidity, a portfolio manager may be unable to execute a buy/sell decision. The percentage of the portfolio represented by L1, L2, or L3 liquidity ratings should be calculated and monitored. Concentration in L3 credits that trade sporadically should be a key focus as the downside risk to these holdings is amplified by their illiquidity.

Duration

For the reasons discussed above, a bond's duration is an important driver of its volatility. Portfolio managers must consider their overall exposure to both longer

and shorter duration bonds. Concentrations in either category can position the portfolio either more defensively (short duration) or more offensively (long duration). It is important to evaluate these concentrations and ensure that they are aligned with the portfolio manager's overall market outlook and portfolio objective.

Trading Strategy

Portfolio managers generally have trading styles that capture their bias toward generating short-term trading profits versus focusing on longer-term outperformance over an entire credit cycle. Given the significant transaction costs and liquidity limitations of the high-yield market, short-term trading can be costly. Furthermore, it incorporates a greater degree of risk associated with attempting to time the market that can impact long-term performance. Regardless of the type of trading strategy, portfolio managers must develop and adhere to a buy and sell discipline that reflects their style and philosophy.

Buy Discipline

In executing a buy decision, a step-by-step process is required to ensure consistency and disciplined decision making. It is critical for portfolio managers to employ a rigorous bottom-up credit/security selection process complemented by top-down macro considerations. Portfolio managers should not sacrifice this process in the name of expediency or believe they might miss a "hot" opportunity. If there is not sufficient time to complete adequate diligence on a particular issue, the investment should not be made. The optimal investment should exhibit positive characteristics across all six of the key security analysis steps discussed above and align with the overall investment objectives and risk tolerance of the portfolio. For example, portfolio managers should bifurcate the decision of whether the company is a good credit from whether the credit's bonds are attractive on a relative value basis.

Sell Discipline

Having a disciplined sale process is crucial for high-yield investing. Knowing when to sell is often times more important than knowing what to buy because losses are typically greater than gains due to the call constrained feature inherent in most high-yield bonds. The ability to execute a sell decision can separate an average portfolio manager from an extraordinary one. The three primary reasons to sell a bond are:

- Credit deterioration
- Relative value (risk/reward imbalance)
- Management drift

Strong credit analysis and continuous in-depth monitoring are key components of managing credit risk as the security analysis process does not end once a security is purchased.

Credit Deterioration. If a credit is undergoing (or forecasted to undergo) a fundamental change that may significantly increase the risk of default, the security should be sold. The more proactive a portfolio manager is, the higher the overall portfolio return as price deterioration and default loss are minimized.

Relative Value. While fundamental reasons should always be the most significant sale criteria, relative value and managing the risk/reward balance are vital factors in driving long-term returns. For example, an issuer may not necessarily be at near-term risk for default, but if its risk profile has increased (or is forecasted to increase) materially, there may be a sale opportunity if yields have not yet reflected this concern. Conversely, if a credit's yield has tightened well beyond the assessed risk, the bond should also be considered for sale. Lastly, credits that have shown significant improvement in their credit risk profile may no longer offer attractive yields. Although the credit profile may now be much stronger, an investment-grade credit profile may not be appropriate for a high-yield portfolio objective.

Management Drift. As previously discussed, the quality of the management team is a significant factor in analyzing a company. The leadership and veracity of management are paramount in making this assessment. To that end, bonds of a company where the management team deviates from its previously stated goal(s) or misleads investors must be sold. These management teams present a higher level of risk that is difficult to assess or quantify.

Red Flags

An important complement to a strong sell discipline is to have a process for uncovering potential risks that may not have been uncovered through traditional monitoring. Price drift and credit drift are two key elements to monitor. Bond prices should be monitored for declines and necessitate automatic reviews for declines of 10%. While ongoing credit analysis may not have uncovered a significant enough change in risk to justify the price movement, it is important discipline for the manager to appreciate and understand the reason for the movement. Credit drift is also an important element to monitor. For this purpose, the credit drift to monitor should be based on the proprietary method by the portfolio manager as discussed above. Reacting to changes in the major rating agencies' (e.g., Moody's and S&P) published credit ratings will invariably be a poor strategy as the market may have already priced-in the revised published credit ratings.

Portfolio Characteristics

A key element of portfolio management is monitoring and evaluating all of the portfolio's holdings. Some of the characteristics to monitor include yield-to-worst, spread-to-worst, average price, ratings, and risk, as well as the diversification considerations discussed above. Monitoring a portfolio's characteristics is an

important tool in portfolio management as it helps ensure a portfolio's holdings are in line with macro considerations and portfolio objectives as opposed to solely a result of bottom-up selection. Daily and weekly review is necessary so that portfolio managers can make informed decisions based on actual facts that reflect changes in the market rather than "seat-of-the-pants" intuition. Organized, customized, and detailed reports showing percentages and variance calculations are essential for critical decision making.

Risk Controls

One of the keys to avoiding significant losses is to establish firm risk control procedures and to develop and maintain a formal credit review process that examines the key risk factors covered in this chapter, namely credit risk, liquidity risk, and portfolio/diversification risk.

Risk controls are typically talked about but are seldom enforced in many money management organizations. Most times, organizations undertake serious, comprehensive risk controls only after a crisis. However, portfolio managers should carefully measure and monitor all three types of risk. Implementing a front-end compliance system to monitor key parameters is a critical tool for controlling risk and helping to guide a portfolio's alignment with its objectives. A front-end compliance system typically involves an integrated portfolio management and trading system in which portfolio constraints and limitations are categorized and monitored real-time. As a result, a portfolio manager is unable to enter a trade order that does not comply with the portfolio's guidelines or risk tolerances. A comprehensive front-end compliance system compares much more favorably to back-end compliance systems, which only capture violations or higher than desired exposures once a trade has already been executed. Monitoring portfolio concentrations and diversification is also another important element of risk controls.

Performance Attribution

Performance attribution is an important tool that enables portfolio managers to assess individual performance and refine the strategy. The objective is to break down the variance between a portfolio's active returns and the returns of the passive market into various segmented detail for further analysis. This analysis serves to illuminate the portfolio manager's decision-making process and reveal factors that benefited or detracted from performance for a given period. It is important to identify the many flaws inherent in utilizing a passive market index as the benchmark, particularly in high-yield, where the relative illiquidity of its underlying constituents makes the index nearly impossible to replicate in practice. Performance attribution serves as a helpful reference for portfolio managers to better understand the results of their investment decisions as well as to guide future adjustments to the portfolio.

KEY POINTS

- High-yield bonds are a unique and dynamic asset class that combine the characteristics of both fixed income securities and equities. As such, the overall approach to managing a high-yield portfolio must involve an inherent underlying focus of the three key risks: credit risk, liquidity risk, and portfolio risk.
- High-yield portfolio management incorporates three key focus areas: (1) bottom-up credit/security analysis; (2) top-down high-yield market drivers and macro considerations; and (3) portfolio considerations. All three elements are critical to effective portfolio management and the individual security selections occur at the intersection of these focus areas.
- The bottom-up credit/security analysis serves as the foundation for the investment decision. While credit analysis is arguably the most important component of the investment process, security structure/terms, covenants, trading liquidity factors and relative value ultimately determine if a "good credit" will make for a "good investment." It is important to emphasize that all of the bottom-up steps are significant in their own right, and that a favorable assessment on many of the steps may not necessarily outweigh an individual risk component that is identified in the process.
- Understanding and evaluating the top-down high-yield market drivers and macro considerations are another critical component of high-yield portfolio management. While the bottom-up component of portfolio management should be the primary driver of security selection, it is important to incorporate a view on key macro top-down factors that will ultimately drive/influence the high-yield market as well as individual industries and credits.
- Portfolio considerations are the framework applied by the portfolio manager to ultimately decide which securities are most appropriate for inclusion in a given portfolio. They create the filter that is used to screen the potential investment universe utilizing bottom-up and top-down considerations.
- The high-yield market offers favorable return opportunities, but investors must also remember the old adage: The greater the return, the greater the risks! Selecting securities with the highest yields is easy. Delivering consistent and superior risk-adjusted returns with lower volatility is what sets apart the best portfolio managers from the average.
- High-yield securities earn interest on weekends and holidays, while equities do not.

CHAPTER
FIFTY-THREE

INTERNATIONAL BOND PORTFOLIO MANAGEMENT

KARTHIK RAMANATHAN
Senior Vice President
Fidelity Management and Research Company/Pyramis Global Advisors

JAMES M. GERARD
Quantitative Research Analyst
Fidelity Management and Research Company/Pyramis Global Advisors

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

This chapter will focus on international bond investing and the many complex factors portfolio managers need to consider when allocating assets to this sector of the fixed income market. After addressing the fundamental building blocks of international portfolio management, including currency risk and benchmark selection, the tools used to generate excess return are described, including management of currency exposure, interest rate management, and sector and security selection.

Strategic and tactical asset allocation are then defined from a fundamental-based investment approach, which leads to the central topic of portfolio construction. Portfolio construction encompasses many components and must fully address the interactions between risk factors active in international bonds. Each component of risk, including currency, interest rate, and security selection, can be broken down analytically. Since the decision to hedge currency risk is the most important determinant of risk and return facing a portfolio manager, the subject is considered in detail before turning to a discussion of the determinants of forward rates and an example of break-even analysis. The analytical foundation of these sections is the framework used by international bond portfolio managers to support investment decision-making, attribute performance, and assess portfolio exposures.

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While many of the examples and illustrations in this chapter apply to international investing from the perspective of a U.S. manager investing in bond markets outside the United States, it is important to keep in mind that the principles apply to any cross-border manager investing outside his domestic bond market. The same issues faced by U.S. managers regarding currency management apply to managers throughout the world when they invest in bonds in which the cash-flows are not denominated in their local currency.

Furthermore, to provide a broad overview of the many aspects of international fixed income investing in one chapter implies that many topics do not receive the depth of discussion they deserve. For example, the topic of currency management is extensive and continues to be a subject of significant debate. We provide only an overview of the fundamental principles here.

OVERVIEW OF INTERNATIONAL BOND MARKET INVESTING

As the breadth and liquidity of fixed income markets outside of the United States continues to grow, investors have increasingly included these securities in their portfolios. These allocations to international bonds offer portfolio diversification and broader opportunities for adding returns. Moreover, as the sophistication of investors evolves through broadened research coverage, robust risk analytical systems, and increased competition for returns, ignoring opportunities in this investable universe simply is not an option.

Many substantial shifts have occurred which have also increased the prominence of global bond markets. The Brady bond market, which resulted from the Latin American crisis of the late 1980s, and the Asian debt and currency crisis, which led to multiple sovereign defaults in the 1990s, gave way to the use of a common currency in Europe in 1999.

Some investors were concerned that the diversification benefits of global bond investing would be diminished by the commencement of the European Monetary Union (EMU) in 1999. But in fact the economies of continental Europe were already very closely tied together before the EMU, with most European central banks following the interest-rate policies of the German Bundesbank for several years before the move to a single currency.

Thus the impact on diversification of a global bond portfolio caused by the EMU was minimal. EMU, however, created a more robust credit market in Europe as issuers and investors, no longer confined to their home markets, access a larger, more liquid pan-European bond market. Corporate bond issuance increased sharply in Europe, and led toward a broader range of credits and instruments similar to those available in the U.S. bond market.

Just as the EMU was a major focus in the early part of the decade, the rise of Asian bond markets once again broadened the investment opportunities in global bond markets. Major sovereigns including South Korea, Mexico, and Brazil are regular issuers in the bond markets. Importantly, corporations and other

institutions within each country are available to access liquidity in both local and non-local currencies.

As the Chinese economy continues to open to investors, and liberalization of the financial system proceeds, offshore and onshore currency trading in the Chinese renminbi will continue to propel this growth. This massive growth in the local currency debt market—and the potential returns associated with both lower interest rates and currency appreciation—have given investors many reasons to enter the international bond markets.

At the same, while the benefits of investing in international bonds certainly are apparent, the risks associated with investing in these markets need to be well understood. Given the many bouts of volatility and capital losses that investors have faced in the past few decades, an allocation to this sector requires a more robust investment process. Management of an international bond portfolio poses more varied challenges than management of a domestic bond portfolio. Differing time zones, local market structures, settlement and custodial issues, and currency management all complicate the fundamental decisions facing every fixed income manager in determining how the portfolio should be positioned with respect to duration, sector, and yield-curve.

The fundamental activities in any investment management process are setting investment objectives, developing and implementing a portfolio strategy, monitoring the portfolio, and rebalancing the portfolio as needed. A well-defined, disciplined investment process is needed to address the additional complexities posed by cross-border investments versus those faced in domestic bond markets. Addressing these challenges is crucial to the investment management process.

INVESTMENT OBJECTIVES AND POLICY STATEMENTS

Most investors are attracted to global bonds as an asset class because of their historically higher returns than U.S. bonds. Others are drawn to global bonds because of their diversification value in reducing overall portfolio risk. An investor's rationale for investing in international bonds is central to developing appropriate return objectives and risk tolerances for a portfolio.

Broadly speaking, investor specifications include return objectives and risk tolerances. Each of these investment objectives has implications for the management of an international bond portfolio and should be reflected in the investment policy statement.

Global bonds initially were just a small part of an overall portfolio added for both return and diversification. As investors have gained a better understanding of international bond markets over the past two decades, allocations to the asset class have increased. The strategic asset allocation for a portfolio is made up of benchmarks that both define the asset class and provide a performance target that each investment manager strives to outperform. Return objectives often are expressed in terms of the benchmark return, for example, benchmark return plus 100 basis points over a market cycle.

The return objectives and risk tolerances will indicate not only the most appropriate benchmark, but also the most suitable investment management style. Investors who are concerned primarily with diversification may wish to place tight limits on the sizes of positions taken away from the benchmark to ensure that diversification is not weakened. A total-return-oriented investor might be far less concerned with diversification and focused on absolute return rather than on benchmark relative return.

Investment policy statements should be flexible enough to allow the portfolio manager sufficient latitude for active management while keeping the portfolio close enough to the benchmark to preserve the desired top-down asset allocation. The policy statements should address allowable investments, including:

1. The countries in the investment universe, including emerging markets
2. Allowable instruments, including mortgages, corporate bonds, asset-backed securities, and inflation-adjusted bonds
3. Minimum credit ratings
4. The currency benchmark position and risk limits
5. The use of derivatives such as forwards, futures, options, swaps, and structured notes

The time horizon for investment performance is also important. A short-term time horizon, such as a calendar quarter, may encourage more short-term trading, which could diminish the natural diversification benefit from international bonds as an asset class. Investors who emphasize the risk-reduction or diversification aspect of international bond investing should have a longer time horizon of perhaps three to five years. Since economic cycles can be prolonged, this provides enough time for a full economic cycle to add any diversification benefit.

Benchmark Selection

Benchmark selection for an international bond portfolio has many ramifications and should be done carefully. As is the case when choosing an international equity benchmark index, the choice of a pure capitalization (market value) weighted index may create a benchmark that exposes the investor to a disproportionate share in the Japanese market given the enormous size of the market relative to the investor's liabilities or diversification preferences. A global bond portfolio, which for a U.S.-based investor includes some allocation to dollar denominated domestic debt in addition to international debt, could increase the investable universe for bond managers—but returns and even diversification benefits could be reduced.

While international equity indexes chosen for benchmarks are most often quoted in the investor's local currency (i.e., unhedged), international bond benchmarks may be hedged, unhedged, or partially hedged, depending on the investor's objectives. The choice of a hedged, unhedged, or partially hedged benchmark

likely will alter the risk and return profile of the investment portfolio and should reflect the rationale for investing in international bonds.

Available Benchmarks

Benchmarks can be selected from one or a combination of the many existing bond indexes:

- Global (all countries, including home country)
- International (ex-home country)
- Government-only or GDP weighted
- Multisector or broad (including corporates and mortgages)
- Currency-hedged
- G7 only
- Maturity constrained, e.g., one to three years, three to five years, seven to ten years
- Emerging markets

Alternatively, a customized index or "normal" portfolio can be created. Some frequently used fixed income benchmarks are the Citigroup World Government Bond Index (WGBI) and the Barclays Capital Global Aggregate Bond Index. The benchmark often provides both the return objective and the measure of portfolio risk. Tracking error, the difference between the performances of the portfolio versus the benchmark, is one such measure of portfolio risk.

Benchmark Currency Position

Currency management is a matter of much debate in the academic literature. Investing internationally naturally generates foreign currency exposures. These currency exposures can be managed either passively or actively, although most global bond managers use active management to some degree.

Many managers are attracted to active currency management because of the large gains that can be attained through correctly anticipating currency movements. Since currency returns are much more volatile than bond market returns, even modest positions in currencies can result in significant tracking error. Some bond managers handle both bond and currency exposures, assuming that the same fundamental economic factors influence both bond yields and currency levels.

However, bonds and currencies frequently behave quite differently in reaction to the same external stimulus. As a result, actively monitoring and managing currency risk is in itself a significant role. Both the risks and opportunities posed by currency movements suggest that some specialization in currency is warranted, particularly as the allocation to international bond markets increases. For bond portfolios, exchange rate risk dominates overall volatility contributing up to

95% of total unhedged return volatility, explaining why practitioners tend to view hedging exchange risk in bonds as much more important.[1]

The first task is to determine the neutral or strategic foreign currency exposure appropriate for the investment objectives. Some of the academic research on currency hedging for U.S. dollar–based investors suggests that the risk-minimizing currency strategy for a global bond investor is close to a full currency hedge, with a modest long position in the U.S. dollar.[2] In fact, currency hedging is sometimes described as a "free lunch" based on the argument that currencies add only volatility, but have zero expected returns.[3]

Other studies suggest that a partially hedged benchmark offers superior risk-adjusted returns as compared with either a fully hedged or unhedged benchmark.[4] This latter research has led some to recommend a 50% hedged benchmark for either a passively managed currency strategy or as a good initial hedged position for an active currency manager. Interestingly, a 2004 survey by Russell/Mellon indicated that only about 13% of institutional investors use hedge ratios other than 0%, 50%, or 100%.[5] Once the benchmark has been selected, a suitable currency hedge position needs to be determined.

For example, a U.S. dollar–based fixed income manager whose primary goal is risk reduction might adopt a hedged or mostly hedged benchmark that has historically shown greater diversification benefit from international bonds. Despite a higher correlation with the U.S. bond market than unhedged international bonds, hedged international bonds offer better risk reduction owing to a lower standard deviation of bond returns than a U.S.-only bond market portfolio.[6]

In addition, this lesser volatility of hedged international bonds results in more predictable returns. Conversely, an investor who has a total-return objective and a greater risk tolerance would be more likely to adopt an unhedged or mostly unhedged benchmark and allow more latitude for active currency management.

From the perspective of a U.S. investor, Exhibit 53–1 shows that for the 25 year period 1985–2010, the currency component of investing in unhedged international bonds accounted for much of the total return volatility. The international bond index used is the Citigroup WGBI excluding the United States (denoted by "non-U.S. WGBI").

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1. Jochen M. Schmittmann, "Currency Hedging for International Portfolios," IMF Working Paper 10/151 (June 2010), p. 12.
2. John Y. Campbell, Karine Serfaty-De Medeiros, and Luis M. Viceira, "Global Currency Hedging," *Journal of Finance* 65(2010), pp. 87–121.
3. Andre F. Perold and Evan C. Schulman, "The Free Lunch in Currency Hedging: Implications for Investment Policy and Performance Standards," *Financial Analysts Journal* 44 (May/June 1988), pp. 45–50.
4. See Gary L. Gastineau, "The Currency Hedging Decision: A Search for Synthesis in Asset Allocation," *Financial Analysts Journal* (May–June 1995), pp. 8–17 for a broad overview of the currency hedging debate.
5. Campbell, Serfaty-De Medeiros, and Viceira, "Global Currency Hedging," p. 4.
6. Recall from modern portfolio theory the important role of correlation in determining the benefits to diversification.

EXHIBIT 53–1

Hedged and Unhedged Returns: 1985–2010

		Non-U.S. WGBI	U.S.	Non-U.S. HEDGED	50% HEDGED
1985–2010	Return	9.57%	7.71%	7.14%	8.46%
	Volatility	10.04%	4.95%	3.25%	5.97%
	SR	0.51	0.66	0.84	0.67
1985–1998	Return	13.23%	9.75%	9.11%	11.28%
	Volatility	10.85%	4.96%	3.63%	6.49%
	SR	0.66	0.77	0.89	0.82
1999–2010	Return	5.46%	5.37%	4.90%	5.26%
	Volatility	8.92%	4.88%	2.62%	5.19%
	SR	0.30	0.54	0.83	0.49

Data obtained from Fidelity Investment Management and Research, Citigroup World Government Bond Index data.

Investing in international bonds on a hedged basis reduced the return in most periods but also substantially reduced the return volatility. As can be seen in Exhibit 53–1, over the 25-year history of the WGBI, hedged international bonds returned less than unhedged international bonds and even lagged the U.S. component of the WGBI slightly. However, the volatility of the hedged non-U.S. WGBI was lower than that of the unhedged index and that of the U.S. component.

To compare returns on a risk-adjusted basis, we can use the Sharpe ratio.[7] Despite the higher return of the unhedged non-U.S. WGBI, its risk-adjusted return was lower than the hedged index and the U.S. bond component alone for the whole 1985–2010 period.

As noted earlier, using a 50% hedged portfolio offers a compromise in that its return is virtually midway between the return of the unhedged non-U.S. WGBI and the U.S. bond component, with substantially lower volatility than the unhedged index, giving it a higher Sharpe ratio than the unhedged index. Of course, the relative performance of the hedged versus the unhedged index depends on the performance of the home currency (here the U.S. dollar), which can experience long cycles of strength or weakness.

The advantage of using a partially hedged benchmark versus a fully hedged or fully unhedged benchmark is illustrated in a mean-variance framework in Exhibit 53–2. We began by assuming that we could invest in any combination of the four asset classes highlighted in Exhibit 53–1. We used the (unweighted)

7. The Sharpe ratio measures returns in excess of the risk-free rate per unit of standard deviation. In the Exhibits, the risk-free rate is taken to be the three-month Treasury bill rate.

EXHIBIT 53–2

Risk-Return for Unhedged and Hedged International Bond Portfolios (U.S. Investor Perspective) 1985–2010 Historical Returns

Data obtained from Fidelity Investments, Citigroup World Government Bond Index data.

sample returns, variances, and covariances of the four portfolios to construct the overall efficient frontier, and overlaid two subfrontiers that constrain the holdings to U.S. bonds + WGBI ex-U.S. (hedged), and U.S. + WGBI ex-U.S. (50% hedged).

From the standpoint of the U.S.-based investor, it is clear that adding an increment of 50% hedged global bonds substantially increased the overall portfolio return over the period, while keeping total portfolio risk very close to that of the U.S.-only portfolio. Indeed, in the neighborhood of U.S.-only portfolio risk, the U.S. + WGBI ex-U.S. (50% hedged) combination turned out to be very close to optimal.

It is important to keep in mind that these historically constructed efficient frontiers are more of an illustration than a guide to long-run portfolio construction. For example, the last row of Exhibit 53–1 shows how much the relationship between the hedged and unhedged portfolios have moved with time. The impetus for this move, of course, has been the secular global rates rally that has been in progress for most of the WGBI's history. Also note that the financial crisis of 2007–2009 greatly upset traditional correlations among all asset classes, including currencies and interest rates.

Returns of partially hedged U.S.-based global bond portfolios have also benefited from the trend of depreciation in the U.S. currency relative to other major global currencies, particularly since the establishment of the EMU. With the convergence of global rates, and the likelihood of future—possibly significant—rate increases, global portfolio managers are going to have to adapt their country allocation and currency risk strategies. The sections to follow outline the analytical foundations of strategy formation.

Risk Limits

Many investment guidelines will include explicit risk limits on bond and currency positions as well as duration and credit risk. Exposure limits can be expressed either as absolute percentages or as weights relative to a benchmark. Increasingly, tracking error limits also have been used to set risk limits in investment guidelines.

Limits on investment in countries outside the benchmark should be specified at the outset. Despite the pitfalls of using duration to measure interest-rate risk across countries,[8] risk limits on duration are nonetheless useful and should be established. The range of allowable exposures is often wider for bond exposures than for currency exposures.

Credit-risk limits, usually a minimum-weighted-average credit rating from the major credit rating agencies, and limits on the absolute amount of low- or non-investment-grade credits also should be included. Apart from default risk, the illiquidity of lower-rated securities may hamper a manager's ability to alter exposures as desired. In the past, this was due to the lack of a liquid corporate bond market in many countries and the relative illiquidity of Eurobonds compared with domestic bond markets.

DEVELOPING A PORTFOLIO STRATEGY

Once the investment policy statement is established, the portfolio manager needs to develop a portfolio strategy appropriate to the investor's objectives and risk tolerances. Just as in many other areas of investment management, portfolio managers often subscribe to different management styles or investment disciplines.

The performance of most portfolio managers is judged against the benchmark return, not absolute returns.[9] There are a number of means by which portfolio managers can add to returns; however, the bulk of excess returns relative to the

8. The use of duration as a measure of interest rate risk when investing in a single bond market has merits; however, such a measure of duration in a portfolio of international bonds is not relevant. A simultaneous *and* identical parallel shift in interest rates in each of the countries in which the portfolio manager has invested would be necessary for the duration metric to be properly applied. As a result, an overall duration measure in an international bond portfolio is not applicable.

9. In the international bond management business, however, absolute return is gaining in prominence as a performance measure, particularly when overall interest rates are at low levels.

benchmark come from broad bond market and currency allocation decisions. A disciplined investment approach based on fundamental economic factors or market indicators of value facilitates the market and currency selection process. Once again, because of the historically high volatility of currency returns, the approach to currency management is a primary concern.

Styles of International Bond Portfolio Management

The challenges faced by international fixed income managers are different from those facing domestic fixed income managers. First, the international fixed income portfolio manager must operate in the U.S. bond market plus 10–20 other markets, each with their own market dynamics. Second, changes in interest rates generally affect different sectors of the U.S. bond market in much the same way (with the exception of mortgage-backed securities), although the magnitude of the changes may vary. However, international bond markets may move in different directions depending on economic conditions and investor risk tolerances.

International bond managers also use one or more different management styles. These can be divided into four general categories: the experienced trader, the fundamentalist, the black box, and the chartist.

The *experienced trader* uses his or her experience and intuition to identify market opportunities. The experienced trader tends to be an active trader, trying to anticipate the next market shift by international fixed income investors such as hedge funds, pension funds, and central banks. The basis for these trades is derived from estimates of market positioning and risk tolerances and supported by observation of market price movements and flow information. The experienced trader is often a contrarian, looking to profit from situations in which many investors may be forced to stop themselves out of losing positions.

The *fundamental style* rests on a belief that bonds and currencies trade according to the economic cycle. Sector rotation within corporate bonds also will be affected by the economic cycle, as different sectors perform relatively better at different points in the cycle. Some of these managers believe that the economic cycle can be forecast and rely mostly on economic analysis and forecasts in selecting bond markets and currencies. These managers tend to have less portfolio turnover because the economic fundamentals have little impact on short-term price movements. "Bottom-up" security selection in corporate bonds could also be characterized as a fundamentalist approach, even though it rests on issuer-specific fundamental analysis rather than on broad economic fundamentals.

The *black-box approach* is used by quantitative managers who believe that computer models can identify market relationships that people cannot. These models can rely exclusively on economic data, price data, or some combination of the two. Quantitative managers believe that using computer models can create a more disciplined investment approach that, because of other managers' emotional attachment to positions, their lack of trading disciplines, or their inability

to process more than a few variables simultaneously, will provide superior investment results.

Some investors called *chartists,* technical analysts, or technicians, may rely primarily on technical analysis to determine which assets to buy or sell. Chartists will look at daily, weekly, and monthly charts to try to ascertain the strength of market trends or to identify potential turning points in markets. Trend-following approaches, such as moving averages, aim to allow the portfolio manager to exploit market momentum. Countertrend approaches, such as relative-strength indexes and oscillators, try to identify when recent price trends are likely to reverse.

Very few international bond portfolio managers rely on only one of these management styles, but instead use some combination of each. Investment managers who rely on forecasts of the economic cycle to drive their investment process will from time to time take positions contrary to their medium-term strategy to take advantage of temporary under- or overvaluation of markets identified by technical analysis or estimates of market positions.

Even "quant shops" that rely heavily on computer models for driving investment decisions will sometimes override the model's decisions and look to other management styles to add incremental returns. Regardless of the manager's investment style, investment decisions must be consistent with the investor's return objectives and risk tolerances and within the investment guidelines.

International bond portfolio managers would do well to maintain a disciplined approach to buy and sell decisions. This would require each allocation away from the benchmark to have a specified price target (or more often yield spread or exchange-rate level) and stated underlying rationale. Depending on the management style, the size of the position should reflect the strength of the investor's conviction or model's signal.

As long as the investment rationale that supported the initial decision remained unchanged, the position would be held or potentially increased if the market moves in the opposite direction. Each trade should be designed with consideration for the relevant bond yield or exchange rate's behavior through time. For example, an exchange rate that exhibits a tendency to trend will require a different buy and sell discipline than one that tends to consistently revert back to an average level.

SOURCES OF EXCESS RETURN

The baseline for any international bond portfolio is the benchmark. However, in order to earn returns in excess of the benchmark, after management fees, the portfolio manager must find ways to augment returns. These excess returns can be generated through a combination of five broad strategies:

1. Currency selection
2. Duration management/yield-curve plays
3. Bond market selection

4. Sector/credit/security selection
5. Investing in markets outside the benchmark (if permitted)

Each of these strategies can add to returns; however, currency and bond market selections generally provide the lion's share of returns. We discuss each of these sources of excess return below.

Currency Selection

Most investment guidelines allow for some active management of currency exposures. The attraction of active currency management is strong because potential gains are so large. Since the volatility of currency returns is generally higher than that of bond market returns, the incremental returns gained from currency exposures must be evaluated relative to the additional risk incurred.

For an active currency management strategy to consistently provide superior risk-adjusted performance, a currency forecasting method is required that can predict future spot rates (i.e., future exchange rates) better than forward foreign exchange rates (i.e., rates that can be locked in today using the market for forward contracts). Forward foreign exchange rates are not forecasts of future spot foreign exchange rates, but are determined by short-term interest-rate differentials between currencies.

Academic studies have shown that several strategies have been successful in generating consistent profits through active currency management. The fact that forward foreign exchange rates are poor predictors of future spot exchange rates is well established. Historically, discount currencies (i.e., those with higher interest rates than the investor's local currency) have depreciated less than the amount implied by the forward rates, providing superior returns from holding unhedged positions in currencies with higher short-term interest rates. Overweighting currencies with high real interest rates versus those with lower real interest rates also has been shown to provide incremental returns.[10]

In addition, some currency movements are not a random walk but exhibit serial correlation (i.e., currency movements have a tendency to trend).[11] In a market that tends to trend, simple technical trading rules may provide opportunities for incremental currency returns.[12] These findings in several academic studies demonstrate that excess currency returns can be generated consistently, providing

10. See Gastineau, "The Currency Hedging Decision," pp 13–14.
11. One suggestion as to why currency markets trend is that central banks attempt to smooth foreign exchange-rate movements through intervention. Thus, because central bank participation in the foreign exchange market is not motivated by profit, their actions keep the market from being truly efficient. See Robert D. Arnott and Tan K. Pham, "Tactical Currency Allocation," *Financial Analysts Journal* (May–June 1993), pp. 47–52.
12. See Richard M. Levich and Lee R. Thomas, "The Merits of Active Currency Risk Management: Evidence from International Bond Portfolios," *Financial Analysts Journal* (September–October 1993), pp. 63–70.

a powerful incentive for active currency management. At the same time, as currency markets have become more transparent and liquid, and these strategies have become more broadly known, the efficacy of standard techniques will likely diminish—requiring the evolution of more sophisticated approaches.

Duration Management

Although closely aligned with the bond market selection decision, duration management also can enhance returns. Bullet versus barbell strategies in a curve-steepening or -flattening environment within a particular country's bond market can enhance yield and total return. In addition to these strategies, which are also available to managers investing in their domestic bond market, the international fixed income portfolio manager has the option of shifting duration between markets while leaving the portfolio's overall duration unchanged.

Tools to manage duration in international bond portfolios have become more widespread over the past few decades. The interest-rate swaps market is generally very liquid across international bond markets and used extensively by institutional investors to manage rate risk. Interest-rate futures, available in most markets, offer a liquid and low-cost vehicle for changing duration or market exposure quickly. More liquid government bond issues and the development of strip markets (which separate government bond cash-flows into individual interest and principal payments) also assist portfolio managers when managing duration exposure.

Bond Market Selection

Excess returns over the benchmark index from overweighting the best-performing bond markets can be extremely large. International bond portfolio managers apply many techniques to identify these bond markets, including macroeconomic forecasts, quantitative models, and sovereign risk. Relative value opportunities can result from market dislocations, illiquidity, and lack of full information, resulting in attractive entry points for bond managers.

Sector/Credit/Security Selection

Some global bond indexes include only government bonds, but others, such as the Barclays Global Aggregate and the Citigroup Global Broad Investment Grade Indexes, incorporate other instruments, including corporate bonds and mortgages. As corporations look to access liquidity beyond their domestic investor base and issue in international markets, the overall corporate bond market has become an even more attractive source of return for portfolio managers.

Those managers who typically apply a core "bottom-up" research approach to identifying value base on credit fundamentals can now focus on an even broader universe of securities. Similarly, mortgage bonds, high-yield debt, covered bonds, and asset-backed securities can offer incremental opportunities for

return. In certain environments in which markets are trendless or the rate environment is fairly stable, sector and security selection can be drivers of return versus duration management.

Investing in Markets Outside the Index

If allowed by investment guidelines, allocating assets to markets outside the index can enhance returns significantly without dramatically altering the risk profile of the portfolio. For example, a portfolio manager who uses the Citigroup World Government Bond Index as his or her benchmark would be taking out-of-benchmark bets if an allocation were made of corporate credit or mortgage debt.

The process for selecting an out-of-index market is similar to that followed by an active manager for a domestic bond portfolio when deciding whether or not to construct a portfolio with allocations different from the benchmark index and whether or not to invest outside the index. The manager will assess the potential performance on a total-return basis of the markets outside the index relative to that of the markets to be underweighted in order to allocate funds to out-of-index markets. An international bond portfolio manager, however, also must take into account the effect of currency movements and hedging decision of an investment outside or within the index.

THE FUNDAMENTAL-BASED INVESTMENT APPROACH

The portfolio strategy is often composed of a medium-term strategic allocation and a shorter-term tactical allocation. The strategic allocation is composed of positions held for one to three months or longer designed to take advantage of longer-term economic trends. A fundamental-based approach is used to develop the portfolio's strategic allocation. The investment style used in the fundamental-based approach is, of course, the fundamental style, but also can be combined with a quantitative or black-box style to forecast relevant strategic factors.

The tactical allocation generally relies on technical analysis or flow information to identify shifts in market prices that are likely to occur within a few days to several weeks. Tactical allocations can be driven by expectations of a reversal in a recent price trend or continued price momentum. The experienced trader, black-box, and chartist investment styles most often use technical analysis combinations in their tactical allocation decisions.

The strategic decision of which bond markets and currencies to overweight usually begins with an economic outlook and bond and currency forecasts in each of the markets considered for investment. The long-run economic cycle is closely correlated with changes in bond yields, and trends in both the economic cycle and bond yields tend to persist for a year or longer. The potential returns that can be achieved by correctly forecasting economic growth or turning points in the economic cycle are significant. As a result, major financial firms and asset managers allocate many resources to these duties.

Forecasting interest rates, however, is extremely difficult. Academic literature generally holds that interest-rate forecasts are unable to generate consistent risk-adjusted excess returns. This is partly so because market prices can deviate substantially over the short term from the level consistent with the economic fundamentals. Economic fundamentals affect bond and currency prices over the medium to long term.

Also, the volatile nature of certain economic data series may result in exaggerated market reactions to individual data releases that may be different from the actual trend in the economy. These deviations may persist for several months until either the initial figure is revised or several subsequent data releases reveal the error in the initial interpretation.

The creation of an independent economic outlook can be useful in several ways. First, it can help to identify when market interpretations of the economic data are too extreme or add value through correctly anticipating economic shifts not reflected in the market consensus.

Second, since it is often not absolute changes in interest rates but changes in interest rates relative to other markets that determine the margin of performance in international fixed income investing, an independent economic outlook does not require accurate growth forecasts for each individual market but only economic growth differentials to be able to add value. Whether the portfolio will invest in U.S. bonds or not, the large influence of the U.S. dollar and the Treasury market on foreign markets underlines the importance of an independent outlook on the U.S. economy.

Thus the economic outlook forms the foundation for the *strategic* allocation to bonds and currencies. An economic outlook for each country should be constructed to assist in ranking the relative attractiveness of markets. However, even though economic fundamentals in a particular country may be extremely bond supportive, bond prices may be too high to make it an attractive investment.

Likewise, bonds are sometimes excessively cheap in countries with poor economic fundamentals and hence may provide an attractive investment opportunity. Thus the economic outlook must be compared with either consensus economic forecasts or some market value measure to identify and rank attractive investment opportunities.

The strategic allocation decision regarding which markets to overweight or underweight relative to the benchmark is thus a complex interaction of expected returns derived from assessing economic trends and technical and value factors. Each set of variables is defined and explored below, beginning with the fundamental factors used to create the economic outlook.

The main fundamental economic factors are cyclic economic indicators, inflation, monetary policy, fiscal policy, debt, balance of payments, and politics. Each factor needs to be evaluated against market expectations to determine its likely impact on bond prices and currency rates. Each of these factors is covered in considerable detail in books on macroeconomics and international economics.

Identifying trends in economic fundamentals can help to identify attractive investment opportunities in markets, but some yardstick to measure relative value

is needed. Determining relative value is highly subjective. Three relatively objective value measures include real yields, technical analysis, and market sentiment surveys.

A *real yield* is the inflation-adjusted rate of return demanded by the market for holding long-term fixed income securities. Real yields can quickly be eroded by sustained inflation. Real yields are affected by a variety of factors, including supply and demand for capital as well as inflation expectations. Real yields are simply nominal bond yields minus expected inflation; however, expected inflation is often difficult to quantify.

Some countries, including the United States, have inflation-indexed bonds that pay a real rate of interest above the inflation rate. These bonds not only provide investors with some protection against a surge in inflation but also offer a means of gauging investor inflation expectations.[13]

Nominal bond yields deflated by current inflation, although not a precise measure of the market's real interest-rate premium, are easily measurable and still can provide some useful insight into bond valuation. Real yields can be compared across markets or against their long-run averages, such as 5 or 10 years, in each market. The usefulness of real yields as a measure of relative value has diminished as global inflation rates have converged to very low levels.

Technical analysis can be as simple as drawing a trend line on a chart or as complex as calculating the target of the third impulse wave of an Elliott wave analysis. In addition to valuing bonds and currencies, technical analysis can be used to value everything from stocks to gold to pork bellies. What all technical analysis has in common is that it tries to predict future prices solely from examining past price movements. Most technical analysis models fall into one of two camps: trend following or countertrend. The former tries to identify trends that should persist for some period of time, and the latter attempts to predict when a recent trend is likely to change.

Market sentiment can be used as a contraindicator of value in the following way. A heavy overweight of a particular country's bond market implies that fewer managers are likely to add to that market, and more managers, at least eventually, are likely to sell. Market sentiment can be estimated by investor sentiment surveys or by estimates of investment flows. Historic trends, as well as the overall levels, should be taken into account when assessing market sentiment.

For example, an indication that managers are underweighting Japanese bonds might lead some to conclude that Japanese bonds are due for a rally. Sentiment surveys, however, may not capture all market participants and therefore simply offer yet another metric for the international bond portfolio manager.

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13. Nominal yield-to-maturity is composed of a real yield and an inflation expectations component (yield-to-maturity = real yield-to-maturity + expected inflation-to-maturity). The nominal government bond yield and the real yield offered by inflation-indexed debt of the same maturity can be used to calculate the expected inflation rate to the maturity, sometimes called the break-even inflation rate.

PORTFOLIO CONSTRUCTION

Translating the strategic outlook into a portfolio allocation requires a framework for assessing expected returns against incremental portfolio risk. Returns can be separated into three components: excess returns on bonds, excess returns on currencies, and the short-term risk-free interest rate. This component methodology can assist in identifying where market prices are most out of line with the economic outlook and whether bond market currency exposures should be hedged or be unhedged.

Components of Return

To explain the total return components of an international bond portfolio[14] we will use the following notation. We will let "home currency" mean the currency of the manager. Thus, for a U.S. manager, it is U.S. dollars. For a Japanese portfolio manager it is yen. In the notation, the subscript H will denote home currency.

We will let "local currency" be the currency of the country where the manager has invested and use the subscript L to denote the local currency. Thus, to a U.S. portfolio manager, yen would be the local currency for bonds purchased in the Japanese bond market and denominated in yen, while for a Japanese portfolio manager, U.S. dollars would be the local currency for bonds purchased in the United States and denominated in U.S. dollars.

The expected total return of an unhedged international bond portfolio in terms of the home currency depends on three factors:

1. The weight of each country's bonds in the overall portfolio
2. The expected bond market return for each country in local currency
3. The expected exchange-rate percentage change between the home currency and the local currency

Mathematically, the expected total return of an unhedged bond portfolio in terms of the home currency can be expressed as follows:[15]

Total expected portfolio return in manager's home currency

$$= W_1 \times (r_1 + e_{H,1}) + W_2 \times (r_2 + e_{H,2}) + \ldots + W_N \times (r_N + e_{H,N}) \qquad (53\text{–}1)$$

where

N = number of countries whose bonds are in the portfolio
W_i = weight of country i's bonds in the portfolio (i = 1, 2, … , N)

14. The structure of this discussion is taken from Brian D. Singer and Denis S. Karnosky, *The General Framework for Global Investment Management and Performance Attribution* (Charlottesville, VA: The Research Foundation of the Institute of Chartered Financial Analysts, 1994). The notation used is consistent with that of the authors.
15. The relationship in Eq. (53–1) is approximate because bond market and currency returns of a foreign investment are more accurately expressed as the compounded gain of the two components: $(1 + r_i) \times (1 + e_{\$,i}) - 1$.

r_i = expected bond return for country i in local currency (i = 1, 2, … N)
$e_{H,i}$ = expected percentage change of the home currency with country i's local currency

We will refer to $e_{H,i}$ as the *currency return*.

The expected portfolio return as given by Eq. (53–1) is changed to the extent the manager alters currency exposures relative to the country distribution of the underlying bond exposures. A common instrument used to alter exposure to exchange rates is a currency forward contract. The relationship among the spot exchange rate, the interest rates in two countries, and the forward exchange rate on a currency forward contract is called *interest-rate parity*.

This extremely important relationship says that a manager, after hedging in the forward exchange-rate market, will realize the same domestic return whether investing domestically or in a foreign country. The arbitrage process that forces interest-rate parity is called *covered interest arbitrage*.

It can be demonstrated that the forward exchange rate between an investor's home currency, denoted H and the currency of country i, is equal to

$$F_{H,i} = S_{H,i}\,(1 + c_H)\;1 + c_i \tag{53–2}$$

where

$F_{H,i}$ = forward exchange rate between investor's home currency and the currency of country i
= spot (or cash) exchange rate between investor's home currency and the currency of country i
c_H = short-term interest rate in the home country which matches the maturity of the forward contract
c_i = short-term interest rate in country i which matches the maturity of the forward contract

c_H and c_i are called the *cash rate*. The cash rate is generally the Eurodeposit rate (i.e., offshore deposit rate) for funds deposited in that currency which matches the maturity of the forward contract. Euro deposit rates are available for U.S. dollars and most other major currencies, including for euro-denominated deposits.

By rearranging the above terms in Eq. (53–2), the forward exchange rate discount or premium (or the percentage change of the forward rate from the spot exchange rate), denoted by $f_{H,i}$, approximately equals the differential between the short-term interest rates of the two countries. That is[16]

$$f_{H,i} = \frac{f_{H,i} - S_{H,i}}{S_{H,i}} \approx c_H - c_i \tag{53–3}$$

16. Equation (53–2) assumes that exchange rates are quoted in "direct terms," i.e., the value of the home currency for one unit of the local currency, though quote conventions vary by market. Over-the-counter forward contracts use market convention, most of which for the U.S. dollar are in indirect terms (local currency units per one dollar). Using indirect terms, the forward discount or premium in Eq. (53–3) becomes $f_{H,i} = c_i - c_H$. To avoid the complexities of compounding, the time period is assumed to be one year.

That is, for the return on cash deposits to be equal in both currencies, the lower-interest-rate currency must appreciate to the forward foreign exchange rate.

The forward rate can also be expressed in "points" or the difference between the forward and spot rate $F_{H,i} - S_{H,i}$. When interest rates are lower in the foreign country (i.e., the forward points are positive), the forward foreign exchange rate trades at a premium.

The Currency Hedge Decision

If a global bond portfolio is fully hedged, the portfolio return of Eq. (53–1) changes. Specifically, if the manager hedged the currency exposure in all countries using currency forward contracts, the total return for a fully hedged portfolio into the home currency can be expressed as follows:

Total expected portfolio return fully hedged into investor's home currency

$$= W_1 \times (r_1 + f_{H,1}) + W_2 \times (r_2 + f_{H,2}) + \ldots + W_N \times (r_N + f_{H,N}) \qquad (53\text{–}4)$$

where $f_{H,i}$ is the forward exchange-rate discount or premium between the home currency and country i's local currency. That is, instead of being exposed to some expected percentage change of the home currency to country i's currency, the manager will have locked in the percentage change of the forward exchange rate from the spot exchange rate (the forward discount/premium) at the time of the hedge.

What will determine whether or not the manager will hedge the exposure to a given country's exchange rate using a currency forward contract? The decision is based on the expected return from holding the foreign currency relative to the forward premium or discount. That is, if the manager has a high level of conviction that the percentage return from exposure to a currency is greater than the forward discount or premium, then the manager will not use a forward contract to hedge the exposure to that currency.

Conversely, if the manager has a high level of conviction that the currency return will be less than the forward discount or premium, the manager will use a forward contract to hedge the exposure to a currency.

In a case in which the manager believes that the percentage return from exposure to a currency will be greater than the forward discount or premium, the unhedged return for country i can be expressed as

$$\text{Unhedged expected return for country } i,\ R_{H,i} = r_i + e_{H,i} \qquad (53\text{–}5)$$

In a case in which the manager believes the currency return will be less than the forward discount or premium, we can express the hedged return for a country in terms of the forward exchange rate between the home and local currencies using the interest rate parity relationship. As Eq. (53–3) showed, the forward premium or discount is effectively equal to the short-term interest rate differential; thus

$$f_{H,i} = c_H - c_i$$

By substituting this relationship into Eq. (53–4) for the forward hedge, the equation for an individual country's hedged return HR is

$$\text{Hedged expected return for country } i,\ HR_{H,i} = r_i + f_{H,i} \approx r_i + c_H - c_i \qquad (53\text{–}6)$$

There remain, however, two further hedging choices for the manager: *cross-hedging* and *proxy hedging*.

Cross-Hedging

Cross-hedging is a bit of a misnomer because it does not reduce foreign currency exposure but only replaces the currency exposure to country i's currency with currency exposure to country j's currency.

For example, suppose a U.S. manager has an unwanted currency exposure in country i that arose from an attractive bond investment in country i. Rather than hedging with a forward contract between U.S. dollars and the currency of country i and eliminating the foreign currency exposure, the manager elects to swap exposure in country i's currency for exposure to country j's currency.

This is accomplished by entering into a forward contract that delivers the currency of country j in exchange for the unwanted currency exposure of country i. The manager might undertake a cross-hedge if there is an expectation of weakening in the home currency, coupled with the view that country j's currency will outperform country i's.

When there is a cross-hedge, the hedged return for country i, $HR_{H,i}$, in Eq. (53–6) can be rewritten as follows:

$$\text{Cross-hedged expected return for country } i,\ CR_{H,i} = r_i + f_{j,i} + e_{H,j}$$

where $f_{j,i}$ is the forward discount or premium between country j and country i.

This expression says that the cross-hedged return for country i depends on:

1. the expected bond return for country i
2. the currency return locked in by the cross-hedge between country j and country i
3. the currency return between the home currency and country j

We can rewrite the preceding equation in terms of short-term interest-rates as given by interest-rate parity. That is, for $f_{j,i}$, we substitute $c_j - c_i$. Doing so and rearranging terms gives

$$\text{Cross-hedged expected return for country } i,\ CR_{H,i} \approx (r_i - c_i) + (c_j + e_{H,j}) \qquad (53\text{–}7)$$

Equation (53–7) says that the cross-hedged expected return for country i depends on:

1. the differential between country i's bond return and country i's short-term interest rate
2. the short-term interest rate in country j
3. the currency return between the home currency and currency j

Proxy Hedging

Proxy hedging keeps the currency exposure in country i, but creates a hedge by establishing a short position in country j's currency. Why would a manager want to undertake a proxy hedge?

This strategy would normally be considered only where the currencies of country i and country j are highly correlated, and the hedge costs in country j are lower than in country i. A proxy hedge also can represent a bullish view on the home currency, with a more negative view on country j's currency than country i's currency.

When there is a proxy hedge, the hedged return for country i, $HR_{H,i}$, in Eq.(53–6) can be rewritten as follows:

Proxy-hedged expected return for country i, $PR_{H,i} = r_i + e_{H,i} + f_{H,j} - e_{H,j}$

where $f_{H,j}$ is the forward discount or premium between the home country and country j.

Notice that in this equation there is still the exposure to the exchange rate between the home currency and currency i. The proxy hedge comes into play by the shorting of the currency return between the home currency and currency j.

Based on interest-rate parity, we can replace $f_{H,j}$ with the difference in short-term interest rates, $c_H - c_j$, to get

Proxy-hedged expected return for country i, $PR_{H,i} \approx r_i + e_{H,i} + c_H - c_j - e_{H,j}$

This is equivalent to (adding and subtracting the country i short interest rate c_i):

Proxy-hedged expected return for country i,

$$PR_{H,i} \approx (r_i - c_i) + (c_i + e_{H,i}) + [(c_H - c_j) - e_{H,j}] \tag{53–8}$$

Equation (53–8) states the expected return for country i using proxy hedging depends on:

1. the differential between the bond return for country i and the short-term interest rate for country i
2. the short-term interest rate for country i adjusted for the currency return for country i relative to the home currency
3. the differential in the short-term interest rates between the home currency and country j adjusted for the short currency position in country j

Recasting Relationships in Terms of Short-Term Interest Rates

When we substituted short-term interest-rate differentials for the forward premia or discounts earlier, it becomes apparent from Eqs. (53–6), (53–7), and (53–8) that the difference in return among hedging, cross-hedging, and proxy hedging is entirely due to differences in short-term interest rates and currency exposure. This

is also true for the unhedged return for a country, as given by Eq. (53–5). This can be seen by simply rewriting Eq. (53–5) as follows:

Unhedged expected return for country i, $R_{H,i} = (r_i - c_i) + (c_i + e_{H,i})$

The unhedged expected return is thus equal to:

1. The differential between the bond return in country i and the short-term interest rate in country i
2. The short-term interest rate in country i adjusted for the currency return

These equations show how integral the short-term interest-rate differential is to the currency hedge decision. This means that:

1. The short-term interest-rate differential should relate to the currency decision
2. Bond market returns should be calculated as an excess return, that is, less the local short-term interest rate

This can be made explicit by adding and subtracting the home currency short-term interest rate to the four return relationships—unhedged, hedged, cross-hedged, and proxy-hedged. By doing so, this allows the forward premium $f_{H,i} = c_H - c_i$ to be inserted into the currency term, giving

Unhedged expected return for country i,

$$R_{H,i} = c_H + (r_i - c_i) + (e_{H,i} - f_{H,i}) \tag{53–9}$$

Hedged expected return for country i,

$$H_{RH,i} = c_H + (r_i - c_i) \tag{53–10}$$

Cross-hedged expected return for country i,

$$CR_{H,i} = c_H + (r_i - c_i) + (e_{H,j} - f_{H,j}) \tag{53–11}$$

Proxy-hedged expected return for country i,

$$PR_{H,i} = c_H + (r_i - c_i) + [(e_{H,i} - e_{H,j}) - f_{j,i}] \tag{53–12}$$

From Eqs. (53–9) through (53–12), we see the return for each strategy can be divided into three distinct return components:

Component 1. The short-term interest rate for the home currency (c_H)

Component 2. The excess bond return of country i over the short-term interest rate of country i ($r_i - c_i$)

Component 3. The excess currency return, unhedged, cross-hedged, or proxy-hedged

The first two components, c_H and $r_i - c_i$, are the same for each strategy. The excess currency return (the third component) is the currency return in excess of the forward

premium (or discount) and forms the basis of the currency hedging decision. (We will illustrate this below.) The bond purchase decision is purely a matter of selecting those markets which offer the best expected excess return ($r_i - c_i$) and the bond and currency allocation decisions are entirely independent.

In a sense, the hedged expected return can be considered the base expected return because it is a component of the unhedged, cross-hedged, and proxy-hedged expected returns. Thus the excess currency returns in the third component are assessed to see if they can add any value over the baseline hedged expected return. This method of analyzing sources of return, in effect, treats bond and currency returns as if they were synthetic futures or forward positions.

It is important to note that only the hedged position eliminates all currency risk, and the only position that has a known return over the investment horizon. The cross-hedge substitutes one currency exposure for another but maintains foreign currency exposure. The proxy hedge leaves the portfolio exposed to "basis" risk if the proxy hedge currency appreciates relative to the investment currency.

Adjusting Bond Yields for Coupon Payment Frequency

In the United States and most other dollar bloc countries, coupon payments are made semiannually. There are other markets that follow this practice. Computing the yield for a semiannual-pay bond can be accomplished using two steps. First, the semiannual interest rate that will make the present value of the semiannual cash-flows equal to the price plus accrued interest is determined. Second, since the interest rate is semiannual, it is annualized by multiplying by 2. The resulting annualized yield is referred to as a bond-equivalent yield.

In European markets (except for the United Kingdom and Italy), coupon payments are made annually rather than semiannually. Thus, the yield is simply the interest rate that makes the present value of the cashflows equal to the price plus accrued interest. No annualizing is necessary.

The yield quoted in terms of the home market's convention for payments is called the *conventional yield*. In countries where coupon payments are made annually (in Germany, for example), the conventional yield is simply the annual yield.

Despite the limitations of yield measures, managers compare yields across market sectors and between countries. Holding aside the problem of potential changes in exchange rates, yield comparisons begin by adjusting conventional yield (i.e., the yield as quoted in the home market) to be consistent with the way the yield is computed for another country.

For example, a French government bond pays interest annually, while a U.S. government bond pays interest semiannually. If the U.S. government bond yield is being compared to a French government bond yield, either (1) the U.S. government bond yield should be adjusted to the yield on an annual-pay basis, or (2) the French government bond yield should be adjusted to a yield on a bond-equivalent yield basis.

The adjustment is done as follows: Given the yield on an annual-pay basis, its bond-equivalent yield (i.e., a yield computed for a semiannual-pay bond) is computed as follows:

$$\text{Bond-equivalent yield of an annual-pay bond} = 2[(1 + \text{yield on annual-pay bond})^{0.5} - 1]$$

For example, suppose that the conventional yield on a French government bond is 4.55%. The bond-equivalent yield is then 4.50%:

$$2[(1 + 0.0455)^{0.5} - 1] = 0.0450 = 4.50\%$$

Notice that the bond-equivalent yield of an annual-pay bond is less than that of the conventional yield.

To adjust the bond-equivalent yield of a semiannual-pay bond to that of an annual-pay basis so that it can be compared to the yield on an annual-pay bond, the following formula can be used:

$$\text{Yield on an annual basis of a bond-equivalent yield} = (1 + \text{bond-equivalent yield}/2)^2 - 1$$

For example, suppose that the conventional yield of a U.S. government bond is 4.20%. The yield on an annual-pay basis is

$$(1 + 0.0420/2)^2 - 1 = 0.0424 = 4.24\%$$

Notice that the yield on an annual-pay basis will be greater than the conventional yield. Yield spreads are typically computed between the yield of a particular bond and that of a benchmark. The U.S. Treasury yield-curve and the Euro swap market are the two most common benchmarks used.

Forward Rates and Break-Even Analysis

As explained earlier, there are various methods of evaluating relative value in international bond markets. Before these can be translated into a market allocation, a manager must compare their strategic outlook to that which is already priced into the market. This can be accomplished by either converting the economic outlook into point forecasts for bond and currency levels or looking at the forward rates implied by current market conditions and comparing them with the economic outlook.

Bond and currency break-even rates, the rate at which two investments produce identical total returns, are usually calculated versus a benchmark market return over a specific time horizon. A large yield spread between two markets implies a larger "cushion" (the required spread widening to equate total returns in both markets or the break-even rate) over the investment time horizon.

Comparing forward interest rates can be instrumental in identifying where differences between the strategic outlook and market prices may present investment opportunities. Forward interest rates use the shape of the yield-curve to calculate implied forward bond rates and allow a quick comparison of what is

required, in terms of yield shifts in each market, to provide a return equal to the short-term risk-free rate (a zero excess return). This would correspond to a bond excess return of zero in Eqs. (53–9) through (53–12), or $(r_i - c_i) = 0$.

Forward interest rates represent a break-even rate not across markets but within markets. The strategic bond allocation then can be derived by increasing exposure to markets in which the expected bond return over the short-term interest rate is most positive—that is, in which the expected bond yield is furthest below the forward yield. Forward rate calculators are available on systems such as Bloomberg.

The forward foreign exchange rate represents a break-even rate between hedged and unhedged currency returns, as shown previously in the components of return analysis. In terms of Eqs. (53–9), (53–11), and (53–12), currency excess return is zero when the percentage change in the currency equals the forward premium or discount. Since forward foreign exchange rates are determined by short-term interest-rate differentials, they can be estimated from the interest rates on deposits, specifically, Euro deposit rates, as in Eqs. (53–2) and (53–3), which can be obtained easily from market data services such as Bloomberg and Reuters.

Break-even analysis provides another tool for estimating relative value between markets. Because the prices of benchmark bonds are influenced by coupon effects and changes in the benchmark, many international fixed income traders and portfolio managers find it easier to keep pace with changes in yield relationships than price changes in each market. A constant spread between markets when yield levels are shifting, however, may result in a variation in returns as differing benchmark bond maturities and coupons result in a wide spread of interest rate sensitivity across markets. Thus market duration must be taken into account when determining break-even spread movements.

To illustrate this and show how break-even analysis is used, the yield spread between the 10-year U.S. and Japanese government bonds on December 3, 2002 was 322 basis points, providing Japanese investors who purchased the U.S. benchmark Treasury with additional yield income of 80 basis points per quarter. This additional yield advantage, however, can be eliminated by the spread widening substantially less than the 80 basis points. The widening can occur in one of the following two ways:

- Yields in Japan can decrease, resulting in price appreciation of the Japanese government bond
- Yields in the United States can increase, resulting in a price decline of the U.S. Treasury bond

Of course, a combination of the two also can occur. To quantify the amount of spread widening that would erase the yield advantage from investing in a higher yielding market, we need to conduct a break-even analysis.

It is important to note this break-even analysis is not a total-return analysis; it applies only to bond returns in local currency and ignores currency movements. This break-even analysis is effective in comparing bond markets that share a common

currency, as within the Euro zone; however, currency must be taken into account when applying break-even analysis to markets with different currencies.

The additional yield advantage in the preceding example is erased if the U.S. dollar depreciates by more than 0.80% during the quarter. Below we illustrate how a hedged break-even analysis can be calculated using hedged returns or simply the forward foreign exchange premium or discount between the two currencies.

The duration of the Japanese bond at the time of this analysis was 9.4. This means that for a 100 basis point change in yield, the approximate percentage price change for the Japanese bond would be 9.4%. For a 50-basis-point change in yield, the percentage price change for the Japanese bond would change by approximately 4.7%. We can generalize this as follows:

$$\text{Change in price} = 9.4 \times \text{change in yield}$$

If we let W denote the spread widening, we can rewrite the preceding equation as

$$\text{Change in price} = 9.4 \times \text{W}$$

We want to determine the amount of yield movement in Japan that would exactly offset the yield advantage of 0.80% from investing in U.S. bonds. Thus we need to calculate what decline in Japanese bond yields would generate exactly 0.80% in price appreciation to make the Japanese investor indifferent between the two investments (ignoring any potential currency movements).

Thus the equation becomes

$$0.80\% = 9.4 \times \text{W}$$

Solving for W,

$$\text{W} = 0.80\%/9.4 = 0.085\% = 8.5 \text{ basis points}$$

Therefore, a spread widening of 8.5 basis points due to a decline in the yield in Japan would negate the additional yield from buying the U.S. Treasury issue. In other words, a change in yields of only 8.5 basis points is needed in this case to negate the three-month yield advantage of 80 basis points.

We refer to this yield spread change as the break-even spread movement. Note that the break-even spread movement must (1) be related to an investment horizon and (2) use the higher of the two countries' modified durations. Using the highest modified duration provides the minimum spread movement that would offset the additional yield from investing in a higher-yielding market.

Thus, in our example, the three-month break-even spread movement due to Japanese yields is 8.5 basis points, meaning that it is the spread movement due to a drop in Japanese rates by 8.5 basis points that would eliminate the three-month additional yield from investing in U.S. Treasury bonds. The break-even spread movement using the 8.1 duration in the U.S. would have been 9.9 basis points (0.8/8.1 = 9.9); a difference of only 1.4 basis points.

The break-even spread movement just described completely ignores the effect of currency movements on returns. It also ignores the implied appreciation

or depreciation of the currency reflected in the forward premium or discount. If we subscribe to the methodology of attributing cash returns to the currency decision and measuring bond market returns as the local return minus the cash rate, the results of the break-even spread movement analysis on a hedged basis may be quite different.

We can easily calculate the hedged break-even spread movement by adding in the forward foreign exchange discount or premium. At the time of this break-even analysis, three-month interest rates were 0.0675% in Japan and 1.425% in the United States.

With this information, we can obtain the embedded forward rate using Eq. (53-3); that is,

$$f_{¥,\$} = c_{¥} - c_{\$} = (0.0675\% - 1.425\%)/4 = -0.34\%$$

The expected hedged return over the three-month period, assuming no change in rates, is the sum of the nominal spread differential (0.80%) and the forward premium (–0.34%), or 0.46%. Thus the break-even spread movement on a hedged basis is a mere five basis points (0.46% = 9.4 × W) instead of the 8.5 basis points of potential widening calculated on a local currency basis.

Consequently, a Japanese investor would have to expect either that spreads would not widen by more than five basis points or believe that the dollar would depreciate versus the yen by less than the embedded forward rate to make the trade attractive. Because currency hedge costs (i.e., the forward premium or discount) are determined by short-term interest rates, the break-even spread movement on a hedged basis always will be smaller when hedging a currency with higher short-term interest rates.

Alternatively, we could use Eq. (53–10) to calculate the expected hedged return to a yen-based investor over a three-month period and compare it to the return on a Japanese 10-year bond over the same period. In order to do so, it is first necessary to adjust the U.S. government bond yield (which is quoted on a bond-equivalent yield basis) to an annual-pay yield basis because the Japanese yield is based on an annual basis. The conventional yield of 4.20% for the U.S. government bond was 4.24% on an annual-pay basis. Assuming no change in rates, the expected hedged return is

$$[(r_{\$} - c_{\$}) + c_{¥}]/4 = [(4.24\% - 1.43\%) + 0.07\%]/4 = (2.88\%)/4 = 0.72\%$$

and the expected Japanese bond return is (1.02%/4, or 0.26%).

Thus the expected return on a hedged basis is 0.44%, which is close to the 0.46% in the first answer that we calculated.

Sector and Security Selection

Once the bond market allocation decisions have been made and the optimal currency, duration, and yield-curve profile selected for each market, the actual portfolio needs to be constructed through the purchase or sale of individual securities.

Many international bond investors prefer to trade only benchmark issues because they are more liquid than other similar-maturity bonds. This can sometimes lead to a "hump" in the yield-curve as investors prefer a certain issue or maturity sector. The same phenomenon can result from a squeeze of certain issues in the repo market or short-term demand imbalances for bonds deliverable into short bond futures positions.

Sector selection involves choosing a certain asset class within the fixed income universe that may be undervalued relative to other opportunities. For example, a portfolio manager looking at opportunities in the United Kingdom may favor domestic corporate bonds over government issued gilts. Such a view need not be confined to just one country however. The same investor, for example, who believes corporate bonds in the United Kingdom look more attractive compared with those issued in Italy may overweight the former versus the latter. Identifying these opportunities requires a thorough analysis of relative sector specific dynamics such as the impact of interest rates, growth prospects and other idiosyncratic risks. Moreover, this sector expertise needs to be translated across regions.

Security selection is yet another source of potential return in a global bond portfolio and necessitates a comprehensive credit research team. This team should be able to dissect credit securities across countries and financial markets. Assembling such a team with deep knowledge of local market conditions and factors affecting credit quality is in itself a significant endeavor. However, portfolio managers who have access to such a bench of credit analysts could generate returns above and beyond those managers focused only on active currency, interest rates, and sectors management.

As an example, a portfolio manager could choose to overweight certain industry groups, such as financial institutions, within a specific country. For example, as a result of global credit research recommendations and perspectives, the portfolio manager may favor certain financial companies in Japan over similar institutions in the United Kingdom. By overweighting the debt of these specific Japanese financial institutions, the portfolio manager potentially can attain better returns. Such a strategy once again requires robust risk management systems to minimize idiosyncratic risk; however, achieving these incremental gains can boost the overall performance of the portfolio's return, particularly in an environment in which rates and/or currencies are range bound.

Similarly, a portfolio manager with a view that gross domestic product (GDP) will grow faster in Japan versus Germany may favor the debt of a consumer goods companies in the former rather than the latter. Consistent with this view, the portfolio manager may choose to make an outright purchase of debt issued by a specific Japanese consumer goods company. Another potential approach would be to overweight the debt issued by the Japanese consumer goods company while underweighting the debt of the German consumer goods company. A portfolio manager with a greater risk appetite and strong conviction with regard to his team's views may even choose to outright sell the debt issued by the German consumer goods company.

Taxation issues also need to be taken into account when selecting individual bonds for purchase. For example, some markets have tax systems that encourage investors to hold lower-coupon bonds; hence, certain bonds will tend to trade rich or cheap to the curve depending on their coupon. In markets that impose withholding taxes on coupon payments, international fixed income portfolio managers often minimize their tax liability by replacing a bond that is near its coupon date with another bond of similar maturity. Market anomalies also can arise from differing tax treatment within markets.

Hence, international bond portfolio managers have many avenues to generate return, including active currency and interest rate management as well as sector-specific investments. Moreover, with the assistance of a strong global research team, these portfolio managers also may be able to identify specific industry sectors or specific issuers that may increase portfolio returns. Given the breadth of the global fixed income universe, all of these asset allocations can be made relative to interest rate, sector, and security-specific opportunities in other countries. At the same time, while international bond portfolio managers have many potential opportunities to generate returns, they do face many more risks than domestic bond managers. To successfully navigate the international bond market, these portfolio managers need to develop a strong risk management framework and embrace a disciplined investment strategy that can be employed on a global basis.

KEY POINTS

- Global bond exposure, a growing segment of overall portfolio asset allocation, is for both return and diversification purposes.
- Investment policy statements should address allowable investments, including the countries in the investment universe, the securities permitted for portfolio inclusion, the currency benchmark position and risk limits, the time horizon, and the use of derivatives.
- Benchmark selection for an international bond portfolio has many ramifications and should be done carefully because it provides both the return objective and the measure of portfolio risk.
- Investing internationally naturally generates foreign currency exposures that can be managed either passively or actively based on risk guidelines and return objectives.
- Using a 50% hedged portfolio generally offers a compromise in that its return is virtually midway between the return of the unhedged non-U.S. WGBI and the U.S. bond component with substantially lower volatility than the unhedged index, giving it a higher Sharpe ratio than the unhedged index.

- International bond managers also use one or more different management styles, which generally can be divided into four general categories: the experienced trader, the fundamentalist, the black box, and the chartist.
- Excess returns in international bond portfolios are driven by a combination of five broad strategies: currency selection, duration management/yield-curve plays, bond market selection, sector/credit/security selection, and out of benchmark investments.
- Factors such as economic growth, monetary policy, fiscal policy, and politics all play a role in making the strategic asset allocation decisions in a fundamental-based approach to international bond management.
- Other tools used to identify attractive investment opportunities include measures such as real yields, technical analysis, and market sentiment surveys.
- The expected total return of an unhedged international bond portfolio in terms of the home currency depends on three factors: the weight of each country's bonds in the overall portfolio, the expected bond market return for each country in local currency, and the expected exchange-rate percentage change between the home currency and the local currency.
- In a hedged international bond portfolio, the expected portfolio return is changed to the extent the manager alters currency exposures using instruments such as currency forward contracts relative to the country distribution of the underlying bond exposures.
- Other hedging choices for the manager include *cross-hedging* and *proxy hedging*.
- The difference in return between hedging, cross-hedging, and proxy hedging is entirely due to differences in short-term interest rates and currency exposure.
- Bond and currency break-even rates, the rate at which two investments produce identical total returns, are usually calculated versus a benchmark market return over a specific time horizon.
- Comparing of forward interest rates can be instrumental in identifying where differences between the strategic outlook and market prices may present investment opportunities.
- Once the bond market allocation decisions have been made and the optimal duration and yield-curve profile selected for each market, the overall portfolio structure needs to be constructed through the purchase or sale of individual securities which are in or out of benchmark.

CHAPTER
FIFTY-FOUR

FIXED INCOME TRANSITION MANAGEMENT

ANANTH MADHAVAN, PH.D.
Managing Director
BlackRock

DANIEL GALLEGOS
Director
BlackRock

Investing is a dynamic process. Portfolios shift over time, as a result of market movement or investment changes. Transition management refers to the process by which institutional portfolios are efficiently and cost-effectively reallocated.

Moving from the current allocation to the desired allocation presents a risk/cost tradeoff similar to the risk/return tradeoff familiar in investment management. In this way, portfolio transitions closely resemble short-term investment assignments. Transition management focuses on identifying and implementing a strategy to arrive at the target portfolio most efficiently, given the investor's risk/cost priorities.

Transitions can be triggered by a variety of events, most commonly changes in fund management (such as replacing a poorly performing investment manager), shifts in asset allocation (equity to fixed income), investment style (index to active), and benchmark universe (S&P 500 to Russell 1000).[1] Transitions range in complexity from a straightforward liquidation of fund assets to a complete portfolio restructuring encompassing multiple asset classes and countries.

Historically, transitions were often viewed as an operational issue, a secondary consequence of a larger investment decision. It was not uncommon for the fiduciary to direct the previous investment manager to liquidate the original (legacy) portfolio and have the new manager invest the cash proceeds in the desired (target) portfolio, thereby incurring round-trip transaction costs. Greater awareness of transaction costs, together with concerns about fiduciary responsibilities, has led

1. Other events, such as fund flows, consolidations, or mergers can also induce transitions.

institutional investors to increasingly use transition managers for portfolio restructurings.[2]

Yet, despite the importance of portfolio transitions, many investment professionals do not fully understand the complexities involved. Indeed, some transitions can experience significant volatility of outcomes in the space of a few days. This is especially important, as we explain below, for fixed income transitions where assets are often illiquid and markets are opaque. In this chapter, we explain the process of transition management and the appropriate balance of portfolio risk and transaction costs. We introduce cost and risk measures, discuss the unique features of fixed income transitions, and illustrate several of these factors in a case study.

BASICS OF FIXED INCOME TRANSITIONS

Before turning to a more in-depth consideration of risk and cost, it is worth outlining the basics of transition management, including a chronology of events, the types of risk that must be managed for all transitions (regardless of asset class), and a discussion of what makes fixed income transitions unique.

Chronology of Transition Events

The fixed income transition management process is made up of various distinct phases: manager selection, communication of objectives, determination of trade list, pre-trade analysis, creation of trade strategy, execution, and post-trade reporting. A description of these phases and their importance to the overall event are provided below.

1. *Manager selection:* After the decision to use a transition manager is made, the fiduciary or plan sponsor undertakes a due diligence process to select the manager. Investors typically seek the same level of market expertise, risk management, liquidity, operational infrastructure, and fiduciary oversight during transitions that they have come to expect from asset managers. Transitions that are not properly managed can result in significant underperformance and excessive fee-taking. Managers can be broker-dealers, custodians, or specialized transition managers; they vary in terms of their access to liquidity, trading skill, and risk control. Successful transition managers actively mitigate transition risk by minimizing market impact and opportunity cost

2. Ideally, investors should use a transition manager when the expected cost of not using a transition manager is greater than the transition management fees. This is usually the case for significant portfolio restructurings, situations in which the investor is concerned about obtaining superior execution quality and/or maintaining a given market exposure, particularly complex transitions (e.g., portfolios containing significant exotic or odd-lot securities), and highly volatile environments.

during trading, and by carefully controlling transaction costs such as commissions and spreads.

2. *Communication of objectives:* The transition manager must understand the client's motivation and desired timing for the transition, as well as their tolerance for risk and cost. The client may also have benchmark preferences for measuring cost (previous closing price, volume-weighted average price, etc.). Other factors that could affect the transition are also communicated to the transition manager at this time (regulatory prohibitions against internal crossing, among others).
3. *Determination of trade list:* Having established the legacy and target portfolios, the manager determines the common holdings that can be transferred in-kind between them (meaning that the underlying securities retained for the target portfolio are transferred directly, cost and risk free, rather than liquidated). The remainder must be traded. Essential operational steps and necessary legal and administrative issues also must be resolved at this point.
4. *Pre-trade analysis:* The manager uses pre-trade analytical models to assess the liquidity characteristics of the trade list (focusing on breakdowns by side, order size, sector, industry, country, etc.) and estimate total portfolio trading costs and likely variation in those costs. Managers also use risk models, typically fundamental multifactor models, to estimate the tracking error between the legacy and target portfolios.
5. *Creation of trading strategy:* Strategies can vary widely in terms of aggressiveness and complexity. A common strategy is simply to trade a constant fraction of the list over the transition, with the objective of executing at the volume-weighted average price (VWAP) for the period. In some cases, managers may use optimization tools to determine the dynamic trading strategy most appropriate for the transition. The transition duration, cost estimate, and dispersion in outcomes are communicated to the client *before* the transition begins, to form an objective benchmark for measuring the eventual outcome of the transition.
6. *Execution:* The manager then executes the trades in a manner consistent with the strategy formulated in the previous step, while also making adjustments necessitated by changing market conditions. Actual transitions can range in duration from a single day to over a month, depending on the client's objectives and complexity of the trades.
7. *Post-trade reporting:* The manager provides a detailed report to the client, with particular attention to the realized costs (including commissions, bid/ask spreads, and market impact costs) relative to the pre-trade estimate. It is important to note that transition performance is measured from the date on which the transition manager is able to start executing the restructuring (as opposed to the client's decision date) to truly reflect the transition manager's efforts.

Types of Transition Risk

A poorly managed portfolio restructuring—one that does not assess and address all risks properly—has the potential to erase an entire year of investment returns. There are four types of risk that must be managed across all transitions:

- *Exposure Risk:* Also known as *investment risk,* exposure risk is associated with factors that can have a negative effect on portfolio value. Transition managers use a variety of processes (various types of trade analytics), tools (portfolio optimizers, for example), and market expertise (including broker-dealer relationships) to help minimize exposure risk.
- *Execution Risk:* After the transition strategy has been set, there is still risk of implementing the plan with suboptimal results, particularly for illiquid asset classes. Key to sourcing liquidity is understanding the intrinsic value and structural nuances of each security being traded.
- *Process Risk:* Communication gaps and unchecked assumptions contribute to process risk, which results in additional transition costs. Rigorous and detailed methodology helps minimize this risk.
- *Operational Risk:* This is the risk that operational details, such as account setup and reconciliation, are overlooked or delayed. Transition managers create transparent and auditable reporting to reduce this possibility.

Each type of risk should be managed comprehensively throughout every transition. For fixed income portfolios in particular, there are several market factors—discussed below—that make these transitions especially challenging.

Uniqueness of Fixed Income Transitions

The nature of fixed income securities makes transitions involving this asset class rather unique relative to those of other asset classes, especially equities. Several factors are particularly relevant here in terms of cost and risk:

- *Market Structure:* Fixed income securities are typically not traded on an open exchange, so pricing lacks uniformity and transparency.[3] Varied maturities, volatility due to interest rate instability, nuances in investment characteristics, and currency fluctuations pose significant challenges for fixed income portfolio transitions, which are well beyond the scope of most equity transitions. In terms of the framework above, the absence of

3. Exceptions include fixed income futures contracts and transactions on certain electronic exchanges such as Market Axxess, and Tradeweb, typically in liquid government issues.

last trade reporting (e.g., a ticker tape for most fixed income securities) makes it very difficult to measure actual costs using the shortfall framework, let alone make accurate estimates before the transition begins.

- *Price Discovery and Liquidity:* Market structure and the complexity of instruments also affect the trading strategy and execution. Unlike equities, price discovery and liquidity sourcing are particularly critical for fixed income transitions. The absence of a single, centralized bond exchange and the proliferation of instruments necessitate the use of available sources of liquidity to achieve best execution. Thus, transition managers actively pursue counterparties across multiple platforms. Transition managers benefit from long-standing relationships with broker-dealers around the world to maximize trading opportunity and achieve better execution.
- *Types of Exposure Risk:* It is difficult to gauge the active risk (tracking error) of a complex bond portfolio and, hence, to implement an optimal trading strategy, as discussed above. The typical fixed income transition may be subject to multiple dimensions of risk, including:
  - Rate risk
  - Volatility risk
  - Credit-spread risk
  - Idiosyncratic risk

Fixed income transition managers develop and implement techniques, metrics, and reporting tools specific to fixed income securities that are designed to achieve the investors' target portfolio with the lowest risk possible.

TRANSITION METRICS AND OBJECTIVES

With an understanding of the challenges specific to fixed income transitions, we can now turn our attention to an in-depth discussion of risk and cost. A variety of metrics for cost and risk are commonly used to measure the performance of a transition. In this chapter, we focus on implementation shortfall and tracking error. The first, implementation shortfall, measures the amount by which the legacy portfolio's return falls short of the target portfolio's return. This metric allows an investor to evaluate how their portfolio performed during the restructuring period. The expected implementation shortfall is established prior to the transition and decomposed into return factors, when the transition manager formulates the restructuring strategy.

For similar insights, we focus on risk in terms of portfolio tracking error (TE), which refers to the absolute difference between the returns of the legacy and target portfolios. With these metrics in hand, we then formally define the transition manager's objective.

EXHIBIT 54–1

Transition Timeline

To illustrate why these measures are most appropriate, a more formal statement is useful. Let N denote the number of assets in the universe defined by the union of the legacy and target portfolios, and let Ω denote the $N \times N$ variance-covariance matrix of asset returns. From the viewpoint of the transition manager, the process begins on day t_0 when the transition manager is first in a position to begin trading the legacy portfolio.[4] We denote by V_0 the initial value of the portfolio at this date. Trading need not occur immediately. For example, transition managers might postpone trading to source liquidity or unexpected delays might arise. At calendar time t_b (where $t_0 \leq t_b$), the manager actually begins executing the transition through trading. Let T denote the duration of the transition, which we think of as days but could also represent hours or other intraday periods. Trading occurs in waves on each day (indexed by $k = 1,\ldots,T$), and the transition is completed on day $t_1 = t_0 + T$. The timeline for the transition is illustrated in Exhibit 54–1.

Denote by L the $N \times 1$ vector of asset holdings of the legacy portfolio, where each row represents the shares held of the asset, and similarly define by Q the holdings in the target portfolio. We denote by h_L and h_Q the corresponding vectors of holdings (weights) in the legacy and target portfolios, where the i-th element of the holding vector represents the portfolio weight in asset i as a fraction of total portfolio value.

Active risk is defined as the distance between the legacy and target portfolios, captured as

$$\sigma_{L,Q} = \sqrt{(\mathrm{h}_L - \mathrm{h}_Q)'\Omega(\mathrm{h}_L - \mathrm{h}_Q)}. \tag{54–1}$$

Note that when the transition is a straight liquidation to cash, we have $\mathrm{h}_Q = 0$, the null vector, and the active risk is simply the standard deviation of the legacy portfolio; that is, $\sigma_L = \sqrt{\mathrm{h}_L{}'\Omega\mathrm{h}_L}$. Similarly, when the transition is a cash investment, $\mathrm{h}_L = 0$, and the active risk is the standard deviation of the target portfolio, $\sigma_Q = \sqrt{\mathrm{h}_Q{}'\Omega\mathrm{h}_Q}$. Thus, the active risk for non-rebalance transitions (either into or

4. The planning process begins before this date, with the selection of the manager and several other operational steps, but our focus is on performance during the actual transition process. For data on actual transition costs, see Anna Obizhaeva, "Information vs. Liquidity: Evidence from Portfolio Transition Trades," Working Paper, Sloan School of Management, MIT, Cambridge, MA (2008).

out of cash) will typically be higher than for transitions in which at least some holdings are in common.

Defining Transition Costs

The trade list is simply the $N \times 1$ vector of shares,

$$X = (Q - L) \tag{54–2}$$

with the convention that positive elements represent purchases and negative elements represent sales.

Total transaction costs incorporate explicit costs (commissions, taxes, and fees) and implicit costs (bid/ask spreads, market impact).[5] In a transition, unlike most institutional trading, orders are (nearly) always completed, so opportunity costs from failing to execute generally are not a factor.[6] In keeping with previous research, costs are expressed relative to the pre-trade benchmark (strike) price. Formally, for asset $i = 1,\ldots, N$, the realized transaction cost is

$$C_i = \frac{\sum_{k=1}^{T}(p_{i,k}^{e} + \varphi_{i,k})x_{i,k}}{p_i^b \sum_{k=1}^{T} x_{i,t}} - 1 \tag{54–3}$$

where

Dates $k = 1,\ldots, N$,

$p_{i,k}^{e}$ is the execution price,

$x_{i,k}$ is the signed trade size,

$\varphi_{i,k}$ represents the explicit trading cost (with the sign convention that costs are positive for buys and negative for sells), and

p_i^b is the benchmark or strike price against which costs are measured.

For purchases, we expect costs to be positive; for sales, the figure should be negative. Dollar implementation shortfall is the total cost measured relative to a benchmark price struck at time t_b is $C(t_b) = \sum_{i=1}^{N}(p_i^b \sum_{i=1}^{T} x_{i,k})C_i$. Throughout this chapter, we use implementation shortfall to refer to the total realized costs relative to initial transition value $c(t_b) = C(t_b)/V_0$.

The return of the target portfolio over the period of the transition (from t_0 to t_1) is denoted $r^Q(t_0, t_1)$; this is the return earned by an investor who already

5. Andre Perold, "The Implementation Shortfall: Paper Versus Reality," *Journal of Portfolio Management* (Spring 1988): 4–9.

6. Donald B. Keim and Ananth Madhavan, "Anatomy of the Trading Process: Empirical Evidence on the Motivation for and Execution of Institutional Equity Trades," *Journal of Financial Economics* (March 1995): 371–398.

held the target portfolio at the beginning of the transition. The actual return of the legacy (restructured) portfolio from t_0 to t_1 is defined as

$$r^L(t_0,t_1) = \frac{\left(V_T^L - V_0\right)}{V_0}$$

The final value of the legacy portfolio once the transition is complete is the end of period share holdings (L + X) evaluated at prices at the end of the transition, less the net cash-flows from trading. Using the definition of costs, it is straightforward to show that

$$r^Q(t_0,t_1) - r^L(t_0,t_1) = c(t_b) + r^L(t_0,t_b) \tag{54–4}$$

where $c(t_b)$ is the total implicit and explicit trading cost as a fraction of portfolio value (given a benchmark struck just prior to trading), and $r^L(t_0,t_b)$ is the return on the legacy portfolio from the time the transition began, a timing cost. In cases in which the transition begins without delay, the benchmark price is struck at time t_0, so $p_i^b = p_{i,0}$, and we see that the implementation shortfall cost is the difference between the actual return of the transition (legacy) account compared with the return on the target fund, had the transition been implemented instantaneously at no cost. This explanation shows why implementation shortfall is the right measure of costs. It accurately captures the slippage between the legacy and target portfolios, reflecting all costs incurred during the transition.[7]

Transition Tradeoffs

Having defined formally both risk and cost, we can now specify possible transition objective functions. As mentioned above, the transition manager and client jointly determine the trading strategy with the client's objectives in mind. Typically this involves a tradeoff between cost and active risk. Formally, predicated upon a horizon of T trading days, the optimal transition strategy can be defined as the set of trading waves that minimize, in expectation, a convex combination of $c(t_b)$ and $\sigma_{L,Q}$, with weight λ. Formally,

$$\min_{\{X_1,\ldots,X_T\}} E_0[(1-\lambda)c(t_b) + \lambda\sigma_{L,Q}] \tag{54–5}$$

subject to

$$\sum \mathrm{X}_k = \mathrm{X}$$

7. The industry has yet to adopt a standard approach to performance measurement in transitions. Many costs are hidden (e.g., when a custodian systematically executes foreign exchange trades at prices worse than prevailing market prices) and transition manager revenues are not transparent (e.g., the manager charges commissions on the other side or engages in proprietary trading). The T Standard is an industry initiative to create uniform standards for measuring transition performance using the implementation shortfall approach.

Both cost and risk depend on the particular waves chosen. For example, if λ is very high and the trading strategy is very aggressive, the bulk of the trade list may be completed in the first or second wave (recall, there could be multiple waves in a day), which might lead to high trading impact but low tracking error.

What is the optimal solution to this objective? Various heuristics are commonly employed but often fail to actually minimize costs. Some managers believe that maximizing the crossing rate will always minimize market impact and, hence, costs. However, this fails to account for the additional risk caused by prolonging the transition, which is a common problem in many fixed income securities in which crossing is a low-probability event. Another common strategy (usually referred to as the VWAP strategy because it is associated with a trading benchmark of the volume-weighted average price) is simply $X_t = X/T$, where the order is broken up equally over time. The VWAP strategy may not, however, be the optimal solution (even if $\lambda = 0$) and it may not minimize costs.

Rather, the optimal solution can be found using stochastic dynamic programming, given assumptions about the evolution of prices and liquidity. This forward-looking approach is based on the idea that the solution (or policy function) at any point throughout the trading session k, must still be optimal for the remaining program.[8] Using a forward-looking approach also allows the transition manager to capture variations in liquidity or volatility (the key drivers of cost) that are known to occur over the period of the transition. For example, a transition executed during a period with highly anticipated macroeconomic events (e.g., earnings season) can take into account likely spikes in volatility and volume. This approach can also provide a tradeoff between cost and risk for various λ, allowing the client to visualize the alternatives. The dynamic programming approach requires a considerable degree of confidence in the input estimates, which may not always be the case for less liquid assets. In those cases, the transition manager can use their experience and judgment (sometimes guided by the formal analysis) to correctly sequence the trades in accordance with client objectives. Whether the strategy is specified formally or informally, however, the basic tradeoffs outlined above are present in every transition.

Implementation Shortfall Example

To illustrate the concepts above, consider a $1 billion international equity transition. A state retirement system sought to rebalance its international positions by reallocating the legacy portfolio to two new managers. The total transition period was eight days, of which the trading period was five days. Forecast costs for the trade list were 0.51%. The transition manager used proprietary analytical tools to match and split out buys and sells, then utilized a transaction cost model to predict the (half) bid/offer spread plus estimated market impact. The manager then added

8. See Robert Almgren and Neil Chriss, "Optimal Execution of Portfolio Transactions," *Journal of Risk* 3 (Winter 2000): 5–39. See also Dmitri Bertsemas Dmitri and Andrew W. C. Lo, "Optimal Control of Liquidation Costs," *Journal of Financial Markets* 1 (February 1998): 1–50.

estimated commissions, fees, and taxes to this figure to determine the total forecast cost, which became the benchmark for evaluating the transition. Annualized active risk (i.e., the tracking error between the legacy and target portfolio) was 3.50%. Based on this figure, the estimated risk over the trading period was 0.39% (with 250 trading days annually, $0.495\% = 3.5\%\sqrt{\frac{5}{250}}$). This figure was used to determine upper and lower bounds for the transition shortfall.

Ex post, the actual average active risk was 0.38%, implying that the manager traded more aggressively to reduce the risk in the early stages of the transition. The legacy portfolio performance over this period was 0.69%, while the target portfolio returned 1.40% over the transition; applying Eq. (54–4) yields a total implementation shortfall of 0.71% (1.40%–0.69%). The realized trading shortfall was 0.58% (market impact of 0.42% and commissions and fees of 0.16%), in line with the pre-trade forecast. Timing costs accounted for 0.14%, reflecting outperformance of the target portfolio relative to the legacy portfolio in the three days before trading started.[9] Overall, although total costs were slightly higher than predicted (7 bps), the outcome was within the range of possible outcomes communicated to the client before the transition, which signifies the success of this transition.

The Risk/Cost Tradeoff Revisited

Fixed income and equity market transitions are similar in terms of the risk/cost tradeoff outlined above, but there are material differences in how these transitions are executed. Like most U.S. equities, the majority of investment-grade debt can be liquidated or purchased within a short period of time. However, additional costs are normally incurred when selling or buying too quickly. Conversely, executing too slowly will extend the restructuring timeline and expose assets to the increased risk of implementation shortfall. Either scenario can have material impact on the cost and quality of the restructuring. It is a transition manager's job to evaluate each portfolio constituent and the expected risk/cost tradeoff in order to design and implement a suitable restructuring strategy, while satisfying the client's timing objectives.

Implementation Issues Specific to Fixed Income

The optimal fixed income transition strategy addresses various concerns:

- Sector misweights
- Term-structure profile differences
- Illiquid securities

9. This may reflect a variety of factors. For example, clients may choose to wait for month-end to allow for greater crossing opportunities; for international transitions, there may be delays in asset delivery.

- Foreign currency
- Timing preferences

Although many of these are common portfolio characteristics, it is crucial to implement a strategy that will decrease the costs associated with portfolio-specific nuances across these parameters. Another of the transition manager's responsibilities is to dissect structural differences between the target and legacy portfolios and then create an optimized transition strategy that will mitigate risks born of those structural differences.

Evaluating Liquidity Sources

Managers must evaluate the many details of each fixed income security to identify the correct liquidity source. Common descriptive data points such as coupon type, maturity, subordinate structure, and issuer are reviewed and logged. There may be numerous issues with various structures, and each issuance may be brought to market by different banking syndicates. For example, there are nearly 30 different corporate bonds listed for IBM, with various terms to maturity and coupon types, as opposed to just one equity security. And this is only for one type of fixed income security. Legacy portfolios may hold many different types of securities (mortgage-backed securities, Treasuries, corporates, munis, etc.). The diverse array of security types makes it increasingly complex to identify the correct liquidity sources for each asset during a restructuring. To effectively evaluate liquidity sources, a trading desk must have expertise across the various markets and security types. Trade research teams can also help identify trading bottlenecks, optimal execution dates and preferred trading counterparties.

Using Derivatives to Manage Risk or Lower Cost

Derivatives can play an important role in fixed income transition management, particularly when liquidity is hindered and formidable differences exist between the legacy and target portfolios' risk characteristics. Since decreasing the performance difference between a legacy and target portfolio is paramount when minimizing implementation shortfall, the ability to quickly and inexpensively restructure the risk characteristics of a portfolio is key.

Derivatives are commonly used during transitions to alter the legacy portfolio's duration. They are an especially important tool when the liquidity timeline of the legacy portfolio is expected to be slow. U.S. Treasury futures contracts have proved particularly useful during transitions: They can be entered into quickly, in large notional sizes, with little or no market impact, and with minimal funding. Derivatives are also used to address sector misweights during a restructuring.

In situations in which operational and legal hurdles make derivatives less efficient, exchange-traded funds (ETFs) may be a more effective option, particularly when beta exposure is desired prior to selecting the target manager. Investors can achieve a diversified sector exposure using ETFs without increasing idiosyncratic risk, which can be associated with large volumes of cash securities.

CASE STUDY OF RISK MANAGEMENT

Having established the framework for transition management, we turn to a case study that illustrates some of the risk factors described above and the role that derivatives can play to reduce risk during a transition. An investment committee decided to shift the duration of a $100 million U.S. Treasury portfolio in its defined benefit plan, moving from exposure at the middle of the maturity curve to a concentration at the short and long ends of the curve. The legacy portfolio is benchmarked to a 7–10 year index; the target portfolio has more of a barbell shape, roughly 60% at the 1–3 year range and 40% at the 20+ year range. Despite the very different compositions, both portfolios have the same weighted-average duration (7.26 years).

There is, however, a mismatch in key rate duration between the two portfolios, or how sensitive each component is to changes in interest rates (Exhibit 54–2). This mismatch could translate into significant risk, even over the course of just one trading day. Consider the impact an abrupt increase in rates at the 15-year point could have had on this portfolio during a transition (Exhibit 54–3).

Price changes range from $0.51 (or 4 bps of yield) on the 15-year bond to $1.10 (or 7 bps of yield) on the 30-year bond. Given the asymmetric nature of bond prices, it is typical to see higher price dispersion at the long end of the yield-curve. Analyzing the portfolio in terms of its key rate duration helps identify where risk resides on the maturity curve.

In this interest rate shock environment, the difference between the two portfolios' term structure profiles created a tracking error valued at $310,000. Approximately 10% of the expected annualized yield was at risk for this single restructuring.

EXHIBIT 54–2

Key Rate Durations

Sources: BlackRock and Barclays Capital, as of 1/13/11. Indexes included are the Barclays Capital U.S. 1–3 Year Treasury Bond Index, Barclays Capital U.S. 7–10 Year Treasury Bond Index, and Barclays Capital U.S. 20+ Year Treasury Bond Index.

EXHIBIT 54–3

Impact of Interest-Rate Shock on 1/13/11

Sources: BlackRock and Barclays Capital, as of 1/13/11.

The strategy for this transition focused on managing the portfolio's key rate risk. The night before the 7–10 year holdings began to trade, futures contracts were bought and sold to rebalance the legacy portfolio's key rate duration profile and better match the profile of the target portfolio. All five contracts were either bought or sold, decreasing exposure at the belly of the curve and increasing exposure at the long end. This single transition almost completely mitigated the mismatch in expected return between the portfolios; annualized active risk shrank from 491 to 24 bps.

As the 7–10 year trades were completed, the futures contracts were unwound and proceeds were used to purchase the target constituents.

Had the transition strategy focused on weighted-average duration—instead of key rate duration—the long bond risk would have been masked and the portfolio would have been vulnerable to price changes from the steepening rate curve.

Even though both the legacy and target portfolios held only U.S Treasuries (which carry neither credit-spread nor idiosyncratic risk) significant value was at risk in this portfolio restructuring. Fixed income transitions typically involve more than just a shift in Treasury duration, which means a heightened need for analytics and process that protect portfolio value throughout each restructuring.

KEY POINTS

- Transition management is the process of restructuring a portfolio in a way that optimizes the risk/cost tradeoff.
- Fixed income transitions are often complicated and potentially costly. The fixed income market structure offers less transparency and is more demanding in terms of identifying and evaluating liquidity; the diverse types of instruments presents additional trading challenges and varied risk factors (compared with equities).

- Because normal market volatility can put a large amount of the expected annualized return of a fixed income portfolio at risk during a transition, the ability to systematically manage the transition is imperative.
- Two metrics in particular can help investors evaluate their restructuring. Tracking error measures the level of active risk for the portfolio. Implementation shortfall gauges how a portfolio performed during the restructuring period.
- Derivatives are an important tool for managing risk and cost for fixed income transitions. They can be entered into quickly, in large notional sizes, with little or no market impact, and with minimal funding.

CHAPTER
FIFTY-FIVE

MANAGING THE SPREAD RISK OF CREDIT PORTFOLIOS USING THE DURATION TIMES SPREAD MEASURE

ARIK BEN DOR, PH.D.
Director, Barclays Capital

LEV DYNKIN, PH.D.
Managing Director, Barclays Capital

JAY HYMAN, PH.D.
Managing Director, Barclays Capital

The standard presentation of the asset allocation in a portfolio or a benchmark is in terms of percentage of market value. It is widely recognized that this is not sufficient for fixed income portfolios, where differences in duration can cause two portfolios with the same allocation of market weights to have extremely different exposures to macro-level risks. As a result, fixed income portfolio managers have become accustomed to expressing their allocations in terms of contributions to duration—the product of the percentage of portfolio market value represented by a given market cell and the average duration of securities comprising that cell. This represents the sensitivity of the portfolio to a parallel shift in yields across all securities within this market cell. For credit portfolios, the corresponding measure would be contributions to spread duration, measuring the sensitivity to a parallel shift in spreads. Determining the set of active spread duration bets (the differences between the exposures of the portfolio and the benchmark) from various market cells and/or issuers is one of the primary decisions taken by credit portfolio managers.

Yet all spread durations were not created equal. Just as one could create a portfolio that matches the benchmark exactly by market weights, but clearly takes more credit risk (e.g., by investing in the longest duration credits within each cell), one could match the benchmark exactly by spread duration contributions and still take more credit risk—by choosing the credits with the widest spreads within each cell. These credits presumably trade wider than their peer groups for a reason; that is, the market consensus has determined that they are more risky—and are often

referred to as "high-beta" credits, because their spreads tend to react more strongly than the rest of the market to any systematic shock.

Based on this idea, and following an extensive analysis of corporate bonds' spread behavior, we have advocated since 2005 a new measure of risk sensitivity that utilizes spreads as a fundamental part of the credit portfolio management process. To reflect the view that higher spread credits represent greater exposures to sector-specific risks, we represent sector exposures by contributions to duration times spread (DTS), computed as the product of market weight, spread duration, and spread. The shift from spread duration exposures to DTS exposures as the measure of market risk embraces a different paradigm for credit-spread movement—in the form of relative spread changes rather than parallel shifts in spread.

The paradigm shift resulting from the DTS concept has many implications for portfolio managers, both in terms of the way they manage exposures to industry and quality factors (systematic risk) and in terms of their approach to issuer exposures (non-systematic risk). First, modeling spread changes in relative rather than absolute terms generates improved forward-looking estimates of excess return volatility. Second, for computing the hedge ratios needed to form market-neutral credit trades, DTS is superior to "empirical betas" as a measure of market sensitivity. Third, for index replication, matching sector-quality allocations of a credit index in terms of contributions to DTS leads to improved tracking compared with matching the contributions to spread duration. This same way of viewing macro exposures can help to more accurately express active portfolio weights as well. Fourth, DTS-based issuer limits can be considered as an alternative to more standard caps on issuer market weight when imposing portfolio diversification constraints. Finally, the incorporation of the DTS approach into the design of multifactor risk models can help make such models more robust, more compact, and more accurate. In this chapter, we will explore each of these applications in turn, after a brief overview of the large body of evidence supporting the DTS concept.

THE NEED FOR A NEW MEASURE OF CREDIT SPREAD EXPOSURE

Two examples of market conditions when spread duration contributions do not suffice are shown in Exhibit 55–1. During the dot.com crisis, a relief rally in January 2001 led to a temporary tightening of spreads throughout the communications sector. However, that rally was not characterized by a purely parallel shift; rather, issuers with wider spreads tightened by more. Panel A displays the changes in spreads experienced in that month by the key issuers that made up the communications sector of the Barclays Capital Corporate Index.[1] Panel B shows

1. "Key issuers" refers to issuers that had outstanding issues with market value in excess of 1% of the sector aggregate market value. Panel A shows 17 issuers that represented 216 outstanding issues; Panel B includes 19 issuers and 420 bonds.

EXHIBIT 55–1

Spread Changes of Key Issuers in the Communications and Banking Sectors of the Barclays Capital U.S. Corporate Index

Panel A. Communications Sector, January 2001

Panel B. Banking Sector, December 2010.

Source: Barclays Capital.

the spread tightening in the key issuers in the banking sector during the month of December 2010; a similar effect is seen in this industry-wide rally.

Motivated by market events of this type, we conducted an extensive analysis of corporate bonds' spread behavior and developed a new measure of spread risk sensitivity. As higher spread credits have greater exposures to sector-specific risks, we represent sector exposures by contributions to duration times spread (DTS), computed as the product of market weight, spread duration, and spread. An overweight of 5% to a market cell implemented by purchasing bonds with a spread of 80 bp and spread duration of three years will be considered to be equivalent to an overweight of 3% using bonds with an average spread of 50 bp and spread duration of eight years ($0.05 \times 0.80 \times 3 = 0.03 \times 0.50 \times 8 = 0.12$).

How does this make sense? As mentioned, a portfolio's contribution to spread duration within a given market cell is its sensitivity to a parallel shift in spreads across all bonds in that cell. What is the intuition behind this new measure?

In fact, the intuition is very simple. Let us look at a simple expression for the return of a given bond due strictly to change in spread R_{spread}. Let D denote the spread duration of the bond and s its spread; the spread change return is then given by

$$R_{spread} = -D \cdot \Delta s \tag{55–1}$$

It is quite easy to see that this equation is equivalent to

$$R_{spread} = -(D \cdot s) \cdot \frac{\Delta s}{s} \tag{55–2}$$

That is, just as spread duration is the sensitivity to an absolute change in spread (e.g., spreads widen by 5 bp), DTS is the sensitivity to a relative change in spread (e.g., spreads increase by 5% of their current levels). Note that this notion of relative spread change provides for a formal expression of the rough idea discussed above—that credits with wider spreads are riskier since they tend to experience greater spread changes in absolute terms.

Based on the absolute spread change approach in Eq. (55–1), the volatility of excess returns can be approximated by

$$\sigma_{return} \cong D \cdot \sigma_{spread}^{absolute} \tag{55–3}$$

while in the relative spread change approach of Eq. (55–2), excess return volatility follows

$$\sigma_{return} \cong D \cdot s \cdot \sigma_{spread}^{relative} \tag{55–4}$$

Given that the two representations above are equivalent, why should one of them be preferable to another? The key advantage of the DTS approach of Eq. (55–4) is that relative spread volatilities are much more stable than absolute spread volatilities. We found extensive empirical evidence that the volatility of absolute spread changes of U.S. corporate bonds (both systematic and idiosyncratic) is linearly proportional to spread level, irrespective of sector, maturity, credit quality or time period.[2] This implies that the second approach, based on relative spread changes, should generate more accurate projections of spread volatility.

2. Arik Ben Dor, Lev Dynkin, Patrick Houweling, Jay Hyman, Erik van Leeuwen, and Olaf Penninga, "DTS (Duration Times Spread): A New Measure of Spread Exposure in Credit Portfolios," *Journal of Portfolio Management*, 33 (Winter 2007), pp. 77–100.

EXHIBIT 55–2

Time Series Volatility of Systematic Spread Changes vs. Spread Level

Based on monthly observations for all constituents of the Barclays Capital Corporate and High-Yield Indices rated B or better, September 1989–January 2005.
Source: Barclays Capital.

SPREAD VOLATILITY AND DTS

The relation between the volatility of systematic spread changes and the average beginning-of-month spread level is plotted in Exhibit 55–2. The analysis was carried out using a large sample with more than 560,000 monthly observations on all constituents of the Barclays Capital Corporate and High-Yield Indices rated B or higher between September 1989 and January 2005.[3] Bonds in each of the three main sectors (financials, industrials, and utilities) were divided into three equally populated duration buckets (short, medium, and long). Bonds in each duration bucket were then partitioned into prespecified cells based on spread. Spread cell breakpoints varied across sector and duration to ensure that each spread cell was well populated monthly.[4] This procedure resulted in 66 distinct time series data sets; each consisted of a fairly homogeneous set of bonds with monthly data for

3. See Ben Dor, Dynkin, Houweling, Hyman, van Leeuwen, and Penninga, "DTS (Duration Times Spread): A New Measure of Spread Exposure in Credit Portfolios" for further detail regarding the analyses shown in Exhibits 55–2 and 55–3. In this section, we report our original results using data through 2005. In what follows, we use market data after this date as an extreme out-of-sample test of these relationships.

4. Bonds were assigned to one of 66 cells with breakpoints ranging from 100 bp to more than 500 bp (the financial, industrial and utility sectors had seven, nine, and six spread cells for each maturity bucket, respectively). To eliminate idiosyncratic effects, months in which a cell was populated by fewer than 20 bonds were excluded. Employing a weighted volatility estimate instead (in which the number of observations in each month was used as the weighing factor) produced very similar results.

their spreads and spread changes. The systematic spread change in a given cell each month was represented simply as the average spread change across all bonds that comprised that cell. We then calculated the time series volatility of these systematic spread changes and the average spread over time for each cell.

The results indicate an almost perfect linear relationship between spread volatility and the level of spread that can formally be expressed as:

$$\sigma_{spread}^{absolute}(s) \cong \theta \cdot s \tag{55–5}$$

Estimating a simple regression based on Eq. (55–5) provides an excellent fit to the data (R^2 in excess of 90%) with the slope coefficient θ equal to 9.1% using all observations and 9.4% if the three circled outliers are excluded.[5] Furthermore, for a given level of spread, the differences across sectors and maturity buckets are fairly small. Hence, the historical volatility of systematic spread movements can be expressed quite compactly, with only minor dependence on sector or maturity, in terms of a relative spread change volatility of about 9% to 10% per month. That is, spread volatility for a market segment trading at 50 bp should be about 4.5–5.0 bp/month, whereas that of a market segment at 200 bp should be about 18–20 bp/month.

We also studied whether idiosyncratic spread volatility is similarly related to the level of spreads. We computed the standard deviation of the differences between all individual bonds' spread changes and the average spread change of their respective cell, pooled across all bonds and months. This pooled measure of idiosyncratic spread volatility per market cell was then plotted against the median spread of the cell. We again found a very strong linear relationship between spread and idiosyncratic spread volatility, with a slope similar to that estimated for systematic volatility.

To corroborate these findings, we also investigated the relation between excess return volatility and DTS. If the volatility of systematic spread changes is proportional to the level of spread, then Eq. (55–4) implies that a portfolio's excess return volatility should increase linearly with its DTS, with the slope equal to the volatility of relative spread changes. In addition, excess return volatility for portfolios with similar DTS should be approximately equal even if their spreads or spread durations differ.

To examine these predictions, bonds were assigned into DTS quintiles, which in turn were further subdivided into six equally populated buckets based on spread. The average excess returns and median DTS were calculated monthly for each bucket separately. These statistics were then used to compute the excess return volatility and average DTS for all time-series.

5. The population of the three highest spread cells (bonds trading at spreads above 500 bps) was very scarce for most of the study period. Consequently, most of their monthly spread realizations were excluded (due to the minimum bond population requirement). The statistical relevance of these most extreme data points is therefore questionable.

EXHIBIT 55–3

Excess Return Volatility vs. DTS

Based on monthly observations for all constituents of the Barclays Capital Corporate Index, September 1989–January 2005.
Source: Barclays Capital.

The results of this analysis are presented in Exhibit 55–3, which plots the time series volatility of excess returns for each of the quintile-bucket combinations against its average DTS. First, it is clear that excess return volatility increases with the level of DTS and that a straight line through the origin provides an excellent fit. This is indeed confirmed by a regression of the excess return volatility against the average DTS, which finds a fit of 98% and an insignificant intercept. Furthermore, the estimate of the slope coefficient (8.8%) is in line with the volatility of relative spread changes found in Exhibit 55–2 as expected. Second, observations representing the same DTS quintile exhibit very similar excess return volatilities despite large difference in their spreads and durations.[6]

In 2009, we re-examined whether the key findings underlying the DTS concept remained valid through the credit crisis of 2007–2009.[7] We showed that the fundamental relationship between the level of spread and subsequent volatility persisted in a linear fashion across all sectors and credit ratings, although the proportionality factor increased from 10% to about 15%. While this implies that a long-term calibrated DTS model would not have fully captured

6. The one exception to this is in the highest DTS quintile, where the subdivision by spread causes wide variations in DTS as well. As a result, the observations no longer form a tight cluster, but they continue to follow the same general relationship between DTS and excess return volatility.
7. Madhur Ambastha and Arik Ben Dor, "DTS (Duration Times Spread) in the Credit Crunch: Did It Live Up to Expectations?" *Barclays Capital* (April 2009).

spread risk during the crisis months, we demonstrated that it was far more effective than any other spread duration–based measure. The explicit use of spread in the DTS framework as a barometer of risk proved to be of paramount importance in managing credit portfolios during that volatile period.

The concept of spread proportionality and DTS are not limited only to U.S. corporate bonds. From a theoretical standpoint, we showed that structural credit risk models such as the Merton model imply a near-linear relationship between spread level and volatility.[8] Subsequent empirical studies indeed found that the applicability of DTS extends to other spread asset classes with a significant default risk. For example, we investigated the dynamics of CDS spreads[9] in both the U.S. dollar and euro markets using a different estimation approach, sample period and data frequency than those used in the original study of U.S. corporate bonds. Despite these differences in data and technique, we found clear evidence of a linear relation between spread volatility and spread level with a very similar slope.[10] Similar results were documented for European corporate and sovereign bonds and emerging market sovereign debt denominated in U.S. dollars.[11]

RISK PROJECTION: PREDICTING SPREAD VOLATILITY

Perhaps the most important requirement for managing a credit portfolio successfully is the ability to measure its risk accurately. A key benefit of DTS in the context of generating volatility forecasts is its use of current spread levels to quickly adapt to changing market conditions. In contrast, estimates based on past realized spread volatility can take longer to adapt, depending on the time window used for calibration. The selected time period is inherently subjective, and may not perfectly reflect the current state of the market.

The credit crisis of 2007–2009 provides an excellent opportunity to examine the differences between forecasts based on DTS and traditional measures relying on historical realized spread changes for at least two reasons. First, the magnitude

8. Arik Ben Dor, Lev Dynkin, and Jay Hyman, "A Theoretical Basis for DTS (Duration Times Spread)," *Lehman Brothers* (December 2007). Robert C. Merton, "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," *Journal of Finance* 29 (May 1974).
9. Arik Ben Dor, Simon Polbennikov and Jeremy Rosten, "DTS (Duration Times Spread) for CDS: A New Measure of Spread Sensitivity," *Journal of Fixed Income*, 16 (Spring 2007), pp. 32–44.
10. Ben Dor, Polbennikov, and Rosten (2007) used maximum likelihood to estimate the relation between spread volatility and spread level of individual U.S. and European default swaps, based on weekly data over the period July 2004 and May 2006.
11. See Arik Ben Dor, Lev Dynkin and Jay Hyman, "DTS—Further Insights and Applicability," *Lehman Brothers* (August 2005). Arik Ben Dor, Albert Desclée, Jay Hyman and Simon Polbennikov, "Managing European Sovereign Spread Risk," *Barclays Capital* (August 2010). Madhur Ambastha, Arik Ben Dor and Lev Dynkin, "DTS (Duration Times Spread) for Emerging Market Securities—A New Measure of Spread Exposure," *Lehman Brothers* (February 2007).

of the crisis was unprecedented. Spreads of U.S. investment-grade bonds widened to an all-time high of more than 6%, from lows of around 1% in the benign 2003–2006 period. Similarly, spreads of high-yield bonds rose to more than 18% and credit default index swap (CDX) spreads increased by a factor of five. Not only the magnitude, but also the extraordinary speed at which spreads widened, caught many investors off guard, with risk estimates calibrated to the sustained "volatility drought" of the previous few years severely underestimating the spread risk of corporate bonds. Second, since the concept of DTS was first introduced in 2005, the crisis period presented a true out-of-sample test of its effectiveness.

Exhibit 55–4 shows the monthly spread changes of the Barclays Capital U.S. Corporate Index normalized by several projections of spread volatility from January 2006, well before the first signs of the crisis were observed, through March 2010, when markets were already in recovery mode. The first forecast of volatility, based on DTS, is the product of the spread level at the beginning of the month and the (approximate) relative spread volatility (10%/month) estimated in our original study, based on the analysis shown in Exhibit 55–2. The plot also includes two estimates using the realized volatility over a trailing 36-month window or during the entire history (since September 1989) available as of the start of each month.

The exhibit illustrates that the forecast based on the trailing 36 months would have fit the low volatility level during the pre-crisis period quite well, but was susceptible to large sudden shocks such as in July 2007 and November 2007, which resulted in 5.1 and 6.3 standard deviation realizations, respectively.

EXHIBIT 55–4

Comparison of Volatility Forecasts Based on DTS and Historical Absolute Spread Changes

Normalized spread changes are monthly changes in spreads divided by a forecast of volatility based on DTS with a 10% slope, absolute spread volatility computed over the trailing 36 months or the entire available history since September 1989. The results are reported monthly between January 2006 and March 2010.
Source: Barclays Capital.

Although the estimator gradually adjusted to the change in market conditions, it continued to understate the level of risk more than a year after the crisis began, with an 8.4 standard deviation realization in September 2008.

In contrast, the "long-term" forecast was better prepared at the beginning of the crisis since it incorporated information from previous extreme market events such as the 1998 and 2002 crisis periods. While its forecast of volatility for July 2007, for example, was higher than that of the "short-term" estimator, it generated grossly underestimated risk projections toward the end of 2008. Because adjustment to changing market conditions is slow, the spread change in September 2008 would have corresponded to an 11.6 standard deviation event, using the forecast generated by the long-term volatility measure. Similarly, the estimator underestimated the magnitude of the spread tightening beginning in early 2009 as market conditions started to improve.

The DTS volatility estimates over the period were consistently superior to both forecasts using realized volatilities. The DTS-based forecasts quickly (albeit not perfectly) reflected both the increased level of risk since the crisis erupted and the reversal in market conditions in 2009, with most spread change realizations corresponding to less than two standard deviations. A notable exception was September 2008. Despite the already heightened level of spreads, the combined effect of Lehman Brothers' and Washington Mutual's defaults and the bailout of AIG in that month resulted in a 4.5 standard deviation event. However, as discussed, the forecasts using realized absolute spread volatility underestimated the risk by a factor of between two and three times more than the DTS-based forecast.

The credit crisis that began in 2007 affected not only corporate but also sovereign issuers. The deteriorating economic conditions in several of the euro area economies with high deficits and/or debt ratios subsequently raised solvency concerns among many investors. As a result, spreads of countries such as Portugal, Ireland, Italy, Greece, and Spain widened significantly in 2010 relative to German treasuries, to the point where the risk contribution of sovereign spreads in investment-grade bond indices grew larger than that of corporate bonds.[12] Many market participants had to suddenly re-evaluate their risk management practices. It was apparent that past volatilities of absolute spread changes could no longer serve as a basis for forward-looking risk projections in this market, as sovereign spreads had mostly been very tight and stable since the inception of the Euro in 1999. The DTS paradigm, keying on rising spread levels, does not require a long period of increased spread volatility to warrant an increase in forward-looking risk estimates. Furthermore, as mentioned earlier, theory suggests that DTS should apply to all securities with a credit component irrespective of the issuing entity, and earlier results indeed confirmed it is applicable to emerging market countries. Therefore, it is interesting to see to what extent using the DTS paradigm to project the spread risk of Euro sovereign issuers could have helped investors in this asset class.

12. See Ben Dor, Desclée, Hyman, and Polbennikov, "Managing European Sovereign Spread Risk."

Exhibit 55–5 compares the daily spread volatility of several Euro countries over two distinct periods, which roughly span the time period of the crisis. Volatility between August 2008 and July 2009 is represented on the horizontal axis, whereas the vertical axis reflects the volatility in the period from August 2009 to July 2010. The time partition was selected such that both periods have about the same length but correspond to different stages of the sovereign debt crisis. Each observation represents either the absolute or relative spread volatility of a particular country. Observations along the diagonal line indicate that the volatilities are the same over the two time periods.

Two clear patterns can be observed in the plot. First, most of the observations representing absolute spread volatilities are located quite far above the line, pointing to a marked increase in volatility in the second period of the sample. In contrast, relative spread volatilities are quite stable, with almost all observations located near the straight line crossing the origin, which represents equal volatilities (absolute or proportional) in both periods. This is because the pick-up in volatility in the second period was accompanied by a similar increase in spreads. In particular, the daily volatility of absolute spread changes for Greece increased by a factor of almost 10 (from 5.9 to 51.6 bp), whereas in relative terms it only increased from 4.3% to 6.8%.

EXHIBIT 55–5

Absolute and Relative Volatility of Daily Spread Changes for Selected European Sovereign Issuers

Both absolute and relative spread volatilities are expressed in units with similar magnitudes. However, the interpretation is different: an absolute spread change of 10 represents a 10 bp widening in a country spread, while a relative spread change of 10 means that spreads changed by 10% of their current values (e.g., from 50 to 55, from 200 to 220).
Source: Barclays Capital.

Second, the daily volatilities[13] of relative spread changes in various countries are quite tightly clustered, ranging from 4.5% to a bit over 8%, whereas the range of absolute volatilities is much wider, ranging from 1.6 to more than 17 bp for Portugal and even higher for Greece. Furthermore, spread proportionality seems to capture well not only the spread dynamics of the countries that were in the center of the crisis (Portugal, Greece, Spain, Ireland, and Italy), but also countries that were less affected such as Belgium and France. While the exhibit suggests that absolute spread volatility also remained essentially unchanged for these two countries, using relative spreads offers the advantage of similar volatilities across all sovereign issuers.

Exhibits 55–4 and 55–5 provide an illustration of the advantage of the DTS approach compared with the risk estimated based on absolute spread changes. The DTS approach does not require a subjective selection of an historical calibration period, and allows for a rapid incorporation of market conditions as reflected in the level of spreads. This feature can be especially valuable in situations where market volatilities exceed any historical precedent, as illustrated in these two exhibits for the credit and sovereign crises of 2007–2010. It is also important to note that DTS-based risk forecasts can immediately adapt to changing conditions. Whereas models based on realized monthly volatility will only be updated at the end of a month, DTS estimates can be updated as soon as spread changes are marked—intra-month or even intra-day.

HEDGING: PREDICTING SENSITIVITIES TO MARKET SPREAD CHANGES

Another natural application of DTS is hedging. Consider an investor whose basic goal is to express a view favoring one issuer over another while taking as little directional market risk as possible. The primary driver of the performance of such a strategy should be the investor's skill at forming views on issuers, while any systematic risk is to be minimized. The success or failure in isolating

13. The results in this section are based on daily data due to the fairly short time period of relevance. The relative spread volatilities reported here thus seem to be much higher than those reported earlier for credit markets. Assuming that all daily spread changes are independent, and that a month contains about 20 business days, a 6% daily volatility would correspond to a monthly relative spread change volatility that is greater by a factor of $\sqrt{20}$, or more than 26%. This apparent discrepancy reflects in part the fact that the analysis in this section directly examines the spread volatilities of individual issuers, without any attempt to separate systematic from issuer-specific effects. If we compute the total spread volatility for an issuer using our estimates of systematic and idiosyncratic spread volatility updated through the 2007–2008 credit crisis (15% per month), the implied *total* spread volatility of about 21% per month is not so different from the daily results (converted to a monthly frequency) shown here for euro sovereigns. It also underscores the approximate nature of this square root rule and the difficulty of comparing daily and monthly volatilities.

issuer-specific risk lies in his ability to forecast the market beta of each security over the return horizon.

Say we are considering a trade as of December 31, and plan to hold it in position for three months. The betas we would like to use for this hedge are the as-yet unknown ones that we will find *ex post* as we later review the returns realized from January through March. What is the best forecast we can make given the data we have at our disposal? An obvious approach would be to use DTS. Since the DTS contribution of a position measures its systematic spread exposure, DTS neutrality should be the best way to hedge the market exposure of an issuer-specific trade that goes long one issuer and short another.

To examine this question, we conducted a study that compared two different methods for forecasting the market betas of individual CDS over a given period using only data available at the beginning of the period.[14] The first relied on the ratio of the DTS (in this case, risky PV01 times spread) of the individual CDS to that of the market as of the beginning of the period. The second approach was one commonly used by investors, based on the empirical beta of the individual CDS to the market from the prior period. We divided the dataset, which contained roughly three years of weekly data, into nonoverlapping periods of equal length, either 26 weeks or 52 weeks each. For each period but the first, the beta of each security was estimated using the two methods: either by using the spread as of the start of the period, or by using the security's beta from the prior period. We then regressed the realized beta during the period on each of these two candidate predictors. Since there were 84 issuers in each period, the regressions had 5×84 observations when a 26-week estimation period was used and 2×84 observations when a 52-week estimation period was used. The results of these regressions are shown in Exhibit 55–6.

Several things are apparent from Exhibit 55–6. First, we see that the DTS ratio provides a better prediction of next-period beta, with R-squared values approximately twice as high as those using the prior-period empirical betas. Second, the regression results tell a very different story for the two models. When using the DTS ratio, the intercept is not statistically significant, and the coefficient is very close to one; that is, the DTS ratio as of the start of the period is an unbiased estimate of market beta in the coming period. For the empirical betas, this is not the case. The intercept plays nearly an equal role as the prior period beta, both in terms of the coefficients and the t-statistics. This means that if we want to forecast the next-period beta based on the empirical beta observed in the prior period, an unbiased forecast would be to assume that the beta will be halfway between the prior observation and 1. That is, betas are mean-reverting. This observation dovetails nicely with the established literature on empirical betas in equity markets. For example, Grinold and Kahn make the following observations regarding equity betas:

> A stock with a high historical beta in one period will most likely have a lower (but still higher than 1.0) beta in the subsequent period. Similarly, a stock with a low beta

14. Arik Ben Dor, Jay Hyman, Simon Polbennikov and Jeremy Rosten, "Hedging Pairwise CDS Trades Using DTS," *Lehman Brothers Global Relative Value* (April 16, 2007).

EXHIBIT 55–6

Predictors of Market Beta Based on Start-of-Period DTS Ratios or Prior-Period Empirical Betas

Explanatory Variable for Predicting Beta	Time Period for Beta Estimation	R - Squared	Variable	Regression Results	
				Coefficients	t Stat
Prior-Period Empirical Beta	26 weeks	0.19	Intercept	0.56	9.83
			Prior-Period Beta	0.44	9.85
Prior-Period Empirical Beta	52 weeks	0.23	Intercept	0.49	5.63
			Prior-Period Beta	0.51	6.97
DTS Ratio	26 weeks	0.36	Intercept	–0.09	–1.1
			DTS Ratio	1.09	15.31
DTS Ratio	52 weeks	0.5	Intercept	–0.04	–0.5
			DTS Ratio	1.05	12.86

Source: Barclays Capital.

in one period will most likely have a higher (but less than 1.0) beta in the following period. In addition, forecasts of betas based on the fundamental attributes of the company, rather than its returns over the past, say, 60 months, turn out to be much better forecasts of future betas.[15]

Rosenberg provides empirical evidence supporting this statement and shows how the predicted betas from Barra's E1 risk model do a much better job of forecasting next-period betas than just using historical betas.[16] His results indicate that a simple regression of the beta in one period on the historical beta from the prior period yield a coefficient of 0.58.

These results can perhaps help add another perspective to the DTS concept in general. Upon their first exposure to the DTS approach, some investors have noticed a striking similarity to the more familiar concept of beta-adjusted spread durations. Both of these approaches recognize that a systematic change in spreads throughout an industry does not tend to result in a parallel shift, but that some issuers will move by more than others. The difference between the two methods is that in one approach, the forward-looking market beta is estimated based on its past market beta, while in the other it is estimated based on its current spread level. Based on the head-on comparison of the two estimation methods shown in

15. Richard C. Grinold and Ronald N. Kahn, *Active Portfolio Management*, 2nd ed. (New York: McGraw-Hill, 2000), p. 14.
16. Barr Rosenberg, "Prediction of Common Stock Betas," *Journal of Portfolio Management* (Winter 1985), pp. 5–14.

Exhibit 55–6, we can bring the two approaches into agreement. A portfolio's DTS exposure to a sector can now be seen to be equivalent to its beta-adjusted spread duration exposure, with the estimation of the betas provided by the market in the form of spreads.

After exploring the use of DTS to estimate hedge ratios of individual issuers relative to the market, we applied this approach to hedging paired long/short trades in CDS of two issuers from the same industry.[17] Selecting a pair of issuers x and y from a given industry at random, we would go long one unit of x (by selling protection) and hedge the systematic sector exposure by going short some amount of issuer y (by buying protection). A hedging strategy that used DTS ratios to determine the amount of issuer y to use was compared with one based on empirical betas. The details of this analysis are somewhat involved, and beyond the scope of this chapter, but they once again established the superiority of DTS-based hedge ratios over those based on empirical betas. The DTS-hedged trades were found to have lower P&L volatilities, more stable hedge ratios, and a smaller percentage of variance from systematic changes in sector spreads. Empirical betas proved to be more difficult to estimate, and prone to instability.

The DTS approach to hedge formation has several clear advantages. First, the calculation of the hedge ratio is simple and unambiguous and spares the investor some difficult decisions about how beta should be estimated (what frequency data? how long a window? Should recent data count more than older data?). Second, the DTS ratio has shown itself to be both a good predictor of market beta at the individual issuer level and a reliable mechanism for neutralizing the market exposure of long/short trades. Finally, when dealing with long/short trades in swaps of matched maturities, the DTS-neutral trade will be carry-neutral as well,[18] neatly avoiding the possibility of forming a portfolio with negative carry.

Although we restricted our investigation to the hedging of individual issuers and paired long/short trades in CDS, the results are applicable to a much broader portfolio context. Even portfolio managers who are able to take long/short positions in CDS do not necessarily hedge each trade on its own. Rather, long and short positions are established according to the manager's views, and the aggregate exposures of the portfolio are hedged to achieve the desired systematic exposures, either passive to the index or to actively reflect the manager's macro views. We believe that the right way to manage spread risk, consistent with the hedging mechanism used here, is to measure industry exposures in terms of net DTS contributions. To maintain a neutral exposure, one would attempt to zero out the exposures in each industry. If a portfolio incorporates active industry

17. For details, see Ben Dor, Hyman, Polbennikov, and Rosten, "Hedging Pairwise CDS Trades Using DTS."

18. If the duration is the same on both sides of the trade, then matching duration × notional × spread will be the same as matching notional × spread, which is exactly the way the monthly premium payments on the CDS are calculated. This means that the monthly premium flows on the two legs of the trade will exactly cancel each other out, and the total return of the trade will be entirely based on spread change.

exposures, the calculation of the overall risk should include correlations among relative spread movements in each sector. This approach is illustrated in the last section, which discusses how a risk model for spread asset classes can be constructed around the notion of DTS.

REPLICATION: CREATING INDEX TRACKING PORTFOLIOS

Portfolio managers often need to build portfolios that closely track the returns of the selected benchmark. Constructing a portfolio of cash instruments to replicate a target index can be accomplished using various methods, but the most commonly used approach is based on stratified sampling. It relies on partitioning the index into cells, which represent the manager's view of common risk factors affecting a given market (e.g., for credit, these might be sector and rating). Bonds are then selected from each "cell" based on certain criteria and weighted such that they match various characteristics of the cell, for example contribution to spread duration. The advantage of this approach is its simplicity and flexibility; its disadvantage is that it ignores the correlations among cells.[19]

In this section, we provide an illustration of the stratified sampling method using the Barclays Capital U.S. Corporate Index, and matching only a single characteristic at a time: DTS or spread duration. Our intention is not to design the "optimal" replicating portfolio, but rather to focus on the relative efficacy of one characteristic relative to the other.

To construct the two replicating portfolios, we first partition the index into 24 cells (eight sectors × three credit ratings).[20] We then select 10 bonds to represent each cell in the portfolio.[21] This same set of 10 bonds is used in both variants of the replicating portfolio, to reduce noise from issuer selection and focus attention on the differences in systematic risk exposures. The key difference is in how we weight the bonds within each cell: in the DTS-based portfolio, we match the DTS exposure of the index in each cell, while in the spread-duration-based portfolio we match the index spread duration exposure.[22] For example, Exhibit 55–7 shows a

19. A stratified sampling approach is "blind" to the relationships among cells. This can be remedied by complementing a stratified sampling approach with the use of an optimizer that accounts for the correlations among cells.
20. The sector breakdown is: Banking, Finance, Basic Industry, Consumer Cyclical, Consumer Non-Cyclical, Communications, Energy, and Utility.
21. The number of bonds selected from each cell is set to 10 since it strikes a good balance between having a realistic size for the replicating portfolio (240 bonds) and reducing idiosyncratic risk. If fewer bonds are used to represent each cell, the variation in tracking errors may reflect not only the difference between the two systematic risk measures (DTS and spread duration), but also the idiosyncratic performance of the set of bonds selected.
22. The scheme used to weight the 10 bonds within each cell is fairly complex, involving a further subdivision of each cell into four quadrants, to ensure that we can match both market weight and the desired additional characteristic by a rule-based algorithm that always results in positive weights to all selected bonds. Details may be found in Ambastha and Ben Dor, "DTS (Duration Times Spread) in the Credit Crunch: Did It Live Up to Expectations?"

EXHIBIT 55–7

Sector/Quality Profile of Barclays Capital U.S. Corporate Bond Index, as of 12/31/2010

	Market Value [%]	OASD	OAS	DTS	OASD [cntr]	DTS [cntr]
Total	**100.00**	**6.30**	**155.7**	**10.26**	**6.30**	**10.26**
Aaa-Aa	17.74	5.65	103.0	6.26	1.00	1.11
A	45.53	6.30	144.2	9.46	2.87	4.31
Baa	36.72	6.63	195.5	13.18	2.43	4.84
Banking	**24.57**	**5.05**	**190.3**	**9.94**	**1.24**	**2.44**
Aaa-Aa	7.28	4.51	123.5	5.77	0.33	0.42
A	15.40	5.25	203.4	10.98	0.81	1.69
Baa	1.88	5.46	342.2	17.54	0.10	0.33
Finance	**11.21**	**5.92**	**191.2**	**11.74**	**0.66**	**1.32**
Aaa-Aa	3.49	5.32	117.8	7.40	0.19	0.26
A	3.78	6.40	176.8	11.49	0.24	0.43
Baa	3.95	5.99	269.9	15.83	0.24	0.62
Basic Industry	**10.30**	**6.26**	**140.6**	**9.30**	**0.64**	**0.96**
Aaa-Aa	0.68	5.11	89.1	4.67	0.03	0.03
A	4.57	6.04	91.4	6.04	0.28	0.28
Baa	5.05	6.61	192.1	12.87	0.33	0.65
Consumer Cyclical	**5.32**	**7.15**	**121.8**	**9.39**	**0.38**	**0.50**
Aaa-Aa	1.18	8.17	75.9	7.97	0.10	0.09
A	1.57	6.78	86.6	7.13	0.11	0.11
Baa	2.57	6.92	164.3	11.41	0.18	0.29
Consumer Noncyclical	**12.82**	**6.49**	**106.7**	**7.59**	**0.83**	**0.97**
Aaa-Aa	2.80	6.86	71.2	5.85	0.19	0.16
A	5.42	6.61	86.0	6.34	0.36	0.34
Baa	4.59	6.12	152.9	10.14	0.28	0.47
Communications	**15.38**	**6.69**	**152.1**	**11.18**	**1.03**	**1.72**
Aaa-Aa	0.30	6.85	49.4	3.97	0.02	0.01
A	8.00	6.78	126.6	9.92	0.54	0.79
Baa	7.08	6.59	185.4	12.90	0.47	0.91

(Continued)

EXHIBIT 55–7

Sector/Quality Profile of Barclays Capital U.S. Corporate Bond Index, as of 12/31/2010 (*Continued*)

Energy	**9.10**	**7.32**	**141.6**	**11.30**	**0.67**	**1.03**
Aaa-Aa	1.68	6.38	72.4	5.28	0.11	0.09
A	2.38	7.09	105.4	8.24	0.17	0.20
Baa	5.04	7.74	181.8	14.76	0.39	0.74
Utility	**11.31**	**7.50**	**146.9**	**11.69**	**0.85**	**1.32**
Aaa-Aa	0.33	11.23	95.3	12.90	0.04	0.04
A	4.41	8.30	109.0	10.44	0.37	0.46
Baa	6.57	6.77	175.0	12.47	0.44	0.82

Source: Barclays Capital.

market structure report of the Barclays Capital U.S. Corporate Index along the sector/quality partition used for this replication exercise. For each cell of the partition, the report characterizes the exposure of the index to that market segment in three different ways: by market weight, contribution to option-adjusted spread duration (OASD), and contribution to DTS. The spread-duration–based replicating portfolio is constructed such that it matches the contributions to OASD in each of the index sectors (the second column from the right); the DTS-based replication matches the DTS contributions in the rightmost column.

A key part of any index replication attempt is selecting the bonds that form the replicating portfolio. In a real-life portfolio management setting, security selection plays an important role in determining performance and several different criteria can be employed in the security selection process, depending on the portfolio setting. If minimizing tracking error is the primary goal, then the security weights within each cell should focus on the primary issuer exposures of the benchmark. Additionally, managers may aim to maximize liquidity, or to add value by choosing securities that they believe will outperform. Ideally, though, as long as the portfolio has matched the benchmark allocations on the macro level, it should track well in the event of any major industry rally or decline. The key is to match the right set of macro exposures.

For the purposes of this study, our interest is not in the issuer selection mechanism, but in checking which set of macro exposures is most important to match. The selection mechanism therefore does not need to be optimal in any sense (e.g., minimizing tracking error volatility or maximizing performance). Rather, we would like to test our replication methods using several different issuer selection mechanisms, to ensure that differences between the two replicating portfolios (DTS-matched and spread duration matched) are independent of the specific bonds that were selected. One approach is simulation, in which bonds

in each cell would be randomly selected, the replication results recorded, and the analysis repeated multiple times. Another approach, which we use instead, is to specify explicit selection criteria based on bond characteristics. While this approach leads to a single replicating portfolio (per criterion), it more closely mimics a realistic process of constructing replicating portfolios for index tracking purposes.

We analyze five potential bond selection criteria. The first criterion, based on market value, selects 10 of the largest bonds in each cell. Hence, it results in the most investible and liquid portfolios (as larger size is generally associated with increased liquidity). The remaining four criteria are designed primarily to maximize our ability to distinguish between the two replication strategies. The second and third criteria rely on spread and select the bonds with the highest (lowest) level of spread. This represents a replication strategy that tries to maximize carry (minimize risk). The last two criteria use an algorithm designed to maximize the dispersion in either spread duration or DTS among the bonds selected within each cell. Selecting bonds with the maximum potential dispersion in the characteristics used to match the index should magnify the mismatch between the portfolio and the benchmark in terms of the exposures not being forced to match. This in turn would facilitate the comparison between the replication results of the two sensitivity measures.

Exhibit 55–8 presents the tracking error volatilities (TEV) of the replicating portfolios during the 24-month period beginning in January 2007, for the various bond selection criteria. Irrespective of the selection criteria, matching each cell's DTS achieves lower tracking error volatility than matching its spread duration, although the improvement varies widely, from 1.2 bp/month to almost 15 bp/month. Looking at the difference in weight given to each bond under the two matching schemes (reported in the third column) suggests that the reduction in TEV is generally more meaningful as the weight differential increases (i.e., as the replicating portfolios are less similar to each other).[23]

For example, if the selection criterion is market value, the average (absolute) difference in the weight of each selected bond under the two replication schemes (in proportion to the total index market value) is 0.46%, and the TEV declines from 22.9 bp/month for matching spread-duration exposures to 21.4 bp/month when matching DTS exposures. If the maximum-spread criterion is used instead, the weight differential rises to 0.72%, and the decline in TEV when matching DTS rather than spread duration exposures is 14.7 bp/month.

It is important to mention that the superior tracking achieved by matching the index DTS does not come at the expense of performance. The last two columns in Exhibit 55–8 display the average tracking errors of the replicating portfolios.

23. For each selected bond, we calculate the difference in the weight (as a proportion of the index aggregate market value) it is assigned under the DTS and spread duration matching. The weight differential per bond in Exhibit 55–8 is computed as the average of the absolute value of the weight difference for all the bonds selected.

EXHIBIT 55–8

Index Replication Using Stratified Sampling

Selection Criteria	*Tracking Error Vol. (bp/month)*		Weight Differential per Bond (as % of Total Index MV)	*Average Tracking Error (bp/month)*	
	SD Match	DTS Match		SD Match	DTS Match
Market Value (largest)	22.9	21.4	0.46%	–11.5	–8.0
Spread (lowest)	20.7	15.6	0.89%	–10.6	–14.0
Spread (highest)	33.0	18.3	0.72%	–11.7	–4.4
Spread Duration Dispersion	17.0	15.8	0.47%	1.9	5.8
DTS Dispersion	28.2	24.7	0.59%	–6.1	–1.5

Replication of the Barclays U.S. Corporate Index is performed through matching the spread duration (SD) or DTS characteristic of each of the 24 cells in the partition (8 sectors × 3 credit ratings). Based on monthly observations (January 2007–December 2008).
Source: Barclays Capital.

The results indicate that while our simple replication exercise tends to underperform the index for any bond selection criteria, the DTS-based approach gives better average tracking errors (with one exception) than the spread duration-based one.

The use of DTS exposures to replicate an index by stratified sampling is far from a theoretical exercise. This approach has been used to form a highly liquid portfolio of bonds to track the Barclays Capital U.S. Investment-Grade Credit Index.[24] A purely rules-driven sampling methodology ensures transparency. The replication methodology uses a partition of five sectors by five duration categories, with each cell represented by two bonds. The bonds are selected based on a proprietary measure of liquidity, and are weighted such that the index DTS exposure in each cell is matched. Historical backtesting of this strategy indicates that it tracks the index much more closely than an alternative strategy based on liquid derivatives including Treasury futures, swaps, and CDX.

EXPRESSING MACRO VIEWS IN ACTIVE PORTFOLIOS

Attention to the DTS exposures of a portfolio is essential for active portfolio managers as well as passive ones. In many financial institutions, the management of a portfolio is a team effort with distinct tasks for different players. Often, one

24. Ariel Edelstein, Siddhartha Dastidar, and Bruce Phelps, "Tradable Credit Portfolio (TCX) to Track the USD IG Credit Index," *Barclays Capital* (April 2010).

group forms a set of macro views and expresses them as a set of overweights and underweights to various market segments that the portfolio should adopt relative to the benchmark. A second group may be charged with the implementation of this plan in terms of individual securities, often following the issuer selection advice of yet a third group. Yet, in order to achieve the most accurate implementation of the macro views, they must be expressed in terms of the type of exposures that best reflect the way the market moves. Referring back to the index profile shown in Exhibit 55–7, we saw that the passive credit investor will most effectively replicate the macro exposures of the index by matching the DTS contributions in the far right column, not the market value weights or the contributions to OASD. Similarly, the active investor should express the desired overweights and underweights relative to the benchmark in terms of contributions to DTS.

PORTFOLIO CONSTRUCTION: OPTIMAL DIVERSIFICATION OF ISSUER RISK

In the management of all but the most passive credit portfolios, the sizing of credit exposures must find the right balance between two opposing needs. To control risk, it is important to avoid taking a position in any given issuer that is overly concentrated. Conversely, to generate alpha based on analyst recommendations, it is important that the recommended names have sufficient weight in the portfolio to drive outperformance; overemphasis on diversification can dilute the value of issuer selection. As a result, investors often seek guidance on what the "correct" level of diversification should be for a given portfolio.

In the traditional approach to portfolio diversification, a plan sponsor imposes constraints on the portfolio that specify the maximum percentage of the portfolio, by market weight, that may be invested in any single issuer. This issuer limit may be dependent on credit quality, allowing larger concentrations in higher-rated issuers. In the past, we have formulated an approach to optimally determine these quality-dependent limits, based on an empirical study of the performance impact of downgrades.[25] This analysis determined that the ratio of allowed position sizes should be based on the relative risks in different quality groups. If the sole concern is downgrade risk, then the ratio indicated based on credit market data gathered from 1988 through 2001 was approximately 9:4:1. This means that if we take the allowed portfolio weight in a Baa-rated issuer as our unit size, a position in a security rated A may be four times as large and positions in Aa-Aaa issuers may be nine times as large. If "natural" spread volatility, which occurs in the absence of a ratings transition, is included in the risk measure as well, the discrepancy between the different ratings categories is lessened, and the ratio becomes 4:3:1. A recent update of this model found that the experience

25. Lev Dynkin, Jay Hyman, and Vadim Konstantinovsky, "Sufficient Diversification in Credit Portfolios," *Journal of Portfolio Management* (Fall 2002), pp. 61–75.

during the 2007–2009 crisis was not supportive of large concentrations even in higher-rated issuers. The same model, updated to include data through the end of 2010, found that the optimal position size ratios were 2.8 : 1.6 : 1 based purely on downgrade risk and 2.6 : 1.6 : 1 when including the effect of all nonsystematic risk, both from downgrades and natural spread volatility.

How can we apply the DTS model to this problem? A first step to this end would be to retain the framework of ratings-dependent caps on issuer market-weight, but compute the position size ratios based on the ratios of average DTS levels in each credit quality group. This approach gives ratios that change over time as spreads widen and tighten, responding quickly to changing market conditions rather than needing to wait for an *ex post* analysis of realized losses. For example, as of December 2001, the position size ratio from the DTS method was 4.3 : 1.7 : 1, similar to the result from the empirical approach including the risk of both downgrades and natural spread volatility. As market volatility (and spread) ground lower in the following years, these ratios increased, peaking in March 2005 at 6.6 : 3.0 : 1. However, when spreads skyrocketed in 2008, the ratio of position sizes declined, reaching as low as 1.4 : 1.1 : 1 in September 2008, as all credit qualities were deemed highly risky. As of December 2010, the DTS-based ratio of 2.1 : 1.4 : 1 agreed well with that from the updated empirical study.[26]

However, the DTS paradigm shift suggests a completely different approach to controlling portfolio concentrations, not just a simple recalibration. Rather than imposing a limit on the portfolio market weight in a given issuer (with the size possibly dependent on quality), a limit on the DTS contribution of any issuer should be imposed regardless of credit quality. This would have the effect of allowing a portfolio to have large concentrations in low-spread issuers while enforcing stricter diversification constraints on high-spread issuers. While this idea is attractive in principle, its implementation encounters several practical problems, as we shall discuss.

This DTS-based approach is in some ways quite similar to the traditional approach, in which issuer caps are specified in terms of market weights that differ based on credit quality; yet there are some crucial differences. In both schemes, the fundamental principle is to allow greater concentrations to issuers perceived to be less risky, and require more diversification where risk is greater. The fundamental difference between the two methods is the source of the risk assessment: the quality assigned by the ratings agencies or the spread assigned by the market. There are advantages to each.

Market weight limits based on credit ratings are very well suited for specifying the investment policy for a particular mandate. A permitted position is easy to identify and not subject to debate. Furthermore, as ratings change rather

26. Lev Dynkin, Jay Hyman, and Vadim Konstantinovsky, "Sufficient Diversification in Credit Portfolios: Balancing Two Approaches," *Barclays Capital* (January 2011).

slowly, the guidelines are stable, and the manager is not forced to churn the portfolio as markets move.

Conversely, spreads can react more quickly to market events. As a particular issuer deteriorates in credit quality, the spread-based indicator will typically register that risk has increased much faster than the ratings-based indicator. Nevertheless, while this may be a clear advantage as far as measuring risk, it is not so clear that it is desirable to require managers to transact on price gyrations; the cost of such a policy could be prohibitive. A strict cap on DTS exposure would have the disadvantage of making the limits dependent on pricing, and could lead to inefficient forced selling.

Consider, for example, a strict implementation of a policy that limits DTS contributions. Say we restrict the maximum DTS contribution to any issuer to be 3.0, and that the manager establishes a 0.5% position in issuer XYZ with a spread of 100 bp and a duration of 5 years, for a DTS contribution of $100 \times 5 \times 0.5\% = 2.5$. If the spread widens out to above 120 bp, the manager would then be required to sell off some of the position to stay within the limits. This simple example highlights a number of difficulties with this arrangement. First, pricing uncertainty can make it unclear whether a given position is within the guidelines or not. Second, the need to adjust positions as spreads change represents both an undue hardship for managers and an increase in transaction costs for investors.

Another difficulty with a policy based exclusively on DTS contributions is that it can potentially allow very large exposures to short-dated corporates. While the risk of such a position may not be large in terms of spread volatility or excess return volatility, it is clearly undesirable from a tail-risk point of view. A prudent approach to tail risk is to limit the overall portfolio exposure to any single event.

Nevertheless, it is hard to ignore the evidence that credit ratings do not always present the full picture. The broad-brush treatment that allows the same position size for all A-rated issuers, even while large differences in spreads exist across this peer group, clearly leaves room for improvement. There is no question that incorporating information on issuer DTS contributions gives an improvement in our ability to estimate issuer risk. The difficulty is in setting up rules or guidelines that can incorporate this information without requiring unreasonably high turnover. With some ingenuity, it might be possible to reap the benefits of DTS-based risk controls without imposing too much of an operational burden. For example, one could establish a two-tiered constraint with different thresholds for new and existing positions. For instance, in the above example, if the DTS contribution limits were set at 3.0 for new purchases and 4.0 for existing positions, the XYZ position would remain within the guidelines unless the spread widened out from 100 to beyond 160. Presumably, the requirement to reevaluate the exposure to an issuer after a spread move of this magnitude would not be perceived as overly intrusive.

A more difficult challenge for a system of limits on issuer DTS contributions would be a generic rise in corporate spreads, as was seen in 2008. In this crisis environment, it is likely that virtually every issuer in the credit portfolio would

exceed the previously established caps on issuer exposures. Would we want to force managers to massively rebalance the portfolio into a market with no liquidity?

In general, forced selling is undesirable, and should be avoided whenever possible. We have conducted empirical studies of the performance impact on corporate bond indices of the forced selling of bonds downgraded to below investment-grade.[27] These studies show that investors would be better served by holding on to "fallen angels" well beyond the downgrade, as on average they tend to eventually recoup the overly large losses that they experience as IG managers are forced to sell all at once. How might these results apply to a policy of selling upon a spread widening, even without any change in ratings? This is not at all clear. One might argue that this could help reduce the losses from eventual downgrades; or, conversely, that this would just serve to lock in losses in many bonds that will recover immediately and never suffer a downgrade. Generally, a momentum strategy like this one will do well in trending markets and poorly in choppy markets.

Even when DTS limits are in place, one would probably want to include a hard limit on market value weights, to make sure that no truly large concentrations exist in the portfolio, even in very short-dated or low-spread securities.

In short, we would recommend that for specifying hard limits on issuer exposures within a portfolio mandate, plan sponsors should retain the time-honored tradition of market-weight limits. However, we also believe that managers should track and control the DTS exposures to issuers, and ensure that no single exposure grows too large. Rather than implementing this rule via a hard cutoff beyond which sales would be mandated, managers should have a roughly defined upper limit for issuer DTS exposures, and use their judgment in managing these exposures according to market conditions.

MODELING: CALIBRATING CREDIT-RISK FACTORS

Many portfolio managers rely on multifactor risk models to help them measure and control portfolio risk, either in absolute terms or relative to a benchmark. The DTS approach is ideally suited to estimate spread risk in such models. For example, a risk model might contain modules for measuring exposures to three different types of adverse credit events: systematic changes in spreads, either market-wide or across a particular sector; issuer-specific spread changes; and

27. Kwok Yuen Ng and Bruce Phelps, "Capturing Credit-Spread Premium: Alternative Benchmarks for Credit Investors," *Barclays Capital* (June 2010). This article traces the effect on credit index excess returns of rules that drop bonds immediately after downgrades to high-yield. Indices and other forced sellers incur significant losses on such bonds but never enjoy the benefits of a subsequent recovery. Also see Arik Ben Dor and Jason Xu, "Fallen Angels: Characteristics, Performance and Implications for Investors," *Journal of Fixed Income* (Spring 2011), pp. 33–58. This article studies the price dynamics of fallen angels over a three-year period around the downgrade date.

defaults. The use of DTS can improve the modeling of the first two of these three types of credit risk.

Exposures to systematic changes in credit-spreads in a particular market segment can be measured as the sum of the DTS contributions of all portfolio investments within that segment. The risk factor that relates to these exposures is a relative shift in spreads across the sector; for example, that all financial spreads increase by 10% of their current levels. The alternative to this, in a model not based on DTS, would be to assume that the risk factor is a parallel shift in spreads across a sector (e.g., all financials widen by 10 bp), and that the exposures are therefore contributions to spread duration. Thus, in the DTS-based model, the key risk factor volatility for a particular sector would be its estimated volatility of relative spread changes, as shown in Eq. (55–4) earlier in this chapter, while the alternative model would estimate the volatility of absolute spread changes as per Eq. (55–3).

The DTS-based approach offers three distinct advantages. First, it offers a better assessment of the relative risks of different portfolios. If two portfolios have the same market weight and average spread duration in a given sector, but portfolio A implements this allocation with higher-spread assets than portfolio B, only the DTS-based model will correctly show that portfolio A has a greater exposure to a widening across this sector than does portfolio B. Second, the DTS-based approach improves the accuracy of the risk projection by reducing the uncertainty in the estimation of risk factor volatilities. As we have seen, relative spread volatilities are much more stable than absolute spread volatilities. Therefore, even if we do continually update our estimates of relative spread volatilities within each sector, we find that they change much more slowly than the corresponding estimates of absolute spread volatility and that they are less sensitive to the choice of the time window used in this estimation process.

The third advantage offered by DTS is perhaps more subtle, but opens the door to the most profound change in the structure of the model. Up to this point, we have discussed the exposure to "a given segment of the market" in the abstract, without specifying exactly how the market is to be partitioned. However, choosing the partition along which to measure systematic exposures is one of the most critical elements of risk model design, involving careful tradeoffs among various goals. It is desirable to limit the model to a small number of intuitive factors, both to maximize the clarity and practical applicability of the risk reports produced and ensure that a sufficient number of bonds are available to accurately calibrate each risk factor. Conversely, it is important to include enough factors to achieve sufficient explanatory power. For example, a single risk factor that measures portfolio exposure to U.S. corporates would measure the effect on the portfolio of a potential rally or decline across the corporate bond universe, but not the effect of a relative widening of financials versus industrials. We would like to partition the universe finely enough to capture all major sector rotation effects.

When constructing a model of systematic spread risk for U.S. corporates prior to the introduction of the DTS model, we partitioned this universe into a sector/quality grid, using nine industry groups and three levels of credit ratings for a total of 27 risk factors.[28] The partitioning by quality was made absolutely necessary by the assumption that the systematic spread movement in a given market cell tends to take the form of a parallel shift in spreads. When we calibrated such a model to market data, we found that the volatility of absolute spread changes for Baa financials was much greater than that of Aa financials. Although the risk factors representing these two cells might be highly correlated, the substantial difference in volatilities precluded us from combining these cells.

If we instead assume that the spread change across an industry is a relative shift, we find that we no longer need to segregate our model by credit quality. The fact that Baa financials tend to have greater risk than Aa financials is reflected in the higher spreads. This will show up in the risk model as a larger exposure to the same risk factor based on relative spread volatility, rather than as an exposure to a different risk factor with greater (absolute spread) volatility. This puts the risk model designer at a great advantage with regard to the tradeoff between compactness and explanatory power. The model can be designed with roughly the same explanatory power as before using a much smaller number of risk factors, or we can use a finer industry breakdown to create a model with a similar number of factors but greater explanatory power. We have chosen the latter approach in our modeling efforts, increasing the level of sector detail to recognize 27 distinct industry groups.[29]

KEY POINTS

- Spread volatilities—both systematic and nonsystematic—tend to be proportional to spreads. This empirical observation, with theoretical backing, has many applications to credit portfolio management.
- Forecasts of spread volatility that combine long-term historical estimates of relative spread volatility with current spread levels are more accurate than historical estimates of absolute spread volatility, and are quicker to adapt to changing market conditions.
- Estimates of market beta based on DTS ratios form better projections of future market beta than those based on past observations of empirical market beta.

28. "The Global Risk Model: A Portfolio Manager's Guide," Chapter 26 in Lev Dynkin, Anthony Gould, Jay Hyman, Vadim Konstantinovsky, and Bruce Phelps, *Quantitative Management of Bond Portfolios* (Princeton, NJ: Princeton University Press, 2007).
29. A detailed exposition of a multifactor risk model in which credit is modeled using the DTS approach may be found in Chapter 47 of this volume.

- Matching index exposures to DTS is a better way to form index-replicating portfolios than matching exposures to market weight or contributions to spread duration. For active managers, credit sector overweights and underweights should be specified and implemented in terms of DTS exposures.
- Measuring and controlling DTS exposures to individual issuers can be viewed as an alternative or a supplement to issuer limits based on market weights and credit qualities.
- Portfolio risk models for fixed income can improve model accuracy and robustness by incorporating the DTS approach to project the risk entailed in both systematic sector overweights and in portfolio concentrations in individual issuers.

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CHAPTER
FIFTY-SIX

INVESTING IN DISTRESSED STRUCTURED CREDIT SECURITIES

ALFRED MURATA, PH.D., J.D.
Executive Vice President
Pacific Investment Management Company

The structured credit market encompasses securities backed by a wide range of assets. Structured credit securities are often secured by residential mortgage loans, commercial mortgage loans, student loans, credit card loans, auto loans, corporate loans, or other structured credit securities. Nevertheless, there are numerous structured credit securities that are backed by more idiosyncratic collateral types such as aircraft, shipping containers, railcars, restaurant franchise right cash-flows, tobacco tax revenues, airport fees, and small business loans. In a buoyant market, a strategy of investing in distressed structured credit securities may not be feasible, but a fixed income investor should be sufficiently familiar with the strategy to take advantage of the opportunity, should it present itself. This chapter discusses the distressed residential mortgage investment strategy in detail, which is a subset of the distressed structured credit securities investment strategy. Ideas from the distressed residential mortgage investment strategy can often be applied to investments in other sectors of the structured credit market.

BACKGROUND

The unprecedented decline in residential housing prices shifted the bulk of the existing universe of nonagency (not guaranteed by any agency of the government such as Fannie Mae, Freddie Mac, or Ginnie Mae) mortgage-backed securities to the distressed market by the end of 2007, leading to a development of a distressed mortgage-backed securities investment strategy.

Nonagency mortgage-backed securities are created by aggregating the cash-flows from a pool of mortgage loans into a trust and distributing these cash-flows

The author expresses his gratitude for the insights provided by Chris Dialynas.

between various tranches according to predetermined rules. Securities that have the highest priority in the cash-flow distribution waterfall (and consequently are least exposed to credit risk) were sold to risk-averse buyers (such as banks, insurance companies, and money managers), which were willing to accept a lower yield to purchase the securities. In addition, an important factor in the purchase decision of the more risk-averse buyers was the fact that these securities were typically rated AAA by a nationally recognized rating agency (such as Moody's, S&P, or Fitch).

By 2010, national housing prices had declined by 29% from the peak, and mortgage credit performance had significantly underperformed original expectations (from the time of deal origination, where a stress scenario housing price assumption typically assumed flat housing prices). In fact, performance was so poor that even the most senior tranches of most securitizations that were created in 2006 and 2007 have now suffered partial principal writedowns or are expected to sustain partial principal writedowns in the future.

As the rating methodologies of Moody's, S&P, and Fitch all require that a bond that suffers any writedown at all (even if 99.99% of the principal is paid back at par) be downgraded to CCC or lower, the vast majority of the nonagency mortgage-backed securities that were issued in 2006 and 2007 have now been downgraded to CCC or lower by all rating agencies. Rating agency downgrades of nonagency mortgage-backed securities are important because many investors (including many of the largest banks, insurance companies, and money managers) are explicitly prohibited from either purchasing or holding securities once the rating agency ranking has been downgraded below a certain threshold. In addition, even if an investor is not constrained by rating agency ranking (e.g., hedge funds or distressed funds), bonds with lower rating agency ranking tend to finance on poorer repo terms, thus reducing the levered yield for such securities.

Consequently, the plunge in residential housing prices not only had a negative fundamental impact on nonagency mortgage-backed securities (due to the impact of defaults on the underlying mortgage loans, leading to principal writedowns), but also had a very significant negative technical impact on the marketplace (due to forced selling from ratings constrained investors). The forced selling from ratings constrained investors resulted in a decline in market trading levels. Following this price decline, many levered investors were hit by margin calls, leading to further forced selling (even from investors that were not ratings constrained), resulting in a self-sustaining decline in market trading levels. In addition, unlike many niche sectors of the investment universe, there was no large distressed buyer willing to take advantage of the forced selling.

To begin with, the nonagency mortgage-backed security marketplace is very large ($1.4 trillion par as of year-end 2010), and reasonably complicated (especially for nonpractitioners). In addition, since almost all market participants that understood how to analyze nonagency mortgage-backed securities already viewed nonagency mortgage-backed securities to be very "cheap" well before the trough in prices had been reached, there were very few investors who had the combination of capital, credibility, and knowledge of how to analyze nonagency

mortgage-backed securities to stand in the way of the forced selling. At the nadir in early 2009, senior pass-through securities backed by 2006 or 2007 vintage prime ARM collateral (which were originally sold around par) had plunged to the high $40s (per $100 par). Subsequently, the market rallied, such that these bonds traded in the $80 area (per $100 par) by the end of 2010.

ECONOMIC (CREDIT) RISK VERSUS FINANCIAL (LEVERAGE) RISK

Cash-flows from each of the underlying mortgage loans are distributed among the various tranches according to a prespecified cash-flow distribution waterfall. Note that it is likely that with a pool of even the lowest quality mortgage loans, at least some cash-flow will be generated, while with a pool of even the highest quality mortgage loans it is possible that one loan could default and sustain a loss (and thus the pool as a whole would suffer a loss). Consequently, by adjusting cash-flow priorities and deal structure it is possible to create very safe bonds from even the riskiest collateral, and to create risky bonds from even the safest collateral.

An investor in nonagency mortgage-backed securities has two main methods to increase returns—either take economic (credit) risk, or take financial (leverage) risk. Employing either strategy will increase the investor's returns in the event of a favorable scenario, at the expense of a reduced return in a negative scenario. An investor taking economic (credit) risk will purchase nonagency mortgage-backed securities either backed by weaker underlying collateral (i.e., bonds backed by subprime collateral instead of bonds backed by prime collateral), and/or securities that have less structural protection (i.e., less senior in the cash-flow waterfall). In contrast, an investor that takes financial (leverage) risk will borrow funds (either explicitly in the repo market, or implicitly in the derivatives market) and use the borrowed funds to purchase additional securities.

In an environment in which mortgage credit performance deteriorates (which is most likely caused by a decline in housing prices or reduced availability of mortgage credit), a strategy of taking mortgage credit risk may result in poor returns, as voluntary prepayments are lower than expected and defaults are higher than expected. In contrast, a strategy of employing financial leverage risk may produce attractive returns if reasonable access to repo funding is maintained, mark-to-mark price declines are not so large as to cause forced selling and the deterioration in mortgage credit performance is not sufficient to negatively impact the cash-flows of the higher-quality bonds in the portfolio that is employing financial leverage instead of credit risk. On the other hand, in an environment in which financial conditions deteriorate (even if the circumstances are not related to the state of housing market), a combination of reduced repo availability and mark-to-market price declines may lead to margin calls and forced selling (leading to very poor performance for a strategy based on financial leverage). Note that by buying securities that are less senior in the cash-flow waterfall, an investor is in effect locking in nonrecourse term funding on the investment, with the funding rate

being the hold-to-maturity yield of the more senior bonds in the waterfall, and the investment being the tranche that was explicitly purchased, plus all of the tranches which are more senior in the cash-flow waterfall.

ANALYSIS OF NONAGENCY MORTGAGE-BACKED SECURITIES

Analysis of nonagency mortgage-backed securities can generally be divided into three main categories: (1) analysis of the underlying mortgage loans; (2) analysis of the servicing, which can impact cash-flows that are received from underlying mortgage loans; and (3) analysis of the deal structure whereby the cash-flows from each of the underlying mortgage loans are divided among the various securities. All three types of analysis must be completed to formulate an informed investment decision.

Analysis of Residential Mortgage Loans

Analysis of residential mortgage loans involves a review of various attributes for each of the underlying mortgage loans backing the mortgage-backed security, with the end goal of generating a vector of prepayment, default, loss severity, and delinquency rates for each of the mortgage loans in the pool under a variety of scenarios. While one is often tempted to simplify the analysis by assuming that the pool consists of one loan with the "average" of the characteristics of each of the underlying loans, such a simplification could lead to erroneous analysis due to the nonlinearity of various loan characteristics on the likelihood of default and prepayment. For example, a mortgage pool with two loans, each with a loan-to-value ratio of 80%, likely has a much lower loss expectation than another mortgage pool with two loans, one with a loan-to-value ratio of 60%, and the other with a loan-to-value ratio of 100% (since the likelihood of default increases dramatically as the amount of equity that a borrower has in his or her property declines). Consequently, the ability to separately analyze each mortgage loan in the pool will lead to much more accurate results than simply lumping all of the loans together and considering the pool of loans to be the "average" mortgage loan.

Predicting mortgage loan voluntary prepayment, default, loss severity, and delinquency rates will depend upon various mortgage loan characteristics. Mortgage loan characteristics can generally be divided into three main types: (1) static loan characteristics, (2) dynamic loan characteristics, and (3) economic drivers. Static loan characteristics are various data that are obtained at the time of the loan origination, such as credit score, debt-to-income ratio, loan-to-value ratio, lien position, combined loan-to-value ratio (the loan-to-value ratio if all mortgage loans encumbering the property are included), original loan size, zip code, etc. Dynamic loan characteristics are observed subsequent to the loan origination, and include loan dependent information such as delinquency status, refinance incentive, and mark-to-market loan-to-value ratio. Economic drivers are factors which are observed

subsequent to loan origination, which can affect numerous loans; such drivers can include regional housing price changes and mortgage rates.

By reviewing historical data, one can construct a mortgage credit model that can predict voluntary prepayment, default, loss severity and delinquency rates for each loan in a mortgage loan pool under various economic scenarios. Although in theory it may appear to be relatively simple to formulate a mortgage credit model, it is difficult to do so in practice. Note that there are numerous variables to consider, many variables appear to change at once (making it difficult to calibrate the model), and there are numerous problems with the data itself (either due to misreporting on the part of participants in the mortgage origination process, or differences in reporting by issuer). Furthermore, given the large data sets to be analyzed (millions of loans, with numerous data for each month of historical performance data), it may be necessary to employ specialized computer systems such as grid computers with hundreds of microprocessors in order to compute model projections within a reasonable time period. In addition, as a mortgage credit model's foundation is historical data, one should also use model projections with caution, especially when attempting to predict what will happen in scenarios that are significantly different from what has happened before (given the ever-increasing likelihood of unanticipated actions in such scenarios, such as governmental public policy activity).

Analysis of Residential Mortgage Loan Servicing

The servicer's role in a mortgage-backed security transaction is to collect the cash-flows from the underlying mortgage loans. Servicers are generally paid a fee on a monthly basis, which is calculated as a percentage of the loan balance being serviced, regardless of what tasks the servicer actually performs. In an environment of increasing housing prices with few delinquencies, the servicer has a relatively simple task, essentially receiving checks from borrowers and cashing them. On the other hand, in a declining housing price environment with skyrocketing delinquencies, the cost of servicing will increase dramatically as the servicer will need to absorb increased costs of collection procedures. In addition to the increased costs of collection when loans become delinquent, servicers are generally required to advance contractual interest and principal payments to the trust (even for delinquent loans). Even though the servicer is entitled to recoup the advances when the loan is liquidated, a capital constrained servicer may have liquidity pressures if the percentage of delinquent loans in its servicing portfolio increases.

Pursuant to deal documents, servicers usually have a duty to maximize the present value of cash-flow to the trust when making servicing decisions. Nevertheless, deal documents typically provide the servicer with wide latitude in determining which decisions maximize present value. The vast majority of mortgage loans in nonagency mortgage-backed securities transactions are serviced by affiliates of large banks. In addition to servicing a particular mortgage loan in a mortgage-backed securities transaction, the bank may have originated the mortgage loan,

invested in securities backed by the mortgage loan, or may own a second lien mortgage that is subordinated to the first lien mortgage in the mortgage-backed securities transaction. Consequently, the servicer may have an incentive to operate in a manner that maximizes their recovery at the expense of other investors.

Given the substantial decline in home prices and skyrocketing delinquency rates, there have been substantial public policy developments attempting to direct servicers to "keep the borrower in the house," and only foreclosing on the property as a last resort. One way to attempt to keep the borrower in the house is to modify the mortgage loan in order to reduce the likelihood that the borrower will default.

Loan modifications can take many forms. When the housing market was buoyant, a common type of loan modification was a loan capitalization. Under a loan capitalization, delinquent mortgage payments are added to the loan balance, and the borrower was deemed to be current (although would now have a larger mortgage balance to repay). This type of loan modification works well if the borrower became delinquent as a result of inadvertently forgetting to make their mortgage payment, or had a temporary (and now resolved) interruption in income (as the borrower has the ability and willingness to pay, and the loan capitalization places the borrower back into current status and allows them to resume making mortgage payments).

In an environment in which housing prices plunge and the economy weakens, the main causes of delinquency are an inability to afford the required payments (if for example the homeowner loses his or her job), or an unwillingness to pay (if the borrower has a negative equity position in the property). A loan capitalization modification does not resolve these more serious drivers of ability to pay and willingness to pay. Consequently, interest rate reduction modifications (reducing the interest rate on the mortgage) or principal forgiveness (reducing the principal balance of the mortgage) modifications have proved to be more successful at keeping the borrower in the house than loan capitalization modifications.

Due to the servicer's expanded involvement in the resolution of delinquent loans, as the performance of the mortgage pool deteriorates, bond cash-flows (and hence bond valuation) become increasingly sensitive to servicing practices. Given the fact that a servicer's profitability has a very tenuous relationship with a mortgage-backed securities investor's returns, when making investment decisions, one must be cognizant of the conflicts of interest between those of a servicer and those of a mortgage-backed securities' investor when making investment decisions.

Analysis of Deal Structure

Nonagency mortgage-backed securities are created by aggregating the cash-flows from a pool of mortgage loans into a trust and distributing these cash-flows between various tranches according to predetermined rules. Given the fact that there are thousands of nonagency mortgage-backed security deals, each with its

own cash-flow waterfall, many market participants use third-party cash-flow modeling systems that project the distribution of cash-flows between the various mortgage-backed security tranches when provided with loan-level, group-level, or deal-level voluntary prepayment, default, loss severity, and delinquency assumptions. While such third-party cash-flow modeling systems are generally accurate, there have been numerous cases in which cash-flows have not been modeled correctly, often leading to a material impact on bond valuation. Consequently, it is extremely important to carefully review deal documents and verify that the modeled cash-flows are consistent with the deal documents before executing trades.

An Illustrative Example

We now discuss the analysis of a sample nonagency mortgage-backed security, a super-senior tranche, backed by negative amortization adjustable-rate mortgages.

Exhibit 56–1 highlights the deal structure of the bond. One can observe that there are numerous A tranches, with an A included in the tranche name (i.e., 1A1, 2A1, etc.). These A tranches, were originally rated AAA, and are senior in loss allocation priority to the M tranche, which is senior in loss allocation priority to the B tranches (which have a B in the tranche name—B1, B2, etc.). Given the weak performance of the collateral pool to date, losses have been higher than expected. As a result, many of the subordinate tranches have now been written off. The B2, B3, B4, and B5 tranche have been completely written off as a result of the losses that have been realized to date. Future losses on the underlying collateral will now be used to write down the B1 tranche, after which subsequent losses will result in writedowns on the M tranche before the A tranches begin to suffer writedowns.

Although all of the A tranches are senior in the loss allocation priority to the M and B tranches, there are also differences in loss allocation priority between the A tranches themselves. First, there are three different pools of collateral. Cash-flow (and losses after the M and B tranches have been written off) from pool 1 is usually distributed between the 1A tranches (1A1, 1A2, etc.), cash-flow (and losses after the M and B tranches have been written off) from pool 2 is usually distributed between the 2A tranches (2A1, 2A2, etc.), while cash-flow (and losses after the M and B tranches have been written off) from pool 3 is usually distributed among the 3A tranches (3A1, 3A2, etc.). Second, by reviewing deal documents, one can observe that the 2A3 tranche is senior in loss allocation priority to the 2A4 tranche, which is senior in loss allocation priority to the 2A5 tranche, which is senior in loss allocation priority to the 2A6 tranche. In fact, given the substantial credit protection provided by more junior tranches in the capital structure, if losses were to be realized immediately, collateral losses would need to amount to 40.9% of the outstanding collateral balance before the 2A3 tranche even absorbs $1 of loss. Listed in the table next to the tranche name is a percentage number called the credit support percentage, which refers to the percentage

EXHIBIT 56–1

Sample Bond Loss Allocation Structure

GROUP 1						GROUP 2			GROUP 3	
1A3 55.2%57.3%	1A6 46.7%48.8%	1A5 46.7%48.8%						2A3 40.8%34.0%	3A1 45.4%67.1%	3A2 25.7%47.4%
1A6 46.7%48.8%	1A7-1 29.6%31.7%		1A4 29.6%31.7%	1A1 12.5%14.6%	1A10 12.5%14.6%	2A1 31.4%24.6%	2A2 22.0%15.2%	2A4 31.4%24.6%	3A3 25.7%47.4%	3A4-2 19.1%40.8%
1A7-2 29.6%31.7%	1A8-1 21.1%23.1%		1A8-3 21.1%23.1%			2A5-1 22.0%15.2%	2A6-3 12.5%5.7%	2A5-2 22.0%15.2%	3A4-1 19.1%40.8%	3A5-2 12.5%34.3%
1A8-2 21.1%23.1%	1A9-1 12.5%14.6%		1A9-3 12.5%14.6%			2A6-1 12.5%5.7%		2A6-2 12.5%5.7%	3A5-1 12.5%34.3%	
1A9-2 12.5%14.6%										
				M 1.7%1.7%						
				B1 0.0%0.0%						
				B2 0.0%0.0%						
				B3 0.0%0.0%						
				B4 0.0%0.0%						
				B5 0.0%0.0%						

of collateral losses that would need to be sustained before the bond begins to sustain losses.

Despite the 40.9% credit support, the 2A3 bond is still at risk of suffering a principal writedown. First, although the 2A3 bond has 40.9% credit support (assuming all losses occur immediately), principal is allocated between the senior bonds on a pro-rata basis, meaning that the credit support provided by the 2A4, 2A5, and 2A6 tranches is materially reduced if the losses occur over time instead of immediately. Second, given the substantial decline in housing prices since the loans were originated, collateral performance is substantially worse than originally expected.

Exhibit 56–2 shows a distribution of mark-to-market combined loan value ratio of each of the loans in the pool. The combined loan-to-value ratio (CLTV) is the sum of all mortgage debt encumbering the property (first lien plus all junior liens) divided by the market value of the property. In addition, to a current distribution of the mark-to-market combined loan to value is included a projection of what the distribution of combined loan-to-value ratios will be one and two years from now. In aggregate, 76% of borrowers currently have negative equity in the property. Given an expectation of declining home prices over the next year, it is expected that 81.2% of borrowers will have negative equity in their property one year from now. In the following year, a modest increase in housing prices is expected, resulting in 80.2% of borrowers expected to have negative equity in their property two years from now.

The underlying loans in this pool are negative amortization adjustable rate mortgages. Pursuant to the terms of these mortgages, for the first five

EXHIBIT 56–2

Sample Bond Combined Loan-to-Value Distribution

years, borrowers were permitted to make minimum monthly mortgage payments, which in many cases were not sufficient to even cover the interest that was accruing on the mortgage loans. In the case that the monthly payment was not sufficient to cover the interest accruing on the mortgage loan, the difference was added on to the existing mortgage balance, meaning that the outstanding principal balance increased over time, instead of decreasing. In conjunction with a declining housing market, the fact that mortgage principal balances on these loans were increasing had a substantial negative impact on mortgage credit performance. As a result, 54.6% of borrowers are now two or more payments delinquent on their mortgage.

Exhibit 56–3 provides a few summary data points regarding the collateral performance of the pool. One can note that the weighted average current combined loan-to-value ratio is currently 130%, a significant increase from the 77% combined loan-to-value ratio at the time that the loans were originated. As previously discussed, the main drivers of the increase in combined loan-to-value ratio are the substantial decline in home prices since deal inception and negative amortization on the underlying loans. Other noteworthy data from the table is the very low voluntary prepayment rate (a prepayment rate of 1% corresponds to a rate at

EXHIBIT 56–3

Collateral Recent Performance

Month	# of Loans	Average Loan Size ($'000)	Average Loan Age (Month)	Current Combined Loan-to-Value Ratio
@Origin	**1,044**	**366.8**	**0**	**77**
Jul-10	511	394.6	61	128
Aug-10	507	394.1	62	130
Sep-10	503	393.6	63	131
Oct-10	501	392.6	64	132
Nov-10	499	392.7	65	134
Dec-10	497	392.0	88	130

Performance	Voluntary Prepayment Rate	Constant Default Rate	Loss Severity in the Event of Loan Default (%)	Cumulative Collateral Loss %
Jul-10	0.0	17.1	52.9	5.6
Aug-10	0.0	8.4	61.2	5.8
Sep-10	1.6	7.1	73.0	6.0
Oct-10	2.3	1.4	75.9	6.1
Nov-10	0.0	3.3	79.9	6.2
Dec-10	0.0	4.1	58.3	6.2

EXHIBIT 56–4

Sample Bond Yield Table

Prepay	Loss Severity		Forward Curve Default Rate			Static Curve Default Rate		
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Avg Life	12.62	7.43	5.21	11.26	6.81	4.74
		Yield	**11.45**	**13.04**	**13.24**	**7.57**	**8.06**	**8.04**
		I Spread	818	941	1,014	--	--	--
	[illegible]	DM	779	922	1,010	713	837	944
		Write Down	0.5	23.3	29.1	0.2	17.8	25.1
		Cumloss (Orig)	11.9	19.4	20.5	11.1	19.7	20.1
		Cumloss (Curr)	26.7	44.1	47.1	24.9	42.4	46.3
		Cum Default (Current)	47.6	84.8	92.7	43.8	81.3	90.4
		Avg Life	13.38	7.86	5.64	11.91	7.15	5.12
		Yield	**11.05**	**7.58**	**2.64**	**7.04**	**4.08**	**(0.25)**
		I Spread	772	484	24	--		--
[illegible]	[illegible]	DM	734	476	41	661	372	(58)
		Write Down	4.7	43.9	51.9	3.2	36.2	47.2
		Cumloss (Orig)	15.4	26.3	29.0	14.3	25.2	27.5
		Cumloss (Curr)	34.7	59.7	64.4	32.2	57.4	63.3
		Cum Default (Current)	47.6	84.8	92.7	43.8	81.3	90.4
		Avg Life	13.93	6.16	5.91	12.39	7.40	5.42
		Yield	**10.47**	**2.80**	**(7.58)**	**6.21**	**(1.20)**	**(11.48)**
		I Spread	711	(28)	(1,037)	--	--	--
	[illegible]	DM	673	(35)	(1,044)	590	(133)	(1,399)
		Write Down	12.3	66.0	75.6	9.2	56.4	79.8
		Cumloss (Orig)	19.0	33.1	35.5	17.5	31.8	34.8
		Cumloss (Curr)	42.8	75.4	81.8	39.4	72.4	80.3
		Cum Default (Current)	47.6	84.8	92.7	43.8	81.3	90.4

which 1% of loans voluntarily prepay a year) and a very low constant default rate (a constant default rate of 1% means that 1% of loans default a year). Note that 54.6% of loans are currently two or more payments delinquent on their mortgage, so it is likely that the constant default rate will have to increase substantially to liquidate this backlog of delinquent loans.

Exhibit 56–4 is an excerpt from what is called a yield table, which shows the yield of the bond in various scenarios (as a function of voluntary prepayment, default and loss severity assumptions), at an assumed purchase price of $62 (per $100 par). In practice, an investor would use a yield table with a much wider range of scenarios (which would then be difficult to display). In addition, yields assuming flat interest rates, and yields assuming that interest rates follow the interest rate forward curve are provided. Note that in the base case (of an assumed 0.5% CPR, 16% CDR, and 68% loss severity for life), 84.8% of remaining loans in the pool default, yet the bonds still provide a yield-to-maturity of 7.66% (when run assuming that interest rates follow the interest rate forward curve). This base case also incorporates a relatively conservative assumption that 7.95% of principal is forgiven due to loan modifications, yet these modifications lead to improved collateral performance. While projected default rates may appear to be high relative to recent experience, one must consider the fact that 54.6% of the loans in the pool have missed two or more payments, and that default rates will have to increase in order to liquidate the backlog of delinquent loans in the pool. One can note (as expected), that bond yields tend to decrease as default rates increase, and the bond yields tend to decrease as loss severity rates increase. Further note that bond yields are significantly higher when the forward interest rates (instead of static interest rates) are assumed.

While the yield table is useful in terms of providing a summary of bond yields in various scenarios, one needs to be cognizant of two main limitations. First, the table shows yields in scenarios in which the voluntary prepayments, defaults, and loss severity are constant—in reality it is likely that these factors will

vary over time. While it is possible to construct yield tables in which prepayment rates, etc. vary over time, it will likely make the yield table very difficult to understand. Second, as previously discussed, there may be significant dispersion in the characteristics of the underlying loans. Assuming a certain prepayment rate, etc. for the pool as a whole, in essence summarizes the loan characteristics of the pool down to the loan characteristics of the "average" loan. While this may be reasonable in certain cases, it may lead to significant errors in other cases.

KEY POINTS

- An investor in nonagency mortgage-backed securities has two main methods to increase returns—either take economic (credit) risk or take financial (leverage) risk.
- Analysis of nonagency mortgage-backed securities can generally be divided into three main categories: (1) analysis of the underlying mortgage loans; (2) analysis of the servicing, which can impact the cash-flows that are received from the underlying mortgage loans; and (3) analysis of the deal structure whereby the cash-flows from each of the underlying mortgage loans are divided among the various securities.
- Analysis of residential mortgage loans involves a review of various attributes for each of the underlying mortgage loans backing the mortgage-backed security, with the end goal of generating a vector of prepayment, default, loss severity and delinquency rates for each of the mortgage loans in the pool under a variety of scenarios.
- The servicer's role in the mortgage-backed security is to collect the money from the underlying borrowers. Due to the servicer's expanded involvement in the resolution of delinquent loans, as the performance of the mortgage pool deteriorates, bond cash-flows (and hence bond valuation) become increasingly sensitive to servicing practices. One must be cognizant of the conflicts of interest between those of a servicer and those of a mortgage-backed securities' investor when making investment decisions.
- Nonagency mortgage-backed securities are created by aggregating the cash-flows from a pool of mortgage loans into a trust and distributing these cash-flows between various tranches according to predetermined rules. It is extremely important to carefully review deal documents and verify that the modeled cash-flows are consistent with the deal documents before executing trades.

CHAPTER
FIFTY-SEVEN

HEDGE FUND FIXED INCOME STRATEGIES

ELLEN RACHLIN
Managing Director
Mariner Investment Group, LLC

CHRIS P. DIALYNAS
Managing Director
PIMCO

VINEER BHANSALI, PH.D.
Managing Director
PIMCO

In this chapter, we discuss many of the most popular hedge fund fixed income investment strategies including macro, asset-backed credit, capital structure arbitrage, long/short credit, distressed, basis trading, index arbitrage and correlation trading, and volatility trading. We believe that a solid understanding of macroeconomic conditions, the economic environment, and the influence of policymakers and participants is critical for any robust investment strategy, including fixed income hedge fund investment strategies. Therefore, we begin with a discussion of macro investing fixed income strategies, focused on interest rates and currencies, and then move into further discussion of other strategies that are relative value, arbitrage strategies, as well as long biased ones. The performance of all of these strategies is dependent upon the portfolio manager's ability to take advantage of deviations of asset prices from their fair values. This process requires having analytical tools and a historical context within which to gauge asset price deviations and their potential for corrections. Relative value, asset-backed and arbitrage strategies require more sophisticated valuation tools for the computation of the expected value of security cash flows.[1]

1. For a more detailed discussion of some of these strategies, see Ellen Rachlin, "Fixed Income Arbitrage," Chapter 1 in Izzy Nelken (ed.), *Hedge Fund& Investment Management Securities* (Oxford, UK: Elsevier, 2006).

MACRO INVESTING

All elements of fixed income investing require an understanding of the macroeconomic framework and the macro-political economic environment. The macro initial condition will dictate a growth and price stability bias. The macro policy bias will determine the set of policy choices appropriate to achieve the policy bias objective. The philosophical bias of policymakers, as shown in Exhibit 57–1, will influence the analytical framework with which the initial condition is diagnosed given the existing institutional architecture of the macro economy.

The complex dynamics of the interaction of these considerations will result in a directional bias for many (if not all) of the risk parameters that concern portfolio managers. The interest-rate direction, yield-curve shape, volatility of interest rates, risk spreads, and currency valuation depicted in Exhibit 57–2, along with the corresponding second derivatives of each, are dominated by the dynamics of the macro system.

Many attributes define the macro-political economic environment. The institutional architecture is certainly very important. The institutional architecture is defined by the political, banking, and legal systems. While these bodies may be easily understood conceptually, they morph over time as the political/philosophical bias of the people in charge change as well as changes in the attitude of the general population occur, which can happen much more slowly.

Understanding the philosophical economic bias of each region is vital to anticipating policy and changes in policy. The primary objectives are simple and straightforward. In the United States, the stated objectives are a stable rate of inflation and full employment. The Europeans concern themselves most with price stability. The Chinese seem concerned with internal industrial development via a mercantilist export policy. Each country will have a particular objective at any particular time, and over time the importance of any particular objective will change as conditions change. Moreover, the philosophical bias evolves as a country evolves. In his *Republic,* Plato describes a very plausible evolution of political rule. Among those considered are: democracy, aristocracy, oligarchy, philosopher kings, monarchy, socialism, totalitarianism, and dictatorship. The implications of each are quite important to investment decisions, as are the migration of regime one to another. Exhibit 57–1 characterizes the institutional composition of a few of the many important financial economies. Note the differences among the market participants.

In his *The Role of Monetary Policy* (American Economic Association, 1968), Milton Friedman elaborates on public policy priorities, potential policy choices, and the difficulty of effective implementation.

> To state the general conclusion still differently, the monetary authority controls nominal quantities—directly, the quantity of its own liabilities. In principle, it can use this control to peg a nominal quantity—an exchange-rate, the price level, the nominal level of national income, the quantity of money by one or another definition—or to

EXHIBIT 57–1

Sizing Things Up as of January 2011

	United States	Europe	Japan	China
Political Framework	Democracy	Democracy	Democracy	Dictatorship
Economic Bias	Strong Keynesian	Austrian	Mild Keynesian	Mercantilist
Banking System	Insured	Insured	Insured	Controlled
Central Bank Bias	Growth	Price Stability	Exports	Exports
Central Bank Political Bias	Radical Reserve Currency	Conservative	Balanced	Controlled
Initial Conditions	Very leveraged; Dependent on foreign capital	Moderately leveraged; Poorly distributed among countries	Extremely leveraged; Internally financed	Net saver; Capital exporter
Govt Balance Sheet	Highly leveraged	Moderately leveraged	Extremely leveraged	Not
Political Decision Making	Difficult	Moderately difficult	Moderately difficult	Easy
Currency	Floating	Floating	Floating	Managed/Fixed

EXHIBIT 57–2

Expected Changes in Market Variables Relative to Changes in Economic Growth

	Early Growth	Mid-Growth	Late Growth	Recession
Rates	Stable	Increasing	Increasing	Falling
Yield-Curve	Positive	Flattening	Inverting	Steepening
Volatility	Low	Moderate	High	High
Risk Spreads	Narrowing	Narrowing	Narrowing	Widening
Currency	Appreciate	Appreciate	Appreciate	Depreciate

peg the rate of change in a nominal quantity—the rate of inflation or deflation, the rate of growth or decline in nominal national income, the rate of growth of the quantity of money. It cannot use its control over nominal quantities to peg a real quantity—the real rate of interest, the rate of unemployment, the level of real national income, the real quantity of money, the rate of growth of real national income, or the rate of growth of the real quantity of money.[2]

Understanding the Components of the Statistics

The investor should analyze the data in Exhibit 57–3 with an eye to dissecting the aggregated statistics. Understanding the trend of any particular statistic is insufficient. Understanding the distribution of components of the statistic is vital. In this regard it is most important to distinguish between the distribution of debt formation, both public and private, directed to consumption and that associated with investments. It is important to understand the distribution of prices associated with inflation. It is important to understand the components of trade, both exports and imports, associated with consumption and investments. The implications of the distributions are vitally important to predictions of the future and to an inferential understanding of the motivations of policymakers and the public at large. Also vital to the process is an understanding of when policy end points are near and the implications thereof. A microscopic understanding of the data will enable the investor to decide what coefficients to assign to each statistic and to change the coefficients when appropriate.

Armed with the data, although estimates differ somewhat among sources, the philosophical economic political persuasion and institutional architecture, the portfolio manager's challenge is to forecast the various risk parameters, knowing that there is more to economic behavior than statistics. The portfolio manager must also account for regulatory changes, sociological conditions, political risk, and the psychology of the participants. One looks to the markets for inferential valuations that presumably

2. Milton Friedman, "The Role of Monetary Policy," *American Economic Review* 58, 1 (1968); 1–17.

EXHIBIT 57–3

Components of the Statistics: January 2011

Nomura	United States	Germany	Japan	China
Debt/GDP	57%	76%	189%	17.70%
Export as % of GDP	12.50%	52%	15.30%	28.50%
Import as % of GDP	16.30%	46%	14.10%	25.50%
Banking system leverage	8	26	19	8
Aggregate bank assets	14.6 trillion	9100 billion	1388 trillion	9520 trillion
Govt nom spending	3.5 trillion	1100 billion	17 trillion	760 trillion
Personal savings rate	5.30%	12.50%	5.50%	36.90%
Net national savings	–3.50%	5%	–0.50%	52%
1-year expected change in FX	–3.40%	–2.50%	–5.80%	6%
Inflation rate	1.10%	1.60%	0.10%	5.10%
GDP nominal rate	4.60%	4.20%	2.60%	12%
GDP real rate	2.60%	3.90%	4.60%	7%
Unemployment	9.40%	7.50%	5.10%	4.20%

(Continued)

EXHIBIT 57–3

Components of the Statistics: January 2011 (*Continued*)

Citi	United States	Germany	Japan	China
Govt debt/GDP ratio	90.9	77.4	209.9	20.4
Export % of GDP	12.5	47.2	15.3	34.8
Import % of GDP	16.3	42.2	14.1	29.1
Banking system average leverage factor	17.2	26.1	20.6	67%
Aggregate notional of banking system assets	6.3 trillion	6900 billion	870 trillion JPY	1373 trillion
Aggregate notional of government spending	3.5 trillion	1127 billion	117 trillion JPY	1060 trillion CNY
Personal saving rate (%)	5.3	11.2	9.3	31%
Net national savings (% of GDP)	11.8	22.6	3.6	54%
1Y expected change in exchange-rate	–10.8	10.8	2	–5%
Inflation rate (y/y %, headline)	1.14	1.85	0.1	5.1
Inflation rate (y/y %, core)	1.1	1.0	–0.9	1.5
GDP nominal (% q/q annualized)	4.6	2.9	2.6	15.6
GDP real (% q/q annualized)	2.6	2.8	4.5	8.9
Unemployment	9.40%	7.50%	5.10%	4.20%

synthesize all of these criteria. After all, money-making is a bet against forward prices. So, forward rates, yield-curves and currency values are all requisite inputs to the portfolio manager's decisions after an assessment of all of the statistics and after an evaluation of all of the political/economic/philosophical judgments.

Big Changes Are Very Important

The price of an asset is simply the intersection of supply and demand. Activist policy institutions like the U.S. Federal Reserve Bank, the European Central Bank (ECB), the Bank of England, and the Bank of Japan have decided to change their status from referee to both player and referee and to engage directly in the markets in such a way that they become price setters. This is a most important fundamental change to capitalism. Direct government interference in capital markets means that prices are less subject to the fundamental macro valuations described herein and more a function of "social" desire of policymakers. This is a gigantic change and during such a change the portfolio manager must consider placing the political, sociological, and philosophical forecasts ahead of the traditional economic forecasts associated with a "capitalist" system.

The Yield Curve

The yield curve is a mapping of interest rates for various lending periods for a particular issuer. The yield-curve shape can vary substantially and changes in the shape of the yield-curve can be an important source of return to the investor. Longer maturities typically yield more because there is more pro-inflation risk and credit risk embedded within them and they are less liquid than shorter maturities. Absent credit risk considerations, longer maturity securities' yields are lowered because of their higher convexity, which takes on greater value when interest rates become more volatile. In Exhibit 57–4 there is displayed two examples of changes in risk from credit to interest-rate (inflation) risk and vice versa. In addition, we observe the proinflation tendency of policy in the United States in Exhibit 57–5.

Creditors generally cannot foreclose on a sovereign issuer. Defaults on sovereign issuers result in "restructuring," in which creditors receive a fraction of their principal back. So, in anticipation of a potential restructuring, rates increase on the sovereign to reflect the increased credit risk. The increase in rates further impairs the sovereign's credit, thereby increasing default probabilities because the interest-rate itself is higher than the rate of sovereign growth; growth that itself is reduced by the higher interest-rate. Moreover, over very long periods, demographic trends become an increasingly important variable if there is a large outstanding debt. Reductions in population growth translate into fewer workers to contribute to debt servicing and increases in the forward population relieve the debt burden.

The sovereign credit default swap (CDS) market is yet another check on the creditworthiness of the sovereign and the change in the credit status. The CDS market is one in which investors can buy and sell insurance on sovereign credit.

EXHIBIT 57–4

Evolution of Interest-Rate Risk

A policy is triggered and the insurance collected if and only if a default occurs or a restructuring, if CDS contract so specifies. The CDS spread is relative to a standardized LIBOR term and should map closely to the yield spread on that sovereign's bond to the same term rate. Technical contract specifications and potential for regulatory interference cause the two spreads to be unequal. However, the direction of the spreads should be consistent most of the time.

Economic inferences and dynamics, forecasts for interest rates and currencies are, as discussed, much more complex in a highly globalized world economy. Traditionally, currency forecasting was a function of interest-rate differentials,

EXHIBIT 57–5

U.S. Inflation Policy

growth and inflation, trade and capital flows, differentials and purchasing-power parity. Post the 2008 financial crisis, there has been an increasing focus on the growth in relative factor productivity and net trade flows. The military strength of a nation is always a very important consideration.

Many financial economists and investors believe the output gap is an important determinant of inflation. The output gap and inflation are inversely related as the output gap measures the degree of abundance of resources in the economy. The output gap theory relies on empirical Phillips curve analysis, which measures the historical relationship between a most important resource—labor and inflation—as depicted in Exhibit 57–6 for both the United States and the United Kingdom.

EXHIBIT 57–6

Phillips Curve

EXHIBIT 57–7

Implications of Policy Choices

	Capital Controls	Increase Taxes	Reduce Taxes	Inflate	Deflate	Increase Spending	Decrease Spending
Bonds	–	+	–	–	+	–	+
Currency	–	Amb	Amb	–	+	Amb	Amb

+ Buy, – Sell, *Amb* ambiguous.

Currency debasement, inflation, and taxation are all substitute expropriating vehicles in addition to regulatory tools such as capital controls the sovereign has at its disposal. The choice of vehicles is employed in combination with the prevailing conditions shown in Exhibit 57–7 make a big difference to an investor in sovereign bonds and to choice of currency—as always relative to forward values. Exhibit 57–7 is a crude mapping of currency and bond strategy given a particular policy circumstance.

Exhibit 57–8 shows the valuation of a few currencies in both the spot and forward markets. Conceptually, any difference between the interest rates implied by the forwards and the prevailing interest-rate differential between that country and the United States, interest rates (in this case) represents the speculative motive in that market or is indicative of high transaction costs.

Political Self-Interest versus Interest of the Sovereign

Politicians and policymakers can be predisposed to do what is in their best interest as opposed to the national interest. The national interest is, as discussed in the beginning of this chapter, a function of one's underlying political/philosophical/economic beliefs. To the extent that politicians get re-elected by providing benefits to the population through spending programs, we will observe an accumulation of debt and a generalized inflation over time. This has certainly been the case for the United States. Exhibit 57–9 provides inferential support for the thesis that

EXHIBIT 57–8

Spot and Forward Currency Valuation

		One-Year		*Three-Year*		*Five-Year*	
	Spot	Fwd	Implied	Fwd	Implied	Fwd	Implied
USD			0.45%		1.33%		2.23%
Europe	1.3592	1.3518	0.98%	1.3405	1.80%	1.3561	2.34%
Australia	0.9912	0.9456	5.28%	0.8725	5.59%	0.8251	5.91%
China	6.585	6.4625	–1.35%	6.2577	–0.40%	6.0015	0.57%

EXHIBIT 57–9

Debt Creation and Inflation

Source: Haver Analytics

Source: Haver Analytics

Source: U.S. Treasury/Haver Analytics

politics in democratic nations are incentivized to increase debt for the purpose of providing greater benefits to its constituents with the hope of reelection.

Investors in bonds and currencies must consider the psychological impact on policymakers' behavior when legacies are in the making. The period from the 2008 financial crisis through 2011 is a period when legacies are at risk and monumental global financial and social change is proceeding. It is a time for bond and currency investors to evaluate the efficiency of policies, the sustainability of policies, as well as, realistic alternatives to prevailing policies and the implications thereof. Investors should heed the council of notable economists of the past. Specifically, Keynes' policy prescription to a financial crisis might result in, "Euthanasia of the rentier,"[3] and Robert Triffin's concern about the responsibility of the custodians of the reserve currency. "We should be as averse as foreign countries—or more so—to incurring again the awesome political responsibilities and inflationary temptations inseparable from the exorbitant privilege of having our national currency used as the main international currency of the world."[4]

Macro fixed income hedge fund investment is one significant hedge fund style of investing. The rest of this chapter is devoted to other styles including: asset-backed credit, capital structure arbitrage, long/short credit, distressed, basis trading, and index arbitrage and correlation trading.

ASSET-BACKED CREDIT STRATEGY

The asset-based credit strategy is a long/short style of portfolio management that focuses on investing in securitized debt obligations, which may encompass a wide variety of types of debt from residential and commercial mortgages to leases and credit cards. The portfolio manager will seek to identify asset-backed securities that they believe are mispriced relative to the value of the supporting loan collateral for long or short investments. This strategy is focused, generally, on higher yielding securities backed by loans to riskier, non-prime borrowers, but not exclusively so.

The best opportunities to purchase mispriced asset-backed securities generally occur during significant dislocations in the credit markets. Practitioners of this strategy will often develop complex proprietary models to value the individual collateral referencing a given security with the goal of ascertaining whether that security may or may not have a greater liquidation value and principal and interest payment stream than is built into the current pricing. These valuation models will include current information such as payment delinquencies as well as payment projections over the expected life of the security. These models will have the ability to analyze loan level data. Hedging or shorting in

3. Chapter 24 in John Maynard Keynes. *The General Theory of Employment, Interest, and Money* (Cambridge, MA: Harcourt, Brace and Company, 1936).
4. Robert Triffin, "The International Role and Fate of the Dollar," *Foreign Affairs*, 57,2 (1978/79), Council on Foreign Relations.

this strategy may tend to focus on hedging macro risk factors such as general market declines as well as use derivatives on specific vintage or year and seniority in the payment of a securitized obligation.

The types of asset-backed credit collateral considered as a potential investment set for the credit strategy includes agency and non-GSE issued residential mortgage securities, primarily, consumer credit asset-backed securities, commercial mortgage securities, and commercial nonmortgage asset-backed securities, among others. The largest asset-backed credit group, residential mortgages, consists of securities backed by differing mortgage loan types, among them Alt-a, option adjustable-rate mortgages, other subprime loans, as well as others.

These loans are not only securitized into pooled obligations securities, but are further divided into tranches tiered by payment priority loss. The lower the payment priority, the higher the default risk, but also the higher the current yield. Part of this investment strategy is for the portfolio manager to not only identify misvalued securities but misvalued tranches. At times the cheapest security may be the first loss and in other instances it may be the top of the structure. The portfolio manager may also choose to allow their impression of the market environment determine where they are most comfortable in the tranche structure with the view that defaults have a cyclical component.

A portfolio manager may also choose to purchase securities that are "seasoned" meaning that they are older. Borrowers that have been current on their payments, historically, tend to continue to pay. However, seasoned securities tend to be more fully priced and are less likely to be cheap. Short strategies tend to be hedges designed to protect from systematic risks such as against general deterioration in all asset prices, both stocks and bonds and less security level specific, other than derivatives due to the limited ability to short or borrow the cash securities in the asset type.

Some of the underlying collateral that is monitored by the portfolio manager include home and commercial property price appreciation, cumulative default rates, delinquency trends, cumulative loss rates, loss severity from sale, loan to value rates, loan modification levels, liquidation rates, geographic, REO levels, commercial sector demand, and unemployment rates, among others. Because default rates are the primary risk factor in this asset class, the asset-backed credit portfolio manager will monitor the performance of the underlying loans behind the asset-backed securities held and the ones under consideration for possible inclusion in their portfolio. Some details include the number of reference loans that are delinquent, length of time delinquent, nonperforming, in foreclosure and liquidated, as well as restructured and re-performing.

Hedging techniques and possibilities have greatly expanded in scope and potential for this hedge fund strategy over time. At one time, one could only primarily think in terms of hedging systematic or cyclical risk. One would choose broad-based credit, interest-rate or even equity indices to provide downside protection. However, during the beginning stages of the housing debt market crisis a proliferation of derivative products that referenced asset-backed securities and tranches of

asset-backed securities by type were developed that offered ways to more directly hedge or short sell residential and later, commercial asset-backed securities. Some of these products include: Markit ABX-HE, Markit CMBX, Markit TRX.NA, and Markit iBoxx European ABS, as well as credit default swaps on home equity asset-backed securities. These derivatives are tranched, allowing for a more specific type of asset-backed hedge or short sale instrument.

CAPITAL STRUCTURE ARBITRAGE

Capital structure arbitrage is an investment strategy that is typically focused on stressed or distressed companies. Typically, these are ones with high balance sheet leverage. A capital structure arbitrage portfolio manager considers all securities of a company (debt and equity) for possible mispricing or relative mispricing. They view the securities by payment priority against current cash and future earnings potential. They assess value by ascertaining probabilistic ability to pay debt obligations as well as potential realized equity valuation. Capital structure arbitrage is an investment strategy that is flexible and broad enough in scope to accommodate opportunities that arise throughout the credit cycle. For example, the portfolio manager may be more constructive on holding equity that appears cheap versus a senior debt short hedge during an economic recovery and shorting equity while holding senior secured debt during economic contraction. Other times, the financial merit of a company's outstanding securities may hold a case independent of economic times. The portfolio manager will likely identify a specific catalyst event that will correct the senior versus junior security relative value mispricing. This catalyst could be an upcoming refinancing or a business specific event. This strategy tends to use low levels of leverage as the companies invested in have high levels of balance sheet leverage.

The layers of securities within a company can be quite varied from senior secured bank debt with strong covenants to the most junior security or equity-based ones. Each of these securities can be expected to have unique volatility characteristics. The more junior a security, the more likely it will be relatively more volatile. The portfolio manager must consider this volatility when positioning long and short as this will affect the overall P&L volatility exposure to their portfolio.

The portfolio manager must evaluate the covenants of outstanding debt and ascertain payment priority, which can be complicated. The most difficult layer of complication comes from companies with multiple subsidiaries. Subsidiaries and holding companies may have cross-liabilities and not be entirely self-reliant. The portfolio manager must also factor in debt maturity schedules as an important element of valuation against their prediction of future ability to make interest and principal payments. Often the clarification of payment priority and asset rights are resolved in a court of law. The portfolio manager must have a thoughtful way of assessing the likely bankruptcy proceeding outcomes in regard to the various debt instruments outstanding. This process can be fairly long and the outcomes uncertain. However, these securities are usually ones that can be sold or traded long before final legal decisions are reached.

A capital structure arbitrage portfolio is likely to contain multiple positions in various securities within the capital structures of many companies. Each of these companies is likely to be or anticipated to be experiencing some form of structural change as a result of meaningful current or prospective corporate events. The events may not only include a changing capital structure specific to one company, but may represent changing financial fortunes inflicted by the larger macroeconomic environment on many sectors of the economy. Often the capital structure arbitrage portfolio can be concentrated by sector as industry dynamics can affect multiple companies at once in a way that creates opportunity uniquely to that sector. The portfolio manager thinks in terms of various scenarios with probabilistic outcomes. The long and short security weightings will reflect their probabilistic assessments. Longs may hold a larger weight if stronger economic fortunes are expected ahead, for example. Events have varying time frames and the portfolio manager is also likely to assess the attractiveness of an opportunity based on the present value of the expected price change of the securities positioned.

Hedging in this strategy tends to be company specific, whether on a junior or senior security basis. However, it is usual to see industry level hedges or even index based ones in this strategy. Capital structure arbitrage portfolios can have a tendency to be net long for the company specific positions. Other more generalized hedging techniques may often make sense to deploy in order to mitigate overall market beta exposures.

LONG/SHORT CREDIT STRATEGY

The long/short credit strategy is also referred to as a relative value strategy or a fixed income arbitrage strategy. Within any of these descriptions are multiple substrategies or investment approaches practiced. Some of these substrategies may have very specific tightly hedged arbitrages while others have more systemic or generalized hedging approaches. Long/short credit strategies can include debt securities within the entire credit spectrum from investment-grade to high-yield and distressed. All approaches depend upon a bottom-up analysis of a given company's ability to pay its debt obligations based on its business model and its revenue prospects. Similarly, portfolio managers are focused on economic and leverage cycles, which affect companies' abilities to meet their debt obligations. A long/short credit portfolio can consist simply of diverse bond positions both long and short of companies that the portfolio manager feels are worthy of taking a positive or negative view on based on current default probability versus current price. A portfolio manager can be expected to hold overall exposure ranging from net long to closer to market neutral. Practically speaking, it is unusual for a portfolio to be consistently net short.

Cash corporate debt (loans, bonds, and preferreds) and derivatives, both single company reference as well as index and tranches of indices are the main instruments used, in addition to sovereign debt instruments. However, interest-rate

and equity instruments are used to hedge or emphasize certain desired exposures. Specifically, cash corporate debt obligations are ones that have some claim or payment priority in the event of corporate default. Derivative instruments, credit default swaps, are generally bi-lateral payment agreements between two contractual parties based upon the financial fortunes of a referenced entity. These instruments represent no direct obligation of the referenced company in the event of default. These instruments will be assessed based on a given entities' prospective cash flows, asset quality, covenant protection, possible catalysts that may alter an entity's future earnings capabilities, industry trends, overall default rates, credit conditions, industry, and broad economic factors, among others.

The long/short credit portfolio manager may take several different approaches toward building their portfolio. They may construct a credit long book and a credit short book with the net and gross exposures reflecting some macro point of view regarding underlying market volatility and near term direction. In general, the gross market value of the aggregated positions versus assets under management can be expected to be larger for higher rated, lower spread debt than lower rated, wider spread debt. Such construction reflects a risk attitude that the latter is likely more volatile in price.

Directional longs may include the debt or credit derivatives of out of favor, stressed, distressed companies, debt whose prices seem to be below their fair price as assessed by the portfolio manager, or of companies undergoing positive changes. Directional shorts may include the debt of or credit derivatives of companies that are experiencing a cyclical decline, whose prices seem to be above their fair price given future earnings potential as assessed by the portfolio manager, or provide opportunity to profit from the part of the leverage cycle in which all corporate bond spreads are widening. The portfolio manager can be expected to use leverage but hold some reasonable portion of unencumbered or excess cash over their margin requirements. The amount of unencumbered cash held will rise and fall depending on the overall conditions of the markets, both by cyclicality and opportunity. Depending on the risk appetite of the portfolio manager, their portfolio may be highly diversified with hundreds of positions or be more concentrated. Generally, over time the more concentrated a portfolio, the more volatile that portfolio's valuation can be expected to be. Concentration can refer to position size, ownership percentage of a particular debt issue, geography, industry, and credit quality, among others.

Of a given debt issue, the higher its investment rating, the lower the probability of its default; however, the return distribution of such a debt issue will be negatively asymmetrically skewed with more downside potential than upside. This is what makes hedging interesting in this strategy. Hedging can be company specific in such a way that overlaps with capital structure arbitrage and involve other debt in the same company as well as reference credit default swaps. Hedging or shorting can be used to express a negative view on a company or a sector as well as to maintain a net short position during times of market turmoil. Hedging can also be as broad in nature to include generalized equity, credit, and interest-rate hedges.

The more tightly hedged, market neutral or investment-grade focused a given portfolio is, the greater likelihood leverage will be higher than otherwise. Concentrated or net long portfolios can be expected to be commensurately less leveraged, as this type of portfolio will be more volatile than a market neutral one.

DISTRESSED

The distressed investing strategy is one that focuses on investing in the securities of companies experiencing financial stress. They may be or may not be in default. The investment situations may be ones that are meant to focus on improving corporate balance sheets, others may be liquidation investments in which a company's securities may represent a claim on valuable assets, including cash, some liquidity investments in which refinancing will provide the necessary time for a company to recover, or litigation investments in which the portfolio manager may participate on creditor committees and the value of certain securities will be determined in a court of law. As well, some positions may be short ones on deteriorating companies that are losing market share or are cyclical in nature. All positions will generally be constructed with an identifiable catalyst or some event, usually corporate specific, that will unlock the value potential of securities held in the portfolio.

The securities held in the portfolio of a distressed strategy can include all parts of the capital structure of a company, holding company or subsidiary as well as aggregated debt securities as described in the asset-backed security strategy section. Securities range from senior secured debt (such as bank loans) to subordinated debt (such as second lien debt) down to more junior secured securities (such as busted convertibles trading well below the convertible price and equities). Other types of debt securities exist only with companies experiencing financial distress such as debtor in possession (DIP) or rescue financing. The lower the debt in the capital structure or payment priority, the lower the dollar price can expected to be.

The distressed portfolio manager may take several approaches to building their portfolio. This strategy is primarily long-biased and the characteristics of the securities held in a sensibly constructed portfolio will include ones that are the debt or equity of companies that are industry leaders or have strategic importance, ones that are cheap relative to not only current valuation but have a cushion to protect during a downturn or market volatility, and well priced for the industry and region in which the company does business. The portfolio manager may use other companies' valuations in a similar industry to ascertain value of a target company as a way of affirming the total valuation of the securities they are holding. It is worth noting that one aspect of this strategy overlaps with the asset-backed credit strategy in that impaired structured credit such as collateralized debt obligations (CDOs) and collateralized loan obligations (CLOs), which are bundled multiple corporate debt obligations are often part of a distressed portfolio manager's investment set. These securities can be disaggregated to the loan or bond level and valued against current market pricing for the debt obligations of the underlying companies. The portfolio

manager will value the sum of the collateralized obligation against the parts and attempt to profit if there is a suitable mismatch. Overall, the distressed portfolio will be likely constructed of multiple positions in multiple companies, but can be concentrated as when the securities of the top 10 companies represent a majority of the invested assets under management.

Hedging for this strategy will span from other parts of the capital structure in which strategic long positions exist to index or interest-rate hedges. Hedges may also include the debt and equity of other companies within the same or similar industries as strategic long positions. This strategy may also encompass short positions for companies whose fortunes are declining given industry trends and economic outlook. However, in this situation, which can be fairly cyclical by nature, portfolio managers may tend to restrict capital inflows, or even return money to investors if opportunities are scarce. Tactically, portfolio managers can move "up or down" in the capital structure, buying senior secured positions during the weaker part of the economic or industry cycle and taking more junior security positions, unsecured or equity, during growth phases of the cycle. While not necessarily a hedging technique, it is a risk mitigation one.

BASIS TRADING

Basis trading involves the simultaneous purchase and sale of two closely related securities to take advantage of relative mispricing.

In the classic futures basis trade, an investor can buy a cash Treasury security and sell a futures contract. In the credit basis trade, an investor purchases or sells a cash corporate bond and hedges the credit risk by the purchase or sale of credit default swaps. Other versions, such as the LIBOR-fed funds, or its longer maturity counterpart, the swap-spread trade, as well as the cross-currency basis swap, which involves funding in one currency and swapping via the currency forward exchange-rate market are also popular.

The hallmark of all basis trades is the isolation of a factor that is not present in one leg of the trade but is present in the other leg. In the futures basis trade, the important factor is the presence of a delivery option. The gross basis of each bond in the delivery basket is computed by computing the difference in its forward price versus the converted price of the futures contract (the delivery price, which equals the futures price times a conversion factor specified by the exchange). To obtain the net basis the gross basis is adjusted by the net carry, which is the coupon income and re-investment income minus the funding cost or repo rate of the bond. When the net basis is positive, a long cash/short futures basis trade has a negative expected loss equal to the basis. For example, if the net basis is 2/32nds, the long-cash, short futures position is expected to lose 2/32nds if held to the futures expiration date. The reason for negative expected return is that the person who is short the futures contract has an option to deliver one of the bonds in the basket, and the price of the option is equal to the value of the net basis. The short

effectively pays the long futures holder for this option. Since all option values are positively correlated to a rise in volatility, the value of the option can rise if interest-rate volatility rises. In the case of the futures basis trade, the probability of another bond switching to become the cheapest to deliver rises as the volatility rises. Thus a person with the short futures position will have the value of the delivery option rise in an environment of rising volatility. Thus futures basis trading is really an option trading enterprise.

In a cash-CDS basis trades, an investor prefers to purchase a cash corporate bond and buy protection against it using credit default swaps contracts. If cash bond yields are higher than the price of protection, then the investor can take out risk-free profits. Following the history of the cash-CDS trade (here depicted at an aggregate level), illustrates some important insights into the fundamental driving factors. Before the crisis of 2008, the cash-CDS basis traded within a small range around zero. However, the crisis created a substantial widening of the spread, and the basis went negative, that is, cash bonds traded substantially wider than the CDS. In other words, at the height of the crisis an investor who had cash could purchase a cash corporate bond and buy protection on the credit risk and still be ahead by hundreds of basis points from those who did not have the cash and were forced to liquidate the cash bonds. In other words, the cash-CDS corporate basis trade is driven by the important risk-factor of liquidity. When liquidity is ample (as illustrated by the convergence of the basis trade after the infusion of liquidity from the Fed) the spread between cash and CDS quickly falls, as shown in Exhibit 57–10.

EXHIBIT 57–10

Spread between Cash and CDS

INDEX ARBITRAGE AND CORRELATION TRADING

Broadly speaking, index arbitrage and correlation trading take advantage of mispricing between the valuation of an index and its tranches (the "composite" securities), and the weighted valuation of its constituents. Since most indices have a large number of constituents, assumptions have to be made about the correlations between the constituents in order to reduce computational complexity. Thus index arbitrage is also known as "correlation" arbitrage.

The investment-grade credit default swap index (CDX) consists of 125 names of investment-grade credits that are selected by a consortium to represent the universe of investment-grade credits. There are similar indices in high-yield, Europe (ITRAXX), emerging markets, and others that make correlation trading possible. For the purpose of the discussion here, we will look at the CDX (investment-grade) indices.

The CDX index tranche market takes the losses on the 125 names and tranches them. The first tranche is the 0% to 3% or the equity tranche, which takes the first 3% of losses. The next three (mezzanine) tranches are the 3% to 7%, 7% to 10%, and the 10% to 15% tranches, which take the losses from 3% to 7%, 7% to 10%, and 10% to 15%, respectively. Finally the senior and the super senior tranches are defined by the attachment and detachment levels of 15% to 30% and 30% to 100%, respectively. These tranches are thus akin to put spreads on losses on the underlying index.

Correlation trading starts with the observation that if all correlations rise, the likelihood of large losses goes up, since many underlying entities become likely to default. Thus, if correlations rise, the premium that one receives for selling protection on super senior tranches should go up. Similarly, as correlations go up, the equity tranche premia fall, since the possibility of no or low losses also increases. The case for the tranches in the middle (the mezzanine tranches) is much more complicated and typically requires a model. In correlation trading, a portfolio manager takes a view on the correlation, and combines different tranches from the capital structure stack to express their view, while keeping the exposure to the underlying index flat or delta-hedged. Similar to trading equity options by using implied volatility, tranche trading with reference to implied correlations is a popular strategy (with similar shortcomings). For equity options trading, the correlations are implied by fitting a Black-Scholes distribution to the option prices and extracting the value of the implied volatility parameter. For tranche trading, the popular approach is to use a Gaussian copula approach to model the joint behavior of defaults, and take views on the implied correlations.

Correlation trading done with simple models such as these ran into trouble in May 2005, when equity tranches hedged with mezzanine tranches diverged greatly from the model implied numbers. This can be traced to the downgrade of companies in the index that created a steep correlation skew (akin to a volatility put skew that occurs when there is a market crash) to account for higher systemic risk.

VOLATILITY TRADING

Volatility trading focuses on the purchase and sale of implied volatility in the market. In its most direct form, volatility trading attempts to benefit from opportunities and perceived mispricing in the fixed income options markets. Since options prices are primarily determined by the implied volatility of the underlying reference security, a portfolio manager can analyze the opportunity from many different angles.

The first approach is to buy or sell options when the implied volatility is rich or cheap compared with some metric of long-term levels. To do so, portfolio managers use various estimation techniques to measure and forecast realized volatilities. If implied volatilities are higher than the forecast of realized volatilities, options are sold and the risk to the underlying is delta-hedged based on some model. Typically, option prices reflect a risk-premium, since sellers of options require compensation over and above the actuarially fair value of the options in order to sell them. Over long periods of time the average return from selling fixed income options, and holding them to maturity, in particular, has been positive since yields are naturally mean-reverting (high rates slow the economy down and hence cause yields to fall). Many portfolio managers follow the ratio of implied to realized volatilities to wait to initiate these trades. For those who do not want to hedge the risk to the underlying by delta hedging, instruments such as variance and volatility swaps are available where a direct bet on the level of volatility levels can be made in relation to a volatility strike. Of course, this strategy is very directional in both the level of volatility and in the level of rates, since the profit or loss is driven by both movements in the level of uncertainty as well as the demand for options from hedgers.

Another approach to trading volatility is to look at the volatility surface and find opportunities from mispricing of particular strikes, expiries, and maturities. The swaption volatility "cube" is specified in terms of swaption expirations, as well as, the swap "tails" that these swaptions exercise into the different strikes given the option expirations and underlying forward swaps. For instance, with low rates and the short-end of the yield-curve pegged to zero rates, a portfolio manager might take the view that the implied volatility for a payer swaptions (one that gives the right to pay fixed) at a higher strike than current forward is pricing in too much volatility. They can sell that swaption and pick both the volatility premium and the payer skew (currently payer swaption volatilities are higher than receiver swaptions due to inflation hedging demand for high strike payer swaptions).

Many portfolio managers also look at implied optionality across various fixed income securities. For instance, a mortgage backed agency pass-through is sensitive to the change in volatilities since rising volatilities increase prepayment probabilities. A mortgage pass-through buyer is naturally short the prepayment option to the homeowner, and is compensated for the option in terms of extra spread. If the level of swaptions volatilities is low compared with the option volatility implicit in the mortgage security, a portfolio manager can position a volatility arbitrage by buying the MBS and buying the swaption.

A further extension of volatility trading is to execute the trades across markets. One might take the view that option volatility in the United States is higher than European fixed income, and sell options in one versus purchase in another. Or that the volatility expressed in the fixed income options market is higher or lower than the volatility expressed in the longer dated currency options markets. The two are related because currency forwards are driven by both the spot exchange-rate and interest-rate differentials, and for longer dated forwards the volatility and correlation of the longer rates becomes a dominant relative value factor.

KEY POINTS

- All elements of fixed income investing require an understanding of the macroeconomic framework and the macro-political economic environment at any point in time; present and future for any country or region within which the investment is derived. The complex dynamics of the interaction of these considerations will result in a directional bias for many (if not all) of the risk parameters that concern portfolio managers. The interest-rate direction, yield-curve shape, volatility of interest rates, risk spreads and currency valuation, and the second derivatives of each are all dominated by the dynamics of the macro system.
- The asset-based credit strategy is a long/short style of portfolio management that focuses on investing in securitized debt obligations, which may encompass a wide variety of types of debt from residential and commercial mortgages to leases and credit cards.
- Capital structure arbitrage is an investment strategy that is typically focused on stressed or distressed companies. Typically, these are ones with high balance sheet leverage.
- The long/short credit strategy is also referred to as a relative value strategy or a fixed income arbitrage strategy. Within any of these descriptions are multiple substrategies or investment approaches practiced. Some of these substrategies may have very specific tightly hedged arbitrages while others have more systemic or generalized hedging approaches. A long/short credit portfolio can consist simply of diverse bond positions both long and short of companies that the portfolio manager feels are worthy of taking a positive or negative view on based on current default probability versus current price.
- The distressed investing strategy is one that focuses on investing in the securities of companies experiencing financial stress. They may be or may not be in default. The investment situations may be ones that are meant to focus on improving corporate balance sheets; others may be

liquidation investments in which a company's securities may represent a claim on valuable assets including cash, some liquidity investments where refinancing will provide the necessary time for a company to recover or litigations investments where the portfolio manager may participate on creditor committees and the value of certain securities will be determined in a court of law.

- Basis trading involves the simultaneous purchase and sale of two closely related securities to take advantage of relative mispricing. In the classic futures basis trade, an investor can buy a cash treasury security and sell a futures contract. In the credit basis trade, an investor purchases or sells a cash corporate bond and hedges the credit risk by the purchase of sale of credit default swaps.
- Index arbitrage and correlation trading take advantage of mispricing between the valuation of an index and its tranches (the "composite" securities), and the weighted valuation of its constituents.
- Volatility trading focuses on the purchase and sale of implied volatility in the market. In its most direct form, volatility trading attempts to benefit from opportunities and perceived mispricing in the fixed income options markets.

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CHAPTER
FIFTY-EIGHT

FINANCING POSITIONS IN THE BOND MARKET

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

STEVEN V. MANN, PH.D.
Professor of Finance
Moore School of Business
University of South Carolina

Leveraging strategies require that an investor borrow funds. There are several well-established arrangements in the bond market for borrowing funds. The most common practice is to use the securities as collateral for a loan. In such instances, the transaction is referred to as a *collateralized loan*. In this chapter we will look at the four types of collateralized loans in which the collateral is a bond: repurchase agreement, dollar roll, securities lending, and margin buying.

A collateralized loan is not the only mechanism available to an investor for creating leverage. Derivative contracts are instruments that allow an investor to synthetically create leverage. This is so because a derivative contract allows an investor to obtain greater exposure to a specific bond issuer per dollar invested than the same dollar amount invested in the cash-market instrument. For example, the initial futures margin that an investor must make to obtain a long position in a Treasury bond futures contract creates an exposure to Treasury bonds much greater than the exposure if that initial futures margin were used to purchase Treasury bonds. In the case of an interest-rate swap, consider the fixed-rate receiver's position. This party is effectively borrowing on a floating-rate basis to obtain exposure to a fixed-rate bond position where the par value of that bond position is equal to the swap's notional amount. Similarly, there are cash-market instruments that have embedded leverage. For example, an inverse floater position is equivalent to borrowing funds on a floating-rate basis in order to obtain a fixed rate.

REPURCHASE AGREEMENT

A *repurchase agreement*, or simply *repo agreement* or *repo*, is the sale of a security with a commitment by the seller to buy the same security back from the purchaser at a specified price at a designated future date. The price at which the

seller subsequently must repurchase the security is called the *repurchase price*, and the date that the security must be repurchased is called the *repurchase date*. Basically, a repurchase agreement is a collateralized loan where the collateral is the security sold and subsequently repurchased.

Suppose that a government securities dealer purchases a 3.125% coupon Treasury note that matures on May 15, 2021 on Tuesday, May 24, 2011. The face amount of the position is $1 million, and the note's full price is $1,001,545.52. Further, suppose that the dealer wants to hold the position overnight. Where does the dealer obtain the funds to finance this position? Of course, the dealer can finance the position with its own funds or by borrowing from a bank. Typically, the dealer uses a repurchase agreement or "repo" market to obtain financing. In the repo market, the dealer can use the purchased Treasury note as collateral for a loan. The term of the loan and the interest rate a dealer agrees to pay are specified. The interest rate is called the *repo rate*. When the term of a repo is one day, it is called an *overnight repo*. Conversely, a loan for more than one day is called a *term repo*. The transaction is referred to as a "repurchase agreement" because it calls for the security's sale and its repurchase at a future date. Both the sale price and the purchase price are specified in the agreement. The difference between the purchase (repurchase) price and the sale price is the loan's dollar interest cost.

Let us return now to the dealer who needs to finance the Treasury note that it purchased and plans to hold for one day. The settlement date is the day that the collateral must be delivered and the money lent to initiate the transaction. Likewise, the termination date of the repo agreement is May 25, 2011. At this point we need to ask, who is the dealer's counterparty (i.e., the lender of funds). Suppose that one of the dealer's customers has excess funds in the amount of $1,001,545.52, called the *settlement money*, and is the amount of money loaned in the repo agreement.[1] On May 24, 2011, the dealer would agree to deliver ("sell") $1,001,545.52 worth of Treasury notes to the customer and buy the same Treasury security for an amount determined by the repo rate the next day on May 25, 2011.[2] Suppose that the repo rate in this transaction is 0.08%. Then, as will be explained below, the dealer would agree to deliver the Treasury notes for $1,001,545.52 and repurchase the same securities for $1,001,547.75 the next day. The $2.23 difference between the "sale" price of $1,001,545.52 and the repurchase price of $1,001,547.75 is the dollar interest on the financing.

The following formula is used to calculate the dollar interest on a repo transaction:

$$\text{Dollar interest} = (\text{dollar principal}) \times (\text{repo rate}) \times (\text{repo term}/360)$$

1. For example, the customer might be a municipality with tax receipts that it has just collected and no immediate need to disburse the funds.
2. We are assuming in this illustration that the borrower will provide collateral that is equal in value to the money that is loaned. In practice, lenders require borrowers to provide collateral in excess of the value of money that is loaned. We will illustrate how this is accomplished shortly when we discuss repo margins.

Notice that the interest is computed using a day-count convention of actual/360 like most money market instruments. In our illustration, using a repo rate of 0.08% and a repo term of one day, the dollar interest is $2.23, as shown below:

$$\$2.23 = \$1{,}001{,}545.52 \times 0.0008 \times (1/360)$$

The advantage to the dealer of using the repo market for borrowing on a short-term basis is that the borrowing rate (i.e., the repo rate) is less than the cost of bank financing. (The reason for this is explained below.) From the perspective of the entity lending funds, the repo market offers an attractive yield on a short-term secured transaction that is highly liquid.

The repo market can be used not only to finance a position in the market but also to cover a short position. For example, suppose that a dealer shorted a bond issue two weeks ago and must now cover the position—that is, deliver the bond issue. The dealer can do a *reverse repo* (i.e., agree to buy the bond issue and sell it back). Of course, the dealer eventually would have to buy the bond issue in the market in order to cover its short position. In this case, the dealer is actually making a collateralized loan to the counterparty.

There are a number of terms associated with repurchase agreements that are used widely. This market-specific vocabulary is discussed in Chapter 16 where private money market instruments are discussed. It is important to be mindful that the transaction is straightforward. One party is lending money and accepting a security as collateral while the other party is borrowing money and providing collateral to do so.

Credit Risks

Repos should be structured carefully to reduce credit risk exposure. The amount lent should be less than the market value of the security used as collateral, thereby providing the lender with some cushion should the market value of the security decline. The amount by which the market value of the security used as collateral exceeds the value of the loan is called *repo margin* or, simply, *margin*. Margin is also referred to as the "haircut." Repo margin is generally between 1% and 3%. For borrowers of lower creditworthiness and/or when less liquid securities are used as collateral, the repo margin can be 10% or more.

To illustrate the role of a haircut in a repurchase agreement, let us once again return to the government securities dealer who purchases a 3.125% coupon Treasury note and needs financing overnight. Recall that the face amount of the position is $1 million, and the note's full price is $1,001,545.52. When a haircut is included, the amount the customer is willing to lend is reduced by a given percentage of the security's market value. In this case, the collateral is 102% of the amount being lent. Accordingly, to determine the amount being lent, we divide the note's full price of $1,001,545.52 by 1.02 to obtain $981,907.37. Suppose that the repo rate in this transaction is 0.08%. Then the dealer would agree to deliver the Treasury notes for $981,907.37 and repurchase the same

securities for $981,909.55 the next day. The $2.18 difference between the sale price of $981,907.37 and the repurchase price of $981,909.55 is the dollar interest on the financing. Using a repo rate of 0.08% and a repo term of one day, the dollar interest is calculated as shown below:

$$\$2.18 = \$981{,}907.37 \times 0.0008 \times (1/360)$$

Another practice to limit credit risk is to mark the collateral to market on a regular basis. (Marking a position to market means recording the value of a position at its market value.) When market value changes by a certain percentage, the repo position is adjusted accordingly. The decline in market value below a specified amount will result in a margin deficit. The BMA Master Repurchase Agreement gives the borrower the option to cure the margin deficit by either providing additional cash or by transferring additional securities that are reasonably acceptable to the lender. Suppose instead that the market value rises above the amount required for margin. This results in a margin excess. In such instances, the BMA Master Repurchase Agreement grants the lender of funds the option to give the borrower cash equal to the amount of the margin excess or to transfer purchased securities to the borrower.

Since the BMA Master Repurchase Agreement covers all transactions where a party is on one side of the transaction, the margin maintenance is not looked at from an individual transaction or security perspective but as all repo transactions with the same counterparty.

The price to be used to mark positions to market is defined in the agreement. The market value is defined as one "obtained from a generally recognized source agreed to by the parties or the most recent closing bid quotation from such a source."

One concern in structuring a repo is delivery of the collateral to the lender. The most obvious procedure is for the borrower to deliver the collateral to the lender or to the cash lender's clearing agent. In such instances, the collateral is said to be "delivered out." At the end of the repo term, the lender returns the collateral to the borrower in exchange for the principal and interest payment. This procedure may be too expensive, though, particularly for short-term repos, because of the costs associated with delivering the collateral. The cost of delivery would be factored into the transaction by a lower repo rate that the borrower would be willing to pay. The risk of the lender not taking possession of the collateral is that the borrower may sell the security or use the same security as collateral for a repo with another party.

As an alternative to delivering out the collateral, the lender may agree to allow the borrower to hold the security in a segregated customer account. Of course, the lender still faces the risk that the borrower may use the collateral fraudulently by offering it as collateral for another repo transaction. If the borrower of the cash does not deliver out the collateral but instead holds it, then the transaction is called a *hold-in-custody repo* (HIC repo). Despite the credit risk associated with an HIC repo, it is used in some transactions when the collateral is difficult to deliver (such

as in whole loans) or the transaction amount is small and the lender of funds is comfortable with the reputation of the borrower of the cash.

Another method is for the borrower to deliver the collateral to the lender's custodial account at the borrower's clearing bank. The custodian then has possession of the collateral that it holds on behalf of the lender. This practice reduces the cost of delivery because it is merely a transfer within the borrower's clearing bank. If, for example, a dealer enters into an overnight repo with customer A, the next day the collateral is transferred back to the dealer. The dealer can then enter into a repo with customer B for, say, five days without having to redeliver the collateral. The clearing bank simply establishes a custodian account for customer B and holds the collateral in that account. This specialized type of repo arrangement is called a *triparty repo*. In fact, for some regulated institutions, for example, federally chartered credit unions, this is the only type of repo arrangement permitted.

The agreement covers the events that will trigger a default of one of the parties (i.e., "events of default") and the options available to the nondefaulting party. In the case of a bankruptcy by the borrower, the bankruptcy code in the United States affords the lender of funds in a qualified repo transaction a special status. It does so by exempting certain types of repos from the stay provisions of the bankruptcy law. This means that the lender of funds can liquidate the collateral immediately to obtain cash.

Determinants of the Repo Rate

Just as there is no single interest rate, there is no unique repo rate. Repo rates vary from transaction to transaction and across time due to a number of factors. These factors include the following: (1) quality of the collateral; (2) term of the repo; (3) delivery of the collateral; (4) availability of the collateral; and (5) the prevailing federal funds rate. These factors are discussed in detail in Chapter 16.

DOLLAR ROLLS

In the mortgage-backed securities (MBS) market, a special type of collateralized loan has developed because of the characteristics of these securities and the need of dealers to borrow these securities to cover short positions. This arrangement is called a *dollar roll*, so-called because the dealer is said to "roll in" securities borrowed and "roll out" securities when returning the securities to the investor.

As with a repo agreement, it is a collateralized loan that calls for the sale and repurchase of a security. Unlike a repo agreement, the dealer who borrows the securities need not return the identical securities. Specifically, the dealer need only return "substantially identical securities." This means that the security returned by the dealer that borrows the security must match the coupon rate and security type (i.e., issuer and mortgage collateral). This provides flexibility to the dealer. In exchange for this flexibility, the dealer provides 100% financing. That is, there is no overcollateralization or overmargin required. Moreover, the

financing cost may be cheaper than in a repo because of this flexibility. Finally, unlike in a repo, the dealer keeps the coupon and any principal paid during the period of the loan.

Determination of the Financing Cost

Determination of the financing cost is not as simple as in a repo. The key elements in determining the financing cost, assuming that the dealer is borrowing securities/lending cash, are

1. The sale price and the repurchase price
2. The amount of the coupon payment
3. The amount of the principal payments due to scheduled principal payments
4. The projected prepayments of the security sold (i.e., rolled in to the dealer)
5. The attributes of the substantially identical security that is returned (i.e., rolled out by the dealer)
6. The amount of under- or overdelivery permitted

Let's look at these elements. In a repo agreement, the repurchase price is greater than the sale price; the difference represents interest and is called the *drop*. In the case of a dollar roll, the repurchase price need not be greater than the sale price. In fact, in a positively sloped yield-curve environment (i.e., long-term rates exceed short-term rates), the repurchase price will be less than the purchase price. The reason for this is the second element, the coupon payment. The dealer keeps the coupon payment.

The third and fourth elements involve principal repayments—scheduled principal and prepayments. As with the coupon payments, the dealer retains the principal payments during the period of the agreement. A gain will be realized by the dealer on any principal repayments if the security is purchased by the dealer at a discount and a loss if purchased at a premium. Because of prepayments, the principal that will be paid is unknown and, as will be seen, represents a risk in determination of the financing cost.

The fifth element is another risk because the effective financing cost will depend on the attributes of the substantially identical security that the dealer will roll out (i.e., the security it will return to the lender of the securities) at the end of the agreement. Finally, delivery tolerances allowing for a small amount of under- or overdelivery are permitted. In a dollar roll, the investor and the dealer have the option to under- or overdeliver: the investor when delivering the securities at the outset of the transaction and the dealer when returning the securities at the repurchase date. The variance is the amount by which the delivery may deviate from the original trade amount. At one time, the variance permitted could have a

significant impact on the effective financing cost. Today, the impact is minimal because for TBA trades of Ginnie Mae, Fannie Mae, and Freddie Mac pass-throughs, the variance is only ±0.01% of the dollar amount of the original transaction agreed on by the parties. No allowance for variance is permitted for specified pool trades.

To illustrate how the financing cost for a dollar roll is calculated, suppose that an investor enters into an agreement with a dealer in which it agrees to sell \$10 million par value (i.e., unpaid aggregate balance) of Ginnie Mae 8s at $101^{7}/_{32}$ and repurchase substantially identical securities a month later at 101 (the repurchase price). The drop is therefore $^{7}/_{32}$. While under- or overdelivery is permitted, we will assume that \$10 million par value will be delivered to the dealer by the investor and that the same amount of par value will be returned to the investor by the dealer. Since the sale price is $101^{7}/_{32}$, the investor will receive in cash \$10,121,875 (101.21875 × \$10 million). At the repurchase date, the investor can repurchase substantially identical securities for 101, or \$10,100,000. Therefore, the investor can sell the securities for \$10,121,875 and buy them back for \$10,100,000. The difference, which is the drop, is \$21,875.

To offset this, the investor forfeits the coupon interest during the period of the agreement to the dealer. Since the coupon rate is 8%, the coupon interest forfeited is \$66,666 (8% × \$10 million/12). The dealer is also entitled to any principal repayments, both regularly scheduled and prepayments. Since the dealer purchases the securities from the investor at $\$101^{7}/_{32}$, any principal repayments will result in a loss of $\$1^{7}/_{32}$ per \$100 of par value of principal repaid. From the investor's perspective, this is a benefit and effectively reduces the financing cost. While the regularly scheduled amount can be determined, prepayments must be projected based on some Public Securities Association (PSA) speed. In our illustration, for simplicity, let's assume that the regularly scheduled principal payment for the month is \$6,500 and that the prepayment is projected to be \$20,000 based on some PSA speed. Since $\$1^{7}/_{32}$ is lost per \$100 par value repaid, the dealer loses \$79 due to the regularly scheduled principal payment ($1^{7}/_{32}$ × \$6,500/100) and \$244 from prepayments ($1^{7}/_{32}$ × \$20,000/100).

The monthly financing cost is then

Lost coupon interest	\$66,666
Offsets	22,198
Drop (gain from repurchase)	21,875
Principal repayment premium gained	323
Due to regularly scheduled principal	79
Due to prepayments	244
Total financing cost	\$44,468
Monthly financing cost	0.00439
Annual financing cost (monthly rate × 12)	5.27%

The financing cost as calculated, 5.27%, must be compared with alternative financing opportunities. For example, funds can be borrowed via a repo agreement using the same Ginnie Mae collateral. In comparing financing costs, it is important that the dollar amount of the cost be compared with the amount borrowed. For example, in our illustration, we annualized the cost by multiplying the monthly rate by 12. The convention in other financing markets may be different for annualizing.

Risks in a Dollar Roll from the Investor's Perspective

Because of the unusual nature of the dollar roll transaction as a collateralized borrowing vehicle, it is only possible to estimate the financing cost. From our illustration, it can be seen that when the transaction prices are above par value, then the speed of prepayments affects the financing cost. The maximum financing cost can be determined by assuming no prepayments. In this case, the total financing cost would be $244 greater, or $44,712. This increases the monthly financing cost from 5.27% to 5.29%, or 2 basis points. In practice, an investor can perform sensitivity analysis to determine the effect of prepayments on the financing cost.

In addition to the uncertainty about prepayments, the dealer can select the securities to deliver as long as they are substantially identical. However, even among substantially identical securities, there are some pools that perform worse than others. The risk is that the dealer will deliver poorly performing pools.

MARGIN BUYING

Investors can borrow cash to buy securities and use the securities themselves as collateral in a standard margin agreement with a brokerage firm. The funds borrowed to buy the additional securities will be provided by the broker, and the broker gets the money from a bank. The interest rate that banks charge brokers for these transactions is known as the *call money rate* (also called the *broker loan rate*). The broker charges the investor the call money rate plus a service charge.

The broker is not free to lend as much as it wishes to the investor to buy securities. The Securities and Exchange Act of 1934 prohibits brokers from lending more than a specified percentage of the market value of the securities. The initial margin requirement is the proportion of the total market value of the securities that the investor must pay for in cash. The 1934 act gives the Board of Governors of the Federal Reserve the responsibility to *set initial margin requirements*, which it does under Regulations T and U. The initial margin requirement varies for stocks and nongovernment/nonagency bonds and is currently 50%, although it has been below 40%. There are no restrictions on government and government agency securities.

The Fed also establishes a *maintenance margin requirement*. This is the minimum amount of equity needed in the investor's margin account as compared

with the total market value. If the investor's margin account falls below the minimum maintenance margin, the investor is required to put up additional cash. The investor receives a margin call from the broker specifying the additional cash to be put into the investor's margin account. If the investor fails to put up the additional cash, the securities are sold.

SECURITIES LENDING

A security lending transaction involves two parties. The first is the owner of a security who agrees to lend that security to another party. This party is called the *security lender* or the *beneficial owner*. The second party is the entity that agrees to borrow the security, called the *security borrower*. A *security lending transaction* is one in which the security lender loans the requested security to the security borrower at the outset, and the security borrower agrees to return the identical security to the security lender at some time in the future. The loan may be terminated by the security lender on notice to the security borrower, typically of not more than five business days.

To protect against credit risk, the security lender will require that the security borrower provide collateral. Collateral can take the form of (1) cash, (2) a letter of credit, or (3) a security whose value is at least equal in value to the securities loaned. In the United States, the most common form of collateral is cash. Outside the United States, all types of securities have been used as collateral, including common stock and convertible securities. Typically, if the collateral is a security, it is marked-to-market on a daily basis.

When cash is the collateral, the proceeds are reinvested by the security lender. The security lender faces the risks associated with reinvesting the cash. The income generated from reinvesting the cash is given to the security borrower less an amount retained by the security lender for loaning the security because the fee earned by the security lender is then the difference between the income earned from reinvesting the cash and the amount the security lender agrees to pay the security borrower. The security lender's fee is called an *embedded fee* when there is cash collateral. The agreed-on amount that the security lender pays to the security borrower is called a *rebate*. The security lender only earns a fee if the amount earned on reinvesting the cash collateral exceeds the rebate. In fact, if the amount earned is less than the rebate, the security lender incurs this cost.

When the collateral is a letter of credit or a security, the security borrower compensates the security lender by a predetermined fee. This fee is called a *borrow fee*, and it is based on the value of the security borrowed. Notice that while the security lender knows what the fee will be in the case of noncash collateral, this is not the case when there is cash collateral. The fee is a function of the performance of the portfolio or security in which the cash collateral is reinvested.

During the period in which the security is loaned to the borrower, there may be an interest payment (dividend payment in the case of stock). The security

lender is entitled to a payment from the security borrower equal in amount to any such payment. The payment made by the security borrower to the security lender for this purpose is called a *substitute payment* or *in-lieu-of payment*.

A party with a portfolio of securities to lend can either (1) lend directly to counterparties that need securities, (2) use the services of an intermediary, or (3) employ a combination of the first two. If a party decides to lend directly, it must have the in-house capability of assessing counterparty risk. When an intermediary is engaged, the intermediary receives a fee for its services. The intermediary could be an agent (i.e., acts on behalf of a security lender but does not take a principal risk position) or a principal (i.e., takes a principal risk position). Possible agents include the current domestic/global custodian of the securities or a third-party specialist in securities lending.

When cash collateral must be reinvested, a securities lender must decide on whether it will reinvest the cash or use the services of an external money manager. As noted earlier, securities lenders may realize a return on the cash collateral that is less than the rebate.

Comparison to Repurchase Agreements

It is worthwhile to compare a security lending transaction in which the collateral is cash to a repurchase agreement because both transactions represent a secured borrowing. We will do this with an illustration. The parties are as follows:

- Manager X, who is the beneficial owner of security A
- Manager Y, who needs security A to cover a short position

Also suppose that security A is a debt instrument that pays coupon interest.

The following agreement is entered into by manager X and manager Y:

1. Manager X agrees to transfer security A to manager Y.
2. Manager Y agrees to give cash to manager X.
3. At some future date, manager Y agrees to return security A to manager X.
4. Manager X agrees to return the cash to manager Y when manager Y returns security A to manager X.

The economics of this transaction are simple: it is a secured loan of cash with the lender of cash being manager Y and the borrower of cash being manager X. The collateral for this loan is security A. This transaction can be structured as a security lending or a repurchase agreement. No matter what it is called, the economics are unchanged.

If this transaction is structured as a security lending agreement, then

1. Manager X is the security lender (beneficial owner).
2. Manager Y is the security borrower.

3. Manager X invests the cash received from manager Y and at the end of the transaction rebates part of the income earned to manager Y.
4. The amount earned by manager X from security lending is uncertain and, in fact, can be negative.
5. Manager Y pays manager X any interest income that manager X would have received from the issuer of the security.
6. At some future time, manager X requests the return of security A and returns the cash collateral to manager Y.

If this transaction is structured as a repurchase agreement, then

1. Manager X is the seller of collateral or, equivalently, the borrower of funds using security A as collateral.
2. Manager Y is the buyer of collateral or, equivalently, the lender of funds.
3. Manager X invests the cash received from manager Y and at the repurchase date pays interest to manager Y based on the repo rate.
4. The amount earned by manager X from the repurchase agreement is uncertain and, in fact, can be negative.
5. Manager Y pays manager X any interest income that manager X would have received from the issuer of the security.
6. At the repurchase date, manager X buys back security A from manager Y at the repurchase price (which includes interest).

Whether the transaction is a repo or reverse repo depends on the perspective of the parties, as discussed earlier in this chapter. Notice that unlike a repurchase agreement, which has a repurchase date—which can be rolled over—there is no repurchase price in a security lending transaction.

KEY POINTS

- A repurchase agreement is the sale of a security with a commitment by the seller to buy the security back from the purchaser at a specified price on a designated future date.
- Repo margin or haircut is the amount by which the security's value exceeds the loan amount.
- A dollar roll is a specialized type of collateralized loan particular to the MBS market.
- Investors can borrow cash to buy securities and use the securities themselves as collateral with a standard margin agreement with a brokerage firm.

- A securities lending transaction involves one party lending a security and accepting collateral while another party borrows a security and provides collateral.
- In order to induce the security borrower to provide cash as collateral as opposed to some other form (e.g., another security or letter of credit), the security lender pays the security borrower a prespecified fee called the rebate rate.

PART

NINE

DERIVATIVES

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CHAPTER
FIFTY-NINE

INTRODUCTION TO INTEREST-RATE FUTURES AND OPTIONS CONTRACTS

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

STEVEN V. MANN, PH.D.
Professor of Finance
Moore School of Business
University of South Carolina

MARK PITTS, PH.D.

ROBIN GRIEVES, PH.D.
Clinical Professor
Moore School of Business
University of South Carolina

With the advent of options, futures, and forwards on interest-rate instruments, proactive fixed income risk management, in its broadest sense, assumes a new dimension. Investment managers and traders can achieve new degrees of freedom. It is now possible to alter the interest-rate sensitivity of a fixed income portfolio economically and quickly. *Derivative contracts,* known as such because they derive their value from an underlying instrument, offer investment managers and traders risk and return patterns that were previously either unavailable or too costly. Futures contracts can be used to control risk exposure with hedging being a special case of eliminating risk. In addition, futures contracts can be used to build synthetic positions in the underlying assets.

The purpose of this chapter is twofold. First, we explain the basic characteristics of options, futures, and forward contracts. Second, we review the most actively traded and most representative over-the-counter (OTC) and listed contracts. We omit from our discussion the use of futures for controlling interest rate risk; this topic will be explained in more detail in Chapter 61.

BASIC CHARACTERISTICS OF DERIVATIVE CONTRACTS

Futures Contracts

A *futures contract* is an agreement between a buyer (seller) and an established futures exchange or its clearinghouse in which the buyer (seller) agrees to take (make) delivery of a specific amount of a valued item such as a commodity, stock, or bond at a specified price during a designated time. For some futures contracts, settlement at expiration is in cash rather than actual delivery.

When an investor takes a position in the market by buying a futures contract, the investor is said to be *long the futures* or have a *long position in the futures.* If, instead, the investor's opening position is the sale of a futures contract, the investor is said to be *short the futures* or have a *short position in the futures.*

Futures contracts based on a financial instrument or a financial index are known as *financial futures.* Financial futures can be classified as interest-rate futures, stock index futures, or currency futures. This chapter focuses on interest-rate futures and includes a description of the most important interest-rate futures contracts currently traded.

To illustrate how financial futures work, suppose that *X* buys a futures contract and *Y* sells a futures contract on a 6% five-year Treasury note for settlement one year from now. Suppose also that the price at which *X* and *Y* agree to transact one year from now is $100. This is the futures price. This means that one year from now *Y* must deliver a 6% five-year Treasury note and will receive $100. *X* will take delivery of a 6% five-year Treasury note and will pay $100.

The profit or loss realized by the buyer or seller of a futures contract depends on the price and interest rate on the delivery date. For example, if the market price of a 6% five-year Treasury note at the settlement date is $110, because rates have declined, the buyer profits, paying $100 for a security that is worth $110. In contrast, the seller loses, because an instrument worth $110 must be delivered in exchange for $100. If interest rates rise on 6% five-year Treasury notes so that the market price is $90, the seller of the futures contract profits and the buyer loses.

When the investor first takes a position in a futures contract, he must deposit a minimum dollar amount per contract as specified by the exchange. As the price of the futures contract fluctuates, the value of the investor's equity in the position changes. At the close of each trading day, any market gain results in an increase in the investor's equity, whereas any market loss results in a decrease. This process is referred to as *marking to market.* Should an investor's equity position fall below an amount determined by the exchange, he must provide additional margin. On the other hand, if an investor's equity increases, he may withdraw funds. Consequently, a futures position may require substantial cash-flows before the delivery date. Margin is described in more detail later in this chapter.

Forward Contracts

A *forward contract* is much like a futures contract. A forward contract is an agreement for the future delivery of some amount of a valued item at a specified price at a designated time. Futures contracts are standardized agreements that define the delivery date (or month) and quality and quantity of the deliverable. Futures contracts are traded on organized exchanges. A forward contract is, in contrast, usually nonstandardized and is traded over the counter by direct contact between buyer and seller.

Although both futures and forward contracts set forth terms of delivery, futures contracts are not intended to be settled by delivery. In fact, generally only a small percentage of outstanding futures contracts are delivered or go to final settlement. However, forward contracts *are* intended to be held to final settlement. Many of the most popular forward contracts, however, settle in cash rather than actual delivery.

Forward contracts may or may not be marked to market. Consequently, there is no interim cash-flow on forwards that are not marked to market.

Finally, both parties in a forward contract are exposed to credit risk because either party may default on its obligation. In contrast, credit risk for futures contracts is minimal because the clearing corporation associated with the exchange guarantees the other side of each transaction.

Options

An *option* is a contract in which the seller of the option grants the buyer of the option the right to purchase from, or sell to, the contract seller a designated instrument at a specified price within a specified period of time. The seller (or *writer*) grants this right to the buyer in exchange for a certain sum of money, called the *option price* or *option premium.*

The price at which the instrument may be bought or sold is called the *exercise* or *strike price.* The date after which an option is void is called the *expiration date.* An *American option* may be exercised any time up to and including the expiration date. A *European option* may be exercised only on the expiration date.

When an option writer grants the buyer the right to purchase the designated instrument, it is called a *call option.* When the option buyer has the right to sell the designated instrument to the writer, the option is called a *put option.* The buyer of an option is said to be *long the option;* the writer is said to be *short the option.*

Consider, for example, an option on a 6% five-year Treasury note with one year to expiration and an exercise price of $100. Suppose that the option price is $2 and the current price of the Treasury note is $100 with a yield of 6%. If the option is a call option, then the buyer of the option has the right to purchase a 6% five-year Treasury note for $100 within one year. The writer of the option must sell the Treasury note for $100 to the buyer if he or she exercises the option. Suppose that the interest rate on the Treasury note declines and its price rises to $110. By exercising the call option, the buyer realizes a profit, paying $100 for

a Treasury note that is worth $110. After considering the cost of buying the option, $2, the net profit is $8. The writer of the option loses $8. If, instead, the market interest rate rises and the price of the Treasury note falls below $100, the call option buyer will not exercise the option, losing the option price of $2. The writer will realize a profit of $2. Thus the buyer of a call option benefits from a decline in interest rates (a rise in the price of the underlying fixed income instrument) and the writer loses.

If the option is a put rather than a call and the interest rate on Treasury notes declines and the price rises above $100, the option buyer will not exercise the option. The buyer will lose the entire option price. If, on the other hand, the interest rate on Treasury notes rises and the note's price falls below $100, the option buyer will profit by exercising the put option. In the case of a put option, the option buyer benefits from a rise in interest rates (a decline in the price of the underlying fixed income instrument) and the option seller loses.

The maximum amount that an option buyer can lose is the option price. The maximum profit that the option writer (seller) can realize is the option price. The option buyer has substantial potential upside return, whereas the option writer has substantial downside risk. The risk/reward relationships for option positions are investigated in Chapter 64.

Options can be written on cash instruments or futures. The latter are called *futures options* and are traded only on exchanges. Options on cash instruments are also traded on exchanges but have been traded much more successfully over the counter. These *OTC,* or *dealer, options* are tailor-made options on specific Treasury issues, mortgage securities, or interest-rate indexes. Option contracts are reviewed later in this chapter.

Differences between Option and Futures (or Forward) Contracts

Unlike a futures or forward contract, an option gives the buyer the *right* but not the *obligation* to perform. The option seller has the obligation to perform. In the case of a futures or forward contact, both the buyer and seller are obligated to perform. In addition, the buyer of a futures or forward contract does not pay the seller to accept the obligation, whereas in the case of an option, the buyer pays the seller an option premium.

Consequently, the risk/reward characteristics of the two contracts also differ. In a futures or forward contract, the long position realizes a dollar-for-dollar gain when the price of the futures or forward increases and suffers a dollar-for-dollar loss when the price of the futures or forward decreases. The opposite holds for a short position. Options do not provide such a symmetric risk/reward relationship. The most a long position may lose is the option premium, yet the long retains all the upside potential. However, the gain is always reduced by the price of the option. The maximum profit the short position may realize is the option price, but the short position has substantial downside risk.

REPRESENTATIVE EXCHANGE-TRADED INTEREST-RATE FUTURES CONTRACTS

Interest-rate futures contracts can be classified by the maturity of their underlying security. Short-term interest-rate futures contracts have an underlying security that matures in less than one year or a short-term reference interest rate. The maturity of the underlying security of long-term futures exceed one year. Exhibit 59-1 displays most interest rate futures contracts traded in the United States. The contracts are arranged along the yield-curve from short-term interest rates through the Ultra Long Bond contract. Notice that some of the contracts have physical settlement. Other contracts are cash settled. The success of cash settled contracts depends on having the price or yield in the calculation not be subject to manipulation. Below we describe the specifications of the long-term futures contracts (Treasury bond futures and Treasury notes futures) and short-term futures contracts (Treasury bill futures, Eurodollar futures, interest-rate swap futures, and federal funds futures).

The Treasury Bond Futures Contract

The Treasury bond (T-bond) futures contract is the most successful interest-rate (or commodity) futures contract. Prices and yields on the T-bond futures contract are quoted in terms of a (fictitious) 20-year 6% Treasury bond, but the exchange where the contract is traded, the Chicago Mercantile Exchange (CME), allows many different bonds to be delivered in satisfaction of a short position in the contract. Specifically, any Treasury bond with a remaining maturity of at least 15 years, but less than 25 years, from the first day of the delivery month is acceptable for delivery. There is an Ultra Long Treasury futures contract that differs only in that it is based on Treasury bonds with at least 25 years to maturity.

The T-bond futures contract calls for the short (i.e., the seller) to deliver $100,000 face value of any one of the qualifying Treasury bonds. However, because the coupons and maturities vary widely, the price that the buyer pays the seller depends on which bond the seller chooses to deliver. The rule used by the CME is one that adjusts the futures price by a conversion factor that reflects the price the bond would sell for at the beginning of the delivery month if it were yielding 6%. Using such a rule, the conversion factor for a given bond and a given delivery month is constant through time and is not affected by changes in the price of the bond or the price of the futures contract.

The seller has the right to choose which qualifying bond to deliver and when during the delivery month delivery will take place. When the bond is delivered, the buyer is obligated to pay the seller the futures price multiplied by the appropriate conversion factor, plus accrued interest on the delivered bond. It is important to emphasize that while the underlying Treasury bond for this contract is a hypothetical issue and therefore cannot itself be delivered into the futures

EXHIBIT 59–1

Representative Exchange-Traded Interest-Rate Futures Contracts

Contract	Form	Contract Size	Contract Months	Settlement
Eurodollar 1-month	Futures	$3,000,000	First 12 consecutive calendar months.	Cash
Fed Funds 30-day	Futures	$5,000,000	First 24 Calendar Months	Cash
Eurodollar 3-month	Futures	$1,000,000	Mar/Jun/Sep/Dec 40 contracts = 10 years	Cash
Overnight Index Swap 3-months	Futures	$1,000,000	First eight months in the March quarterly cycle (i.e., White and Red expiry years)	Cash
Treasury 2-year	Futures	$200,000	The first five consecutive contracts in the March, June, September, and December quarterly cycle	Physical
OTR 2-year	Futures	$100,000	Corresponds to 2-year Treasury notes auctions. Final Settlement Date is the morning of the following new Treasury note auction (in the named expiry month).	Cash
Treasury 3-year	Futures	$200,000	The first five consecutive contracts in the March, June, September, and December quarterly cycle	Physical
Treasury 5-year	Futures	$100,000	The first five consecutive contracts in the March, June, September, and December quarterly cycle	Physical
OTR 5-year	Futures	$100,000	Corresponds to 5-year Treasury notes auctions. Final Settlement Date is the morning of the following new Treasury note auction (in the named expiry month).	Cash

EXHIBIT 59–1

Representative Exchange-Traded Interest-Rate Futures Contracts (*Continued*)

Contract	Form	Contract Size	Contract Months	Settlement
Swap 5-year	Futures	$100,000	The first three consecutive contracts in the March, June, September, and December quarterly cycle.	Cash
Swap 7-year	Futures	$100,000	The first three consecutive contracts in the March, June, September, and December quarterly cycle.	Cash
Treasury 10-year	Futures	$100,000	The first five consecutive contracts in the March, June, September, and December quarterly cycle	Physical
OTR 10-year	Futures	$100,000	Corresponds to 10-year Treasury notes auctions. Final Settlement Date is the morning of the following new Treasury note auction (in the named expiry month).	Cash
Swap 10-year	Futures	$100,000	The first three consecutive contracts in the March, June, September, and December quarterly cycle.	Cash
Treasury Bond	Futures	$100,000	The first five consecutive contracts in the March, June, September, and December quarterly cycle	Physical/ Maturity at last 15 years from first day of delivery month, but less than 25 years, from first day of delivery month.
Treasury Ultra Bond	Futures	$100,000	The first five consecutive contracts in the March, June, September, and December quarterly cycle	Physical/ Remaining maturity of not less that 25 years from the first day of delivery month
Swap 30-year	Futures	$100,000	The first three consecutive contracts in the March, June, September, and December quarterly cycle.	Cash
Barclay's U.S. Index	Futures	$100 × Index Value of Barclays Capital Aggregate Bond Index.	March, June, September, and December (March quarterly cycle)	Cash

contract, the bond futures contract is not a cash settlement contract. To close out a Treasury bond futures contract, one can either initiate an offsetting futures position or deliver a qualifying issue.

Paradoxically, the success of the CME Treasury bond contract can in part be attributed to the fact that the delivery mechanism is not as simple as it may first appear. There are several options implicit in a position in bond futures. First, the seller chooses which bond to deliver. Thus, the seller has an option to swap between bonds. If the seller is holding bond A for delivery, but bond B becomes cheaper to deliver, she can swap bond B for bond A and make a more profitable delivery. Second, within some guidelines set by the CME, the seller decides when during the delivery month delivery will take place. She thus has a timing option that can be used to her advantage. Finally, the short retains the possibility of making the wildcard play. This potentially profitable situation arises from the fact that the seller can give notice of intent to deliver for several hours after the exchange has closed and the futures settlement price has been fixed. In a falling market, the seller can use the wildcard option to profit from the fixed delivery price.

The seller's options tend to make a contract a bit more difficult to understand, but at the same time they make the contract more attractive to speculators, arbitrageurs, dealers, and anyone else who understands the contract better than other market participants. Thus, in the case of the Treasury bond futures contract, complexity has helped provide liquidity.

Treasury Note Futures

There are three Treasury note futures contracts: 10-year, 5-year, and 2-year. All three contracts are modeled after the Treasury bond futures contract and are traded on the CME. The underlying instrument for the 10-year Treasury note futures contract is $100,000 par value of a hypothetical 10-year 6% Treasury note. There are several acceptable Treasury issues that may be delivered by the short. A note is acceptable if the maturity is not less than 6.5 years and not greater than 10 years from the first day of the delivery month. The delivery options granted to the short position are the same as for the Treasury bond futures contract.

For the 5-year Treasury note futures contract, the underlying is $100,000 par value of a U.S. Treasury note that satisfies the following conditions: an original maturity of not more than five years and three months and a remaining maturity of not less than four years and two months as of the first day of the delivery month.

The underlying for the 2-year Treasury note futures contract is $200,000 par value of a U.S. Treasury note with a remaining maturity of not more than two years and not less than one year and nine months. Moreover, the original maturity of the note delivered to satisfy the two-year futures cannot be more than five years and three months.

Treasury Bill Futures Contract

The IMM's futures contract on Treasury bills was the first contract on a short-term debt instrument, and has been the model for most subsequent contracts on short-term debt. The contract is based on three-month Treasury bills with a face value of $1 million. As of the third quarter of 2011, there was very little open interest in this contract.

The contract is quoted and traded in terms of a futures "price," but the futures price is, in fact, just a different way of quoting the futures interest rate. Specifically, the futures price is the annualized futures rate subtracted from 100. For example, a futures price of 97.50 means that Treasury bills are trading in the futures market at a rate of 2.50%. The actual price that the buyer pays the seller is calculated using the usual formula for Treasury bills:

$$\text{Invoice price} = \$1{,}000{,}000 \times \left[1 - \text{rate} \times \left(\frac{\text{days to maturity}}{360}\right)\right]$$

where the rate is expressed in decimal form. As this formula shows, each basis point change in the interest rate (or each 0.01 change in the futures price) leads to a $25 change in the invoice price for a 90-day bill. Consequently, the value of a 0.01 change in the futures contract is always $25.

The Treasury bill futures contract is considerably simpler than the T-bond and T-note futures contracts. First, because all Treasury bills of the same maturity are economically equivalent, there is effectively only one deliverable issue, namely, Treasury bills with three months to maturity. Three months may have 90, 91 or 92 days depending on the month in which the contract is initiated. The fact that the three-month bills may be either new three-month bills or older bills that currently have three months of remaining life makes little difference because the new and old issues will trade the same in the cash market. Thus, all the subtleties surrounding conversion factors and most deliverable issues are absent from the Treasury bill futures market. Furthermore, there is little uncertainty or choice involved in the delivery date, because delivery must take place during a very narrow time frame, usually a three-day period. The rules of the exchange make clear well in advance the exact dates on which delivery will take place. Finally, because there are no conversion factors, there is no wildcard play in the Treasury bill futures market.

Although the Treasury bill futures contract is simple and thus may not provide as many speculative and arbitrage opportunities as the more complex long- and intermediate-term futures contracts, it does provide a straightforward means of hedging or speculating on the short end of the yield-curve. Because the Treasury bill rate is a benchmark off which other short-term rates may be priced, the bill contract fills a well-defined need of many market participants.

Eurodollar Futures Contract

Eurodollar CDs are U.S. dollar-denominated CDs issued primarily in London by U.S., Canadian, European, and Japanese banks. These CDs earn a fixed-rate of

interest related to dollar LIBOR. The term LIBOR comes from the London Interbank Offered Rate and is the interest rate at which one London bank offers funds to another London bank of acceptable credit quality in the form of a cash deposit. The rate is "fixed" by the British Bankers Association every business morning by the average of the rates supplied by member banks.

Three-month LIBOR is the underlying instrument for the Eurodollar futures contract. The contracts are traded on the International Monetary Market of the CME and the Eurex International Financial Futures Exchange (LIFFE). This contract has a $1 million face value and is traded on an index price basis. The index price basis in which the contract is quoted is equal to 100 minus the annualized futures LIBOR. For example, a Eurodollar futures price of 97.50 means a futures 3-month LIBOR of 2.50%.

The minimum price fluctuation or tick for this contract is 0.005 or 1/2 basis point. Accordingly, the tick value for this contract is $12.50 as determined by the following expression:

$$\text{Tick value} = \$1{,}000{,}000 \times (0.005 \times 90/360) = \$12.50$$

The Eurodollar futures contract is a cash settlement contract. There are Eurodollar futures contracts available to trade with quarterly expiration dates (March, June, September, and December) that extend out 10 years. Accordingly, it is possible for market participants to hedge or speculate on the level of three-month LIBOR for the next decade.

The Eurodollar futures contract is used frequently to trade the short end of the yield-curve and many hedgers believe this is the ideal contract for a wide range of hedging situations. Moreover, the Eurodollar futures market and interest rate swaps are intensely interconnected. When valuing swaps at their inception, the future path of floating rates are derived from positions in Eurodollar futures contracts.

The 90-day sterling LIBOR interest rate futures contract trades on the main London Futures Exchange, LIFFE. The contract is structured similarly to the Eurodollar futures contract described above. Prices are quoted as 100 minus the interest rate and the expiration months are March, June, September, and December. The contract size is £500,000. A tick is 0.01 or one basis point and the tick value is £12.5.

The LIFFE also trades short-term interest rate futures for other major currencies including euros, yen, and Swiss francs. Short-term interest rate futures contracts in other currencies are similar to the 90-day sterling LIBOR contract and trade on exchanges such as Deutsche Terminbourse in Frankfurt and MATIF (Marché à Terme International de France) in Paris.

Swap Futures Contracts

Interest-rate swaps are discussed in Chapter 62. The CME introduced a swap futures contract in 2001. The underlying instrument is the notional price of the fixed-rate side of a 10-year interest-rate swap that has a notional principal equal

to $100,000 and that exchanges semiannual interest payments at a fixed annual rate of 6% for floating interest-rate payments based on three-month LIBOR.

This swap futures contract is cash-settled, with a settlement price determined by the International Swap and Derivatives Association (ISDA) benchmark 10-year swap rate on the last day of trading before the contract expires. This benchmark rate is published with a one-day lag in the Federal Reserve Board's statistical release H.15. Contracts have settlement months of March, June, September, and December, just like the other CME interest-rate futures contracts that we have discussed.

The London International Financial Futures Exchange (LIFFE) introduced the first swap futures contract called Swapnote, which is referenced to the euro interest-rate swap curve. Swapnotes are available in 2-, 5-, and 10-year maturities.

Fed Funds Futures Contracts

The 30-day federal funds futures contract is designed for financial institutions and businesses who want to control their exposure to movements in the federal funds rate. These contracts have a notional amount of $5 million, and the contract can be written for the current month up to 24 months in the future. Underlying this contract is the simple average overnight federal funds rate (i.e., the effective rate) for the delivery month. As such, this contract is settled in cash on the last business day of the month. Just as the other short-term interest-rate futures contracts discussed earlier, prices are quoted on the basis of 100 minus the overnight federal funds rate for the delivery month. These contracts are marked to market using the effective daily federal funds rate as reported by the Federal Reserve Bank of New York.

Other Futures Contracts

If the yield-curve were flat and moved in parallel shifts, a single futures contract would be sufficient for all fixed income hedging and speculative purposes. Different note or bond positions would differ only in the number of contracts needed for a hedge. For example, with perfectly correlated interest rate changes, one could hedge long bonds with Treasury bill futures. It would require many multiples of the bond's par value in Treasury bills futures for the hedge, but it would work perfectly. The only challenge would be to get the scale of the hedges right.

Historically, the yield-curve shifts parallel to itself, steepens or flattens, and becomes more or less curved. Consequently, multiple kinds of contracts are needed to hedge bonds of varying maturity. In addition, because credit-spreads widen and narrow, at least one contract with credit risk embedded is needed to allow complete hedging.

The on-the-run (OTR) U.S. Treasury futures contracts are based on prices derived from the yields of on-the-run (most recently auctioned) 2-year, 5-year, and 10-year Treasury notes. These contracts are designed to give users synthetic exposure to the most liquid benchmark maturities on the U.S. Treasury yield curve.

Unlike traditional Treasury futures, OTR Treasury futures have cash settlement. The notional underlying is a U.S. Treasury note with a face value of $100,000 paying a 4% coupon rate per annum on a semiannual basis.

As noted above, credit-spreads widen and narrow and are not perfectly correlated to shifts in the yield-curve. This fact suggests there should be a futures contract derived from bonds with exposure to credit risk. Consider the Barclays Capital U.S. Aggregate Bond Index futures contract that trades on the CME. The underlying instrument is the index value multiplied by $100. The index includes all of the sectors of the bond market: Treasury, agency, corporate, agency mortgage-backed, asset-backed, and commercial mortgage-backed.

MECHANICS OF FUTURES TRADING

Types of Orders

When a trader wants to buy or sell a futures contract, the price and conditions under which the order is to be executed must be communicated to a futures broker. The simplest type of order, yet potentially the most perilous from the trader's perspective, is the *market order.* When a market order is placed, it is executed at the best price available as soon as the order reaches the trading pit, the area on the floor of a futures exchange where all transactions for a specific contract are made. The danger of market orders is that an adverse move may take place between the time the trader places the order and the time the order reaches the trading pit.

To avoid the dangers associated with market orders, the trader can place a *limit order* (or *resting order*) that designates a price limit for the execution of the transaction. A *buy limit order* indicates that the futures contract may be purchased only at the designated price or lower. A *sell limit order* indicates that the futures contract may be sold only at the designated price or higher.

The danger of a limit order is that there is no guarantee that it will be executed at all. The designated price may simply not be obtainable. Even if the contract trades at the specified price, the order may not be filled because the market does not trade long enough at the specified price (or better) to fill all outstanding orders. Nevertheless, a limit order may be less risky than a market order. The trader has more control with a limit order, because the price designated in the limit order can be revised based on prevailing market prices as long as the order has not already been filled.

The limit order is a conditional order: It is executed only if the limit price or a better price can be obtained. Another type of conditional order is the *stop order.* A stop order specifies that the order is not to be executed until the market reaches a designated price, at which time it becomes a market order. A *buy stop order* specifies that the order is not to be executed until the market rises to a designated price (i.e., trades at or above, or is bid at or above, the designated price). A *sell stop order* specifies that the order is not to be executed until the market price falls below a designated price (i.e., trades at or below, or is offered at or below, the designated price). A stop order is useful when a futures trader already has a position on but

cannot watch the market constantly. Traders can preserve profits or minimize losses on open positions by allowing market movements to trigger a closing trade. In a sell (buy) stop order, the designated price is less (greater) than the current market price of the futures contract. In a sell (buy) limit order the designated price is greater (less) than the current market price of the futures contract.

There are two dangers associated with stop orders. Because futures markets sometimes exhibit abrupt price changes, the direction of the change in the futures price may be very temporary, resulting in the premature closing of a position. Also, once the designated price is reached, the stop order becomes a market order and is subject to the uncertainty of the execution price noted earlier for market orders.

A *stop-limit order,* a hybrid of a stop order and a limit order, is a stop order that designates a price limit. Thus, in contrast to the stop order, which becomes a market order if the stop is reached, the stop-limit order becomes a limit order if the stop is reached. The order can be used to cushion the market impact of a stop order. The trader may limit the possible execution price after the activation of a stop. As with a limit order, the limit price might never be reached after the order is activated, and therefore the order might not be executed. This, of course, defeats one purpose of the stop order—to protect a profit or limit a loss.

A trader also may enter a *market-if-touched order.* A market-if-touched is like a stop order in that it becomes a market order if a designated price is reached. However, a market-if-touched order to buy would become a market order if the market *falls* to a given price, whereas a stop order to buy becomes a market order if the market *rises* to a given price. Similarly, a market-if-touched order to sell becomes a market order if the market rises to a specified price, whereas the stop order to sell becomes a market order if the market falls to a given price. One may think of the stop order as an order designed to exit an existing position at an acceptable price (without specifying the exact price), and the market-if-touched order as an order designed to enter a position at an acceptable price (also without specifying the exact price).

Orders may be placed to buy or sell at the open or the close of trading for the day. An *opening order* indicates that a trade is to be executed only in the opening range for the day, and a *closing order* indicates that the trade is to be executed only within the closing range for the day.

Futures brokers may be allowed to try to get the best possible price for their clients. The *discretionary order* gives the broker a specified price range in which to fill the order. For example, a discretionary order might be a limit order that gives the broker a one-tick (i.e., one basis point or $^1/_{32}$) discretion to try to do better than the limit price. Thus, even if the limit price is reached and the order could be filled at that limit, the broker can wait for a better price. However, if it turns out that the market goes in the wrong direction, the broker must fill the order but at no worse than one tick from the limit price. A *not held order* gives the broker virtually full discretion over the order. The not held order may be placed as any of the orders mentioned so far (market, stop, limit, etc.), but if the broker believes that filling the orders is not advisable, he or she need not fill them.

A client may enter orders that contain order cancellation provisions. A *fill-or-kill* order must be executed as soon as it reaches the trading floor, or it is canceled immediately. A *one-cancels-other order* is a pair of orders that are worked simultaneously, but as soon as one order is filled, the other is canceled automatically.

Orders may designate the time period for which the order is effective—a day, week, or month, or perhaps by a given time within the day. An *open order,* or *good-til-canceled order* is good until the order is specifically canceled. If the time period is not specified, it is usually assumed to be good only until the end of the day. For some orders, like the market order, a specific time period is not relevant, because they are executed immediately.

On execution of an order, the futures broker is required to provide confirmation of the trade. The confirmation indicates all the essential information about the trade. When the order involves the liquidation of a position, the confirmation shows the profit or loss on the position and the commission costs.

Taking and Liquidating a Position

Once an account has been opened with a broker, the futures trader may take a position in the market. If the trader buys a futures contract, she is said to have a long position. If the trader's opening position is the sale of the futures contract, she is said to have a short position.

The futures trader has two ways to liquidate a position. To liquidate a position before the delivery date, she must take an offsetting position in the same contract. For a long position, this means selling an identical number of contracts; for a short position, this means buying an identical number of contracts.

The alternative is to wait until the delivery date. At that time, the investor liquidates a long position by accepting the delivery of the underlying instrument at the agreed-on price or liquidates a short position by delivering the instrument at the agreed-on price. For interest-rate futures contracts that do not call for actual delivery (e.g., Eurodollar futures), settlement is in cash at the settlement price on the delivery date.

The Role of the Clearing Corporation

When an investor takes a position in the futures market, there is always another party taking the opposite position and agreeing to satisfy the terms set forth in the contract. Because of the *clearing corporation* associated with each exchange, the investor need not worry about the financial strength and integrity of the party taking the opposite side of the contract. After an order is executed, the relationship between the two parties is severed. The clearing corporation interposes itself as the buyer for every sale and the seller for every purchase. Thus the investor is free to liquidate a position without involving the other party to the original transaction and without worry that the other party may default. However, the investor *is* exposed to default on the part of the futures broker through which the trade is placed. Thus, each institution should make sure that the futures broker (and specifically the *subsidiary* that trades futures) has adequate capital to ensure that there is little danger of default.

Margin Requirements

When first taking a position in a futures contract, an investor must deposit a minimum dollar amount per contract as specified by the exchange. (A broker may ask for more than the exchange minimum, but may not require less than the exchange minimum.) This amount is called the *initial margin,* and constitutes a good faith deposit. The initial margin may be in the form of Treasury bills. As the price of the futures contract fluctuates, the value of equity in the position changes. At the close of each trading day, the position is marked to market, so that any gain or loss from the position is reflected in the equity of the account. The price used to mark the position to market is the settlement price for the day.

Maintenance margin is the minimum level to which an equity position may fall as a result of an unfavorable price movement before additional margin is required. The additional margin deposited, also called *variation margin,* is simply the amount that will bring the equity in the account back to its initial margin level. Unlike original margin, variation margin must be in cash. If there is excess margin in the account, that amount may be withdrawn.[1]

If a variation margin is required, the party is contacted by the brokerage firm and informed of the additional amount that must be deposited. A margin notice is sent as well. Even if futures prices subsequently move in favor of the institution such that the equity increases above the maintenance margin, the variation margin must still be supplied. Failure to meet a request for variation margin within a reasonable time will result in the closing out of a position.

Margin requirements vary by futures contract and by the type of transaction; that is, whether the position is an outright long or short or a spread (a long together with a short), and whether the trade is put on as a speculative position or as a hedge. Margins are higher for speculative positions than for hedging positions and higher for outright positions than for spreads. Margin requirements also vary between futures brokers. Exchanges and brokerage firms change their margin requirements as contracts are deemed to be more or less risky, or as it is felt that certain types of positions (usually speculative positions) should be discouraged.

REPRESENTATIVE EXCHANGE-TRADED FUTURES OPTIONS CONTRACTS

Although futures contracts are relatively straightforward financial instruments, options on futures (or *futures options,* as they are commonly called) deserve extra explanation. Options on futures are very similar to other options contracts.

1. Although there are initial and maintenance margin requirements for buying stocks and bonds on margin, the concept of margin differs for futures. When securities are bought on margin, the difference between the price of the security and the initial margin is borrowed from the broker. The security purchased serves as collateral for the loan and interest is paid by the investor. For futures contracts, the initial margin, in effect, serves as good-faith money, indicating that the investor will satisfy the obligation of the contract. No money is borrowed by the purchaser. Similarly, the seller of futures borrows neither money nor securities.

Like options on cash (or spot) fixed income securities, both put and call options are traded on fixed income futures. The buyer of a call has the right to buy the underlying futures contract at a specific price. The buyer of a put has the right to sell the underlying futures contract at a specific price. If the buyer chooses to exercise the option, the option seller is obligated to sell the futures in the case of the call, or buy the futures in the case of the put.

An option on the futures contract differs from more traditional options in only one essential way: The underlying instrument is not a spot security, but a futures contract on a security. Thus, for instance, if a call option buyer exercises her option, she acquires a long position in futures instead of a long position in a cash security. The seller of the call will be assigned the corresponding short position in the same futures contract. For put options the situation is reversed. A put option buyer exercising the option acquires a short position in futures, and the seller of the put is assigned a long position in the same futures contract. The resulting long and short futures positions are like any other futures positions and are subject to daily marking to market.

An investor acquiring a position in futures does so at the current futures price. However, if the strike price on the option does not equal the futures price at the time of exercise, the option seller must compensate the option buyer for the discrepancy. Thus, when a call option is exercised, the seller of the call must pay the buyer of the call the current futures price minus the strike price. On the other hand, the seller of the put must pay the buyer of the put the strike price minus the current futures price. (These transactions are actually accomplished by establishing the futures positions at the strike price, then immediately marking to market.) Note that, unlike options on spot securities, the amount of money that changes hands at exercise is only the difference between the strike price and the current futures price, not the whole strike price. Of course, an option need not be exercised for the owner to take her gains; she can simply sell the option instead of exercising it.

We now turn to the options contracts themselves. We describe two of the most important contracts, the CME's options on the long-term bond futures contract and on the Eurodollar contract. There are also options on the 5- and 10-year note futures contracts, but because they are both very similar in structure to options on Treasury bond futures, they are not included in this section.

Options on Treasury Bond Futures

Options on CME Treasury bond futures are in many respects simpler than the underlying futures contracts. Usually, conversion factors, most deliverables, wildcard plays, and other subtleties of the Treasury bond futures contract need not concern the buyer or seller of options on Treasury bond futures. Although these factors affect the fair price of the futures contract, their impact is already reflected in the futures price. Consequently, they need not be reconsidered when buying or selling an option on the futures.

The option on the Treasury bond futures contract is in many respects an option on an index; the "index" is the futures price itself, that is, the price of the fictitious 20-year 6% Treasury bond. As for the futures contract, the nominal size of the contract is $100,000. Thus, for example, with futures prices at 95, a call option struck at 94 has an intrinsic value of $1,000 and a put struck at 100 has an intrinsic value of $5,000.

In an attempt to compete with the OTC option market, *flexible Treasury futures options* were introduced. These futures options allow counterparties to customize options within certain limits. Specifically, the strike price, expiration date, and type of exercise (American or European) can be customized subject to CME constraints. One key constraint is that the expiration date of a flexible contract cannot exceed that of the longest standard option traded on the CME. Unlike an OTC option, where the option buyer is exposed to counterparty risk, a flexible Treasury futures option is guaranteed by the clearinghouse. The minimum size requirement for the launching of a flexible futures option is 100 contracts.

The premiums for options on Treasury bond futures are quoted in terms of points and 64ths of a point. Thus an option premium of 1-10 implies a price of $1\,{}^{10}/_{64}\%$ of face value, or $1,156.25 (from $100,000 × 1.15625%). Minimum price fluctuations are also ${}^{1}/_{64}$ of 1%.

Although an option on the Treasury bond futures contract is hardly identical to an option on a Treasury bond, it serves much the same purpose. Because spot and futures prices for Treasury bonds are highly correlated, hedgers and speculators frequently find that options on bond futures provide the essential characteristics needed in an options contract on a long-term fixed income instrument.

Options on Eurodollar Futures

Options on Eurodollar futures fill a unique place among exchange-traded hedging products. These options are currently the only liquid listed option contracts based on a short-term interest rate.

Options on Eurodollar futures (traded on the CME) are based on the quoted Eurodollar futures price (i.e., 100 minus the annualized yield). Like the underlying futures, the size of the contract is $1 million and each 0.01 change in price carries a value of $25. Likewise, the option premium is quoted in terms of basis points. Thus, for example, an option premium quoted as 20 (or 0.20) implies an option price of $500; a premium of 125 or (1.25) implies an option price of $3,125.

Like other debt options, buyers of puts on Eurodollar futures profit as rates move up and buyers of calls profit as rates move down. Consequently, institutions with liabilities or assets that float off short-term rates can use Eurodollar futures options to hedge their exposure to fluctuations in short-term rates. Consider institutions that have liabilities that float off short-term rates. These include banks and thrifts that issue CDs and/or take deposits based on money market rates. Also included are industrial and financial corporations that issue commercial paper, floating-rate notes, or preferred stock that floats off

money market rates. Likewise, those who make payments on adjustable-rate mortgages face similar risks.[2] In each instance, as short-term rates increase, the liability becomes more onerous for the borrower. Consequently, the issuers of these liabilities may need a means of capping their interest-rate expense. Although options on Eurodollar futures do not extend as far into the future as many issuers would like, they are effective tools for hedging many short-term rates over the near term. Consequently, an institution with floating-rate liabilities can buy an interest-rate *cap* by buying puts on Eurodollar futures. As rates move up, profits on the put position will tend to offset some or all of the incremental interest expense.

On the other side of the coin, and facing opposite risks, are the purchasers of floating-rate instruments—that is, investors who buy money market deposits, floating-rate notes, floating-rate preferred stock, and adjustable-rate mortgages. Investors who roll over CDs or commercial paper face the same problem. As rates fall, these investors receive less interest income. Consequently, they may feel a need to buy interest-rate *floors,* which are basically call options. As rates fall, calls on debt securities increase in value and will offset the lower interest income received by the investor.

In conclusion, options on Eurodollar futures can be used to limit the risk associated with fluctuations in short-term rates. This is accomplished by buying puts if the exposure is to rising rates, or by buying calls if the exposure is to falling rates.

Mechanics of Trading Futures Options

To take a position in futures options, one works with a futures broker. The types of orders that are used to buy or sell futures options are generally the same as the orders discussed for futures contracts. The clearinghouse associated with the exchange where the futures option is traded once again stands between the buyer and the seller. Furthermore, the commission costs and related issues that we discussed for futures also generally apply to futures options.

There are no margin requirements for the buyer of futures options, but the option price must be paid in full when the option is purchased. Because the option price is the maximum amount that the buyer can lose regardless of how adverse the price movement of the underlying futures contract, there is no need for margin.

Because the seller has agreed to accept all of the risk (and no reward other than the option premium) of the position in the underlying instrument, the seller generally is required to deposit not only the margin required for the underlying futures contract but also with certain exceptions, the option price as well. Furthermore, subsequent price changes adversely affecting the seller's position will lead to additional margin requirements.

2. To the extent that the interest-rate payment on an adjustable-rate mortgage has an upper and lower bound, the risk to issuers and investors is limited by the nature of the instrument.

OTC CONTRACTS

There is a substantial over-the-counter (OTC) market for fixed income options and forwards. (Forward contracts are the OTC equivalent of futures contracts.) For example, in the OTC market, one can easily buy or sell options on LIBOR, commercial paper, T-bill, and prime rates. One can buy and sell options on virtually any Treasury issue. One can buy and sell options on any number of mortgage securities. One can buy and sell options with expirations ranging from as short as one day to as long as 10 years. In the OTC market, one can easily take forward positions in three- and six-month LIBOR going out to about 2 years.

In the options market in particular, a natural division has evolved between the OTC market and the listed market. Given the relatively small number of futures contracts, the exchanges' need for standardization, and the synergy created by the futures options contract trading side by side with the underlying futures contract, the exchanges have been most successful with options on futures contracts. Because off-exchange options on futures are prohibited, futures options cannot be traded over the counter. On the other hand, because the OTC market is very good at creating flexible structures and handling a diversity of terms, the OTC market has been more successful than the exchanges in trading options on cash securities and on cash market interest rates.

In the following sections, we discuss the structure of the OTC fixed income derivative markets and their advantages and disadvantages relative to the exchange-traded markets. We also discuss the most important contracts traded in the OTC market. These are options on mortgage securities, options on cash Treasuries, caps and floors on LIBOR, and forward rate agreements on LIBOR.

The Structure of the OTC Market

As in other OTC markets, there is no central marketplace for OTC fixed income options and forward contracts. A transaction takes place whenever a buyer and seller agree to a price. Unlike an exchange transaction, the terms, size, and price of the contract generally remain undisclosed to other market participants. Accordingly, the OTC market is much less visible than the exchange markets and it is more difficult to ascertain the current market price for a given option or forward contract. Two groups, however, help to alleviate this problem. First, there are the OTC market makers. Market makers in OTC fixed income options and forwards are typically large investment banks and commercial banks. A market maker, by definition, stands ready to buy or sell a given option or forward contract to accommodate a client's needs. To be effective, the market maker must be willing and able to handle large orders and must keep the bid/ask spreads reasonably narrow.

The other group that helps bring order to the OTC market is the brokers. The sole job of the brokers is to bring together buyers and sellers; it is not the brokers' job to take positions in option and forward contracts. The buyers and sellers that the brokers bring together can be market makers or the end users of the contracts. To do their job, the brokers must distribute information about the prices where they

see trades taking place and the prices at which they believe further trades can be completed. This information is distributed to potential buyers and sellers over the phone and over publicly available media such as Telerate pages.

Because there is no central market for OTC fixed income options and forwards, there can be no clearinghouse. Consequently, those who position OTC contracts may have to give considerable weight to the creditworthiness of their counterparty. For example, entities that sell options or position forward rate agreements (FRAs) can have potential liabilities equal to several times their net worth. Furthermore, there is no guarantee that these counterparties have effective hedges against their positions or, in fact, that they are hedging at all. Furthermore, financial problems on the part of the counterparty can jeopardize the ability or willingness of the counterparty to make good on the terms of a contract even if it is hedged. Consequently, unlike the exchange-traded markets, where one neither knows nor cares who is on the other side of a trade, in the OTC market it is usually very important to know who is on the other side. Creditworthiness can be one of the most important considerations in the trade.

The potential credit problems associated with OTC trades are mitigated in a number of ways. First, some institutions will not buy options from or take either side of an FRA contract with any party other than a major entity with a sound credit rating. Second, some institutions require their counterparty to post collateral immediately after the transaction is completed. This collateral serves much the same purpose as initial margin in the futures and futures options market. Finally, some institutions reserve the right to call for additional collateral from their counterparties if the market moves against the counterparty. This is analogous to variation margin in the exchange-traded markets. Although these provisions may not be as good as a central clearinghouse, they are apparently good enough for a very large number of institutions and good enough for a very large market to develop.

Liquidity, in terms of being able to easily close out an existing position, can be a constraint in the OTC market. OTC options and forwards generally are not assignable transactions. Thus, for example, if one sells an option, the contingent liability associated with that option cannot be transferred to a third party without the express permission of the option buyer. If an option seller wants to cover a short option position, often the best strategy is to buy a similar option from a third party to offset the risks of the original option. However, if the credit of the offsetting party is in question, or the offsetting option is not identical, risks will remain for the option seller. The option buyer can face similar problems if closing out the option before expiration. Credit considerations and the fact that the option buyer may not be able to sell an identical option to offset the first option make it more difficult to effectively close out the long option position. Because FRAs involve contingent liabilities for both sides of the transaction, similar problems exist for both buyers and sellers of FRAs.

Some of the problems associated with the OTC market arise from the fact that the contracts are not standardized. However, nonstandardization leads to

many benefits as well. As indicated earlier, OTC contracts can be specified in virtually any terms that are acceptable to both buyer and seller. A potential buyer or seller thus can approach a market maker with whatever structure is needed and in many (but certainly not all) cases obtain the desired structure at a reasonable price. Compared to the very rigid structure of the exchange-traded markets, this is a remarkable advantage.

The OTC Contracts

Options on Mortgages

The OTC market for options on fixed income instruments began in the mid-1970s with *standby* commitments. Standbys were essentially put options on mortgages that allowed the holder (usually a mortgage banker) to sell mortgages at a given price during a given period of time. Although standbys were popularized by the Federal National Mortgage Association, other institutions soon got into the business of selling options. Thrift institutions, in particular, soon became sellers of puts, as well as calls, on mortgages. The thrift would typically sell out-of-the-money puts (struck at a yield that seemed attractive relative to current yields) and out-of-the-money calls (often struck at the thrift's cost of the underlying securities). Until the early 1980s, there were no real market makers in the OTC mortgage options market. Thus a trade typically did not occur until an end user who wanted to buy an option could be paired with an end user who wanted to sell the very same option. The intermediary who stood in between these two parties was usually not willing to position one side without the other.

Today, the market for options on mortgages includes many more participants, although the original standby commitments no longer exist. Investment banks and commercial banks now play a major role in the mortgage options market. Many of the large investment and commercial banks are now willing to position mortgage options without having the other side of the trade. This makes the market much more liquid and flexible than it would be otherwise. The end users of options on mortgages have not changed greatly, but the number of users has increased greatly. Mortgage bankers continue to buy puts on mortgages. Thrifts continue to sell both puts and calls. As some thrifts now play the role of mortgage banker, they too have become buyers of puts on mortgages. Money managers have also become a part of the market, usually as sellers of call options against mortgages in their portfolios.

The market for mortgage options today is composed almost entirely of options on the standard agency pass-through mortgage securities. Options on CMO tranches, IOs, POs, and the like are not a significant part of the OTC mortgage options market. The majority of the options traded are on 30-year mortgages, but options on 15-year products are also readily available. In terms of expiration, trading in mortgage options tends to be concentrated in the shorter expirations, with most of the options expiring within 60 days, and the vast majority expiring within one year. In terms of strike price, most of the trading is in at-the-money and out-of-the-money options.

Options on Treasury Securities

Although not as old as the OTC options market for mortgages, the OTC options market for Treasury securities is now just as large and liquid. As in the mortgage options market, investment banks and commercial banks play major roles as market makers, frequently standing ready to buy or sell options on $100 million (or more) of Treasury securities. Most of the action is in options expiring within 60 days, written at the money or out of the money. Options on Treasuries are concentrated in the on-the-run issues, with most of the remaining business being done in the off-the-run issues.

Except for the mortgage bankers, who have considerably less interest in options on Treasuries, the end users of options on Treasuries mirror the market for options on mortgages. Thrifts tend to be writers of out-of-the-money puts and calls, and money managers and mutual funds tend to be covered call writers.

Caps and Floors on LIBOR

The primary OTC options covering the short end of the yield-curve are the caps and floors on three- and six-month LIBOR. A cap on LIBOR is, in essence, a series of puts on LIBOR-based debt, whereas a floor on LIBOR is, in essence, a series of calls on LIBOR-based debt.

The buyer of a cap or floor holds most of the rights in the contract, as with other options. The seller of a cap or floor will of course receive an options premium from the buyer, but is then obligated to perform on the contract.

To see how these contracts work, consider a five-year, $100 million cap on three-month LIBOR struck at 4%. Such a contract will specify reset dates occurring every three months for a total of 20 resets. The first reset will usually occur immediately or within a couple of weeks of the trade date, and the last reset will usually be about three months before the stated maturity of the contract. To determine what the payoff to the cap buyer will be, on every reset date one compares the three-month LIBOR (taken from a predetermined source) with the 4% strike rate. If the three-month LIBOR is at or below 4%, nothing is owed to the cap buyer. However, if the three-month LIBOR is above 4%, the cap seller must pay the cap buyer the monetary value of the amount by which three-month LIBOR exceeds 4%. In this case, for a 90-day interest accrual period, the value of each basis point is $2,500 (from $0.0001 \times \$100{,}000{,}000 \times 90/360$). Thus, for example, if three-month LIBOR on a particular reset date is 4.50%, the cap seller owes the cap buyer $125,000 for that reset. If, on the next reset date, three-month LIBOR is 6%, the cap seller owes the cap buyer $500,000 for that reset. If, on the next reset date, three-month LIBOR is 3.50%, the cap seller owes nothing to the cap buyer for that reset. In most cases, the cap seller pays the cap buyer the amount of money owed for a particular reset at the end of the interest accrual period-in this case, three months after the reset date.

The mechanics of floors are similar, except that the payoff comes when rates fall below a given level, instead of when they rise above a given level. For example, if one buys a $25 million seven-year 3% floor on six-month LIBOR, there are a total of 14 reset dates. On each of these reset dates, one compares six-month

LIBOR to 3%. If six-month LIBOR is above 3%, nothing is owed to the buyer of the floor for that reset. However, if six-month LIBOR is below 3%, for a 180-day interest accrual period the floor seller owes the floor buyer $1,250 for every basis point by which six-month LIBOR is below 3% (from $0.0001 \times \$25{,}000{,}000 \times {}^{180}/_{360}$).

Like other OTC options markets, the cap and floor market is composed of market makers, end users, and brokers. The market makers are once again the large investment banks and commercial banks. However, there are fewer market makers and generally wider spreads in the cap and floor market than there are in the options market for mortgages or Treasury securities. Nonetheless, there is an active market out to 10 years, particularly for out-of-the-money caps and, to a lesser degree, out-of-the-money floors.

The end-user buyers of caps and floors are primarily institutions with risks that they need to cover. For example, institutions that fund short and lend long will tend to have losses as short-term rates rise. Similarly, businesses that fund by rolling over short-term obligations such as commercial paper or by bank borrowings tied to LIBOR or the prime rate will tend to have losses as short-term rates rise. These institutions, which include many thrifts, banks, and finance companies, as well as industrial and construction companies, can protect themselves against rising short-term rates by buying caps. End-user buyers of floors tend to be firms that face losses if rates fall. Such a case might occur, for example, if an institution borrows at a floating rate with a built-in floor. Such an institution may be structured so that floating rates, per se, pose no problem; the problem arises when the floating rate at which they borrow is no longer really floating because the floor has been hit. This institution may buy a floor so that it will receive monetary compensation from the floor seller whenever the floating rate falls below the floor rate, thus covering the risks of lower rates.

The sellers of caps and floors, other than the market makers, are quite varied. In some cases, sellers sell caps or floors outright to bring in premium income. Others sell caps and/or floors to smooth out the cash-flows on other fixed income instruments, such as certain derivative mortgage products. In other cases, sellers only implicitly sell the caps or floors. The following example illustrates both kinds of sellers.

When the cap market was developing, it quickly became obvious that there were many natural buyers of caps, but few natural sellers of caps. One successful effort to create sellers of caps occurred when investment bankers, who had many potential buyers of caps, realized that caps could be created as a derivative of the floating-rate note (FRN) market. Issuers of FRNs routinely issue notes reset off LIBOR. Furthermore, there were known buyers of *capped* FRNs; but of course, capped FRNs must have a higher coupon than uncapped FRNs to compensate the FRN buyer for the cap risk. If an issuer sells capped floating-rate notes, the issuer, in effect, buys a cap on LIBOR from the buyer of the FRN. This cap can then be sold to the investment banker, who in turn sells it to capbuying clients. The deals that took place took exactly this form. The investment bankers underwrote capped FRNs for certain FRN issuers who agreed to make caplike payments to their

investment banker. The banker then sold caps to another client but did not incur any market risks because the two sets of potential payments offset one another. Using part of the proceeds of the sale of the cap, the investment bank agreed to make payments to the issuer to bring the cost of the floating-rate debt down to a level below that of uncapped floating-rate notes. Thus the investment bankers, the issuers of the FRNs, the buyers of the FRNs, and the ultimate cap-buying clients all walked away with a satisfactory transaction.

Such a transaction illustrates how creative financing can be used to create a seller of an instrument when no obvious seller exists. In this example, the issuers of the FRNs are willing to sell caps, given the fact that they, in turn, find someone willing to sell the caps to them. The ultimate seller of caps is the buyer of the capped FRNs. The buyers of the FRNs are, however, only implicit sellers of caps in the sense that they never explicitly have a position in caps on their books.

This example, which is just one of dozens, shows how market makers explicitly and implicitly induce end users of financial products to buy or sell the instruments that allow the market makers to cover their positions in the OTC market. This is not to say that the market makers are taking advantage of the other parties to their trades. As is often the case, all parties to a transaction can come out ahead.

Forward Rate Agreements (FRAs)

The FRA market represents the OTC equivalent of the exchange-traded futures contracts on short-term rates. FRAs are a natural outgrowth of the interbank market for short-term funds. However, unlike the interbank market, virtually any creditworthy entity can buy or sell FRAs.

The liquid and easily accessible sector of the FRA market is for three- and six-month LIBOR. Rates are quoted widely for settlement starting one month forward, and settling once every month thereafter out to about six months forward. Thus, for example, on any given day forward rates are available for both three- and six-month LIBOR one month forward, covering, respectively, the interest period starting in one month and ending in four months, and the interest period starting in one month and ending in seven months. These contracts are referred to as 1×4 and 1×7 contracts. On the same day, there will be FRAs on three- and six-month LIBOR for settlement two months forward. These are the 2×5 and 2×8 contracts. Similarly, settlements occur three months, four months, five months, and six months forward for both three- and six-month LIBOR. These contracts are also denoted by the beginning and end of the interest period they cover.

On each subsequent day, contracts with the same type of structures, that is, contracts with one month, two months, and so on, to settlement date, are offered again. Thus, although on any given day a relatively limited number of structures are widely quoted, new contracts with new settlement dates are offered at the beginning of each day. This is quite different from the futures market, where the same contracts with the same delivery dates trade day after day.

As for other OTC debt instruments, there are market makers and brokers who make the market work. However, unlike the other OTC derivative instruments, in

the FRA market the commercial banks are clearly the dominant force among the market makers. This dominance is due to the ability of the banks to blend their FRA transactions into their interbank transactions and overall funding operations. Consequently, many banks are willing to quote on a much wider variety of structures than the standard structures explained above. One can choose maturities other than three- and six-month LIBOR, and one can choose many settlement dates other than at an even number of months in the future.

In most cases, FRAs are written so that no money changes hands until the settlement date. To determine the cash-flows on the settlement date, LIBOR taken from some predetermined source is compared to the LIBOR rate specified in the FRA contract. The actual dollar amount that changes hands is the dollar value of the difference between the two rates, *present valued* for a period equal to the maturity of the underlying LIBOR, either three or six months. The rationale behind present valuing is that if an FRA is used to hedge the rate on a deposit (or other short-term instrument), the loss (gain) due to a change in interest rates will be paid (saved) at the maturity of the deposit, not at the issue date. Thus, because cash payments on the FRA are made on the settlement date (which presumably is the same as the issue date of the deposit) the present value of the interest expense (or saving) on the deposit will equal the amount of money actually received or paid on the FRA.

Finally, one peculiarity of the FRA market deserves note. If one *buys* an FRA, one profits from an *increase* in rates, and if one *sells* an FRA, one profits from a *decline* in rates.

KEY POINTS

- A forward contract is an agreement for the future delivery of something at a specified price at the end of a designated period of time but differs from a futures contract in that it is nonstandardized and does not trade on an organized exchange.
- Parties to a forward contract are exposed to counterparty risk which is the risk that the counterparty will not satisfy its contractual obligations.
- A futures contract is an agreement between a buyer (seller) and an established exchange or its clearinghouse in which the buyer (seller) agrees to take (make) delivery of something at a specified price during a designated period of time.
- The parties to a futures contract are required to satisfy margin requirements.
- An investor who takes a long futures position realizes a gain when the futures price increases; an investor who takes a short futures position realizes a loss when the futures price decreases.
- For the Treasury bond futures contract, the underlying instrument is $100,000 par value of a hypothetical 20-year, 6% coupon Treasury bond.

- Conversion factors are used to adjust the invoice price of a Treasury bond futures contract to make delivery equitable to both parties.
- The short in a Treasury bond futures contract has several delivery options.
- The 2-year, 5-year, and 10-year Treasury note futures contracts are modeled after the Treasury bond futures contract.
- Three-month LIBOR is the underlying instrument for the Eurodollar futures contract. This futures contract is a cash settlement contract and is one of the most heavily traded futures contracts in the world.
- The federal funds futures contract is a cash settlement contract whose underlying is the average overnight federal funds for the delivery month.
- The underlying instrument for a swap futures contract is the notional price of the fixed-rate side of a 10-year interest rate swap that has a notional principal equal to $100,000 and that exchanges semiannual interest payments at a fixed annual rate of 6% for floating interest rate payments based on 3-month LIBOR.
- Interest rate options include options on fixed income securities and options on interest rate futures called futures options.
- Caps and floors are agreements between two parties whereby one party for an upfront fee agrees to compensate the other if a designated interest rate is different from a predetermined level.
- A forward rate agreement is an over-the-counter derivative instrument which is essentially a forward-starting loan, but with no exchange of principal, so the cash exchanged between the counterparties depend only on the difference in interest rates.
- The elements of an FRA are the FRA rate, reference rate, notional amount, contract period, and settlement date.
- The buyer of an FRA is agreeing to pay the FRA rate and the seller of the FRA is agreeing to receive the FRA rate. The amount that must be exchanged at the settlement date is the present value of the interest differential.
- In contrast to an interest rate futures contract, the buyer of an FRA benefits if the reference rate increases and the seller benefits if the reference rate decreases.

CHAPTER
SIXTY

PRICING FUTURES AND PORTFOLIO APPLICATIONS

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

MARK PITTS, PH.D.

BRUCE M. COLLINS, PH.D.
Professor of Finance
Western Connecticut State University

One of the primary concerns most traders and investors have when taking a position in futures contracts is whether the futures price at which they transact will be a fair price. Buyers are concerned that the price may be too high and that they will be picked off by more experienced futures traders waiting to profit from the mistakes of the uninitiated. Sellers worry that the price is artificially low and that savvy traders may have manipulated the markets so that they can buy at bargain-basement prices. Furthermore, prospective participants frequently find no rational explanation for the sometimes violent ups and downs that occur in the futures markets. Theories about efficient markets give little comfort to anyone who knows of or has experienced the sudden losses that can occur in the highly leveraged futures markets.

Fortunately, the futures markets are not as irrational as they may at first seem; if they were, they would not be so successful. The interest-rate futures markets are not perfectly efficient markets, but they probably come about as close as any market. Furthermore, there are very clear reasons why futures prices are what they are, and there are methods by which traders, investors, and borrowers will quickly eliminate any discrepancy between futures prices and their fair levels.

In this chapter we will explain how the fair or theoretical value of a futures contract is determined. We then explain several portfolio applications of interest-rate futures.

PRICING OF FUTURES CONTRACTS

There are several different ways to price futures contracts. Fortunately, all lead to the same fair price for a given contract. Each approach relies on the *law of one price.* This law states that a given financial asset (or liability) must have the same price

regardless of the means by which one goes about creating that asset (or liability). In this section we will demonstrate one way in which futures contracts can be combined with cash market instruments to create cash-flows that are identical to other cash securities.[1] The law of one price implies that the synthetically created cash securities must have the same price as the actual cash securities. Similarly, cash instruments can be combined to create cash-flows that are identical to futures contracts. By the law of one price, the futures contract must have the same price as the synthetic futures created from cash instruments.

Illustration of the Basic Principles

To understand how futures contracts should be priced, consider the following example. Suppose that a 20-year 100 par value bond with a coupon rate of 12% is selling at par. Also suppose that this bond is the deliverable for a futures contract that settles in three months. If the current three-month interest rate at which funds can be loaned or borrowed is 8% per year, what should be the price of this futures contract?

Suppose the price of the futures contract is 107. Consider the following strategy:

Sell the futures contract at 107.

Purchase the bond for 100.

Borrow 100 for three months at 8% per year.

The borrowed funds are used to purchase the bond, resulting in no initial cash outlay for this strategy. Three months from now, the bond must be delivered to settle the futures contract and the loan must be repaid. These trades will produce the following cash-flows:

From settlement of the futures contract	
Flat price of bond	107
Accrued interest (12% for three months)	+3
Total proceeds	110
From the loan	
Repayment of principal of loan	100
Interest on loan (8% for three months)	+2
Total outlay	102
Profit	8

1. For other ways to price futures contracts, see Chapter 5 in Mark Pitts and Frank J. Fabozzi, *Interest-Rate Futures and Options* (Chicago: Probus Publishing, 1990).

This strategy will guarantee a profit of 8. Moreover, the profit is generated with no initial outlay because the funds used to purchase the bond are borrowed. The profit will be realized *regardless of the futures price at the settlement date.* Obviously, in a well-functioning market, arbitrageurs would buy the bond and sell the futures, forcing the futures price down and bidding up the bond price so as to eliminate this profit. This strategy of purchasing a bond with borrowed funds and simultaneously selling a futures contract to generate an arbitrage profit is called a *cash and carry trade.*

In contrast, suppose that the futures price is 92 instead of 107. Consider the following strategy:

Buy the futures contract at 92.

Sell (short) the bond for 100.

Invest (lend) 100 for three months at 8% per year.

Once again, there is no initial cash outlay. Three months from now a bond will be purchased to settle the long position in the futures contract. That bond will then be used to cover the short position (i.e., to cover the short sale in the cash market). The outcome in three months would be as follows:

From settlement of the futures contract	
Flat price of bond	92
Accrued interest (12% for three months)	+3
Total outlay	95
From the loan	
Principal received from maturing investment	100
Interest earned from the three-month investment (8% for three months)	+2
Total proceeds	102
Profit	7

The 7 profit is a pure arbitrage profit. It requires no initial cash outlay and will be realized regardless of the futures price at the settlement date. Because this strategy involves initially selling the underlying bond, it is called a *reverse cash and carry trade.*

There is a futures price, however, that will eliminate the arbitrage profit. There will be no arbitrage if the futures price is 99. Let's look at what would happen if the two previous strategies were followed and the futures price were 99. First, consider following cash and carry trade:

Sell the futures contract at 99.

Purchase the bond for 100.

Borrow 100 for three months at 8% per year.

In three months, the outcome would be as follows:

From settlement of the futures contract	
Flat price of bond	99
Accrued interest (12% for three months)	+3
Total proceeds	102
From the loan	
Repayment of principal of the loan	100
Interest on the loan (8% for three months)	+2
Total outlay	102
Profit	0

There is no arbitrage profit.

Next, consider the following reverse cash and carry trade:

Buy the futures contract at 99.

Sell (short) the bond for 100.

Invest (lend) 100 for three months at 8% per year.

The outcome in three months would be as follows:

From settlement of the futures contract	
Flat price of bond	99
Accrued interest (12% for three months)	+3
Total outlay	102
From the loan	
Principal received from maturing investment	100
Interest earned from the three-month investment (8% for three months)	+2
Total proceeds	102
Profit	0

Thus neither strategy results in a profit. The futures price of 99 is the equilibrium price because any higher or lower futures price will permit arbitrage profits.

Theoretical Futures Price Based on Arbitrage Model

Considering the arbitrage arguments just presented, the equilibrium futures price can be determined on the basis of the following information:

- The price of the bond in the cash market.
- The coupon rate on the bond. In our example, the coupon rate was 12% per annum.

- The interest rate for borrowing and lending until the settlement date. The borrowing and lending rate is referred to as *the financing rate.* In our example, the financing rate was 8% per annum.

We will let

r = financing rate

c = current yield, or coupon rate divided by the cash market price

P = cash market price

F = futures price

t = time, in years, to the futures delivery date

and then consider the following cash and carry trade that is initiated on a coupon date:

Sell the futures contract at F.

Purchase the bond for P.

Borrow P until the settlement date at r.

The outcome at the settlement date is as follows:

From settlement of the futures contract	
Flat price of bond	F
Accrued interest	$+ctP$
Total proceeds	$F + ctP$
From the loan	
Repayment of principal of the loan	P
Interest on loan	$+ rtP$
Total outlay	$P + rtP$

The profit will equal

$$\text{Profit} = \text{total proceeds} - \text{total outlay}$$
$$\text{Profit} = F + ctP - (P + rtP)$$

In equilibrium, the theoretical futures price occurs where the profit from this strategy is zero. Thus, to have equilibrium, the following must hold:

$$0 = F + ctP - (P + rtP)$$

Solving for the theoretical futures price, we have

$$F = P + Pt(r - c) = P[1 + t(r - c)] \tag{60–1}$$

Alternatively, consider the following reverse cash and carry trade:

Buy the futures contract at F.

Sell (short) the bond for P.

Invest (lend) P at r until the settlement date.

The outcome at the settlement date would be as follows:

From settlement of the futures contract	
Flat price of bond	F
Accrued interest	$+ ctP$
Total outlay	$F + ctP$
From the loan	
Proceeds received from maturing of investment	P
Interest earned	$+ rtP$
Total proceeds	$P + rtP$

The profit will equal

$$\text{Profit} = \text{total proceeds} - \text{total outlay}$$
$$\text{Profit} = P + rtP - (F + ctP)$$

Setting the profit equal to zero so that there will be no arbitrage profit and solving for the futures price, we obtain the same equation for the futures price as Eq. (60–1).

Let's apply Eq. (60–1) to our previous example in which

$$r = 0.08$$
$$c = 0.12$$
$$P = 100$$
$$t = 0.25$$

Then the theoretical futures price is

$$F = 100 + 100 \times 0.25(0.08 - 0.12)$$
$$= 100 - 1 = 99$$

This agrees with the equilibrium futures price we derived earlier.

The theoretical futures price may be at a premium to the cash market price (higher than the cash market price) or at a discount from the cash market price (lower than the cash market price), depending on the value of $(r - c)$. The term $r - c$ is called the *net financing cost* because it adjusts the financing rate for the coupon interest earned. The net financing cost is more commonly called the *cost of carry,* or simply *carry. Positive carry* means that the current yield earned is greater than the financing

cost; *negative carry* means that the financing cost exceeds the current yield. The relationships can be expressed as follows:

Carry	Futures Price
Positive ($c > r$)	Will sell at a discount to the cash price ($F < P$)
Negative ($c < r$)	Will sell at a premium to the cash price ($F > P$)
Zero ($r = c$)	Will be equal to the cash price ($F = P$)

In the case of interest-rate futures, carry (the relationship between the short-term financing rate and the current yield on the bond) depends on the shape of the yield-curve. When the yield-curve is upward-sloping, the short-term financing rate will generally be less than the current yield on the bond, resulting in positive carry. The futures price will then sell at a discount to the cash price for the bond. The opposite will hold true when the yield-curve is inverted.

A Closer Look at the Theoretical Futures Price

To derive the theoretical futures price using the arbitrage argument, we made several assumptions. We will now discuss the implications of these assumptions.

Interim Cash-Flows. No interim cash-flows owing to variation margin or coupon interest payments were assumed in the model. However, we know that interim cash-flows can occur for both of these reasons. Because we assumed no variation margin, the price derived is technically the theoretical price for a forward contract (which is not marked to market at the end of each trading day). If interest rates rise, the short position in futures will receive margin as the futures price decreases; the margin can then be reinvested at a higher interest rate. In contrast, if interest rates fall, there will be variation margin that must be financed by the short position; however, because interest rates have declined, the financing can be done at a lower cost. Thus, whichever way rates move, those who are short futures gain relative to those who are short forward contracts that are not marked to market. Conversely, those who are long futures lose relative to those who are long forward contracts that are not marked to market. These facts account for the difference between futures and forward prices.

Incorporating interim coupon payments into the pricing model is not difficult. However, the value of the coupon payments at the settlement date will depend on the interest rate at which they can be reinvested. The shorter the maturity of the futures contract and the lower the coupon rate, the less important the reinvestment income is in determining the theoretical futures price.

The Short-Term Interest Rate (Financing Rate). In deriving the theoretical futures price, it is assumed that the borrowing and lending rates are equal. Typically, however, the borrowing rate is greater than the lending rate.

We will let

$$r_B = \text{borrowing rate}$$
$$r_L = \text{lending rate}$$

Consider the following strategy:

Sell the futures contract at F.

Purchase the bond for P.

Borrow P until the settlement date at r_B.

The futures price that would produce no arbitrage profit is

$$F = P + P\,(r_B - c) \tag{60–2}$$

Now consider the following strategy:

Buy the futures contract at F.

Sell (short) the bond for P.

Invest (lend) P at r_L until the settlement date.

The futures price that would produce no profit is

$$F = P + P(r_L - c) \tag{60–3}$$

Equations (60–2) and (60–3) together provide boundaries for the theoretical futures price. Equation (60–2) provides the upper boundary, and Eq. (60–3) the lower boundary. For example, assume that the borrowing rate is 8% per year, or 2% for three months, and the lending rate is 6% per year, or 1.5% for three months. Then, using Eq. (60–2) and the previous example, the upper boundary is

$$\begin{aligned} F(\text{upper boundary}) &= \$100 + \$100(0.02 - 0.03) \\ &= \$99 \end{aligned}$$

The lower boundary using Eq. (60–3) is

$$\begin{aligned} F(\text{lower boundary}) &= 100 + \$100(0.015 - 0.03) \\ &= \$98.50 \end{aligned}$$

In calculating these boundaries, we assumed no transaction costs were involved in taking the position. In actuality, the transaction costs of entering into and closing the cash position as well as the round-trip transaction costs for the futures contract, must be considered and do affect the boundaries for the futures contract.

Deliverable Bond and Settlement Date Unknown. In our example, we assumed that only one bond is deliverable and that the settlement date occurs three months from now. As explained in Chapter 59, futures contracts on Treasury bonds and Treasury notes are designed to allow the short position the choice of delivering one of a number of deliverable issues. Also, the delivery date is not known.

Because there may be more than one deliverable, market participants track the price of each deliverable bond and determine which is the cheapest to deliver. The futures price will then trade in relation to the bond that is cheapest to deliver.

The cheapest to deliver is the bond or note that will result in the smallest loss or the greatest gain if delivered by the short futures position.[2]

In addition to the reasons we have already discussed, there are several reasons why the actual futures price will diverge from the theoretical futures price based on the arbitrage model. First, there is the risk that although an issue may be the cheapest to deliver at the time a position in the futures contract is taken, it may not be the cheapest to deliver after that time. Thus, there will be a divergence between the theoretical futures price and the actual futures price. A second reason for this divergence is the other delivery options granted the short position. Finally, there are biases in the CME conversion factors.

Deliverable Is a Basket of Securities. The municipal index futures contract is a cash settlement contract based on a basket of securities. The difficulty in arbitraging this futures contract is that it is too expensive to buy or sell every bond included in the index. Instead, a portfolio containing a smaller number of bonds may be constructed to track the index. The arbitrage, however, is no longer risk-free because there is the risk that the portfolio will not track the index exactly. This is referred to as *tracking-error risk.* Another problem in constructing the portfolio so that the arbitrage can be performed is that the composition of the index is revised periodically. Therefore, anyone using this arbitrage trade must constantly monitor the index and periodically rebalance the constructed portfolio.

APPLICATIONS TO PORTFOLIO MANAGEMENT

This section describes various ways in which a money manager can use interest-rate futures contracts.

Interest-Rate Risk Control

Interest-rate risk control is probably the most common use of interest rate futures. This is accomplished by altering the portfolio's duration. Money managers who have strong expectations about the direction of interest rates will adjust the duration of their portfolio to capitalize on their expectations. Specifically, if they expect interest rates to increase, they will shorten the duration of the portfolio; if they expect interest rates to decrease, they will lengthen the duration of the portfolio. Also, anyone using structured portfolio strategies must periodically adjust the portfolio duration to match the duration of some benchmark.

Although money managers can alter the duration of their portfolios with cash market instruments, a quick and less expensive means for doing so (especially on a temporary basis) is to use futures contracts. By buying futures contracts

2. An alternative procedure is to compute the implied (break-even) repo rate. This rate is the yield that would produce no profit or loss if the bond were purchased and a futures contract were sold against the bond. The cheapest-to-deliver bond is the one with the highest implied repo rate.

on Treasury bonds or notes, they can increase the duration of the portfolio. Conversely, they can shorten the duration of the portfolio by selling futures contracts on Treasury bonds or notes.

Hedging

Hedging is a special case of interest-rate risk control whereby the manager seeks to obtain a duration of zero.[3] Hedging with futures involves taking a futures position as a temporary substitute for transactions to be made in the cash market at a later date. If cash and futures prices move together, any loss realized by the hedger from one position (whether cash or futures) will be offset by a profit on the other position. When the net profit or loss from the positions are exactly as anticipated, the hedge is referred to as a *perfect hedge.*

In practice, hedging is not that simple. The amount of net profit will not necessarily be as anticipated. The outcome of a hedge will depend on the relationship between the cash price and the futures price when a hedge is placed and when it is lifted. The difference between the cash price and the futures price is called the basis. The risk that the basis will change in an unpredictable way is called *basis risk.*

In most hedging applications, the bond to be hedged is not identical to the bond underlying the futures contract. This kind of hedging is referred to as *cross-hedging.* There may be substantial basis risk in cross-hedging. An unhedged position is exposed to price risk, the risk that the cash market price will move adversely. A hedged position substitutes basis risk for price risk.

A short (or sell) hedge is used to protect against a decline in the cash price of a fixed income security. To execute a short hedge, futures contracts are sold. By establishing a short hedge, the hedger has fixed the future cash price and transferred the price risk of ownership to the buyer of the futures contract. As an example of why a short hedge would be executed, suppose that a pension fund manager knows that bonds must be liquidated in 40 days to make a $5 million payment to the beneficiaries of the pension fund. If interest rates rise during the 40-day period, more bonds will have to be liquidated to realize $5 million. To guard against this possibility, the manager would sell bonds in the futures market to lock in a selling price.

A long (or buy) hedge is undertaken to protect against an increase in the cash price of a fixed income security. In a long hedge, the hedger buys a futures contract to lock in a purchase price. A pension fund manager may use a long hedge when substantial cash contributions are expected and the manager is concerned that interest rates will fall. Also, a money manager who knows that bonds are maturing in the near future and expects that interest rates will fall can employ a long hedge to lock in a rate.

3. Hedging is discussed in more detail in Chapter 61.

Asset Allocation

A pension sponsor may wish to alter the composition of the pension fund's assets between stocks and bonds. An efficient means of changing asset allocation is to use financial futures contracts: interest-rate futures and stock index futures.

Creating Synthetic Securities for Yield Enhancement

A cash market security can be synthetically created by using a position in the futures contract together with the deliverable instrument. The yield on the synthetic security should be the same as the yield on the cash market security. If there is a difference between the two yields, it can be exploited so as to enhance the yield on the portfolio.

To see how, consider an investor who owns a 20-year Treasury bond and sells Treasury futures that call for the delivery of that particular bond three months from now. The maturity of the Treasury bond is 20 years, but the investor has effectively shortened the maturity of the bond to three months.

Consequently, the long position in the 20-year bond and the short futures position are equivalent to a long position in a three-month riskless security. The position is riskless because the investor is locking in the price that he or she will receive three months from now—the futures price. By being long the bond and short the futures, the investor has synthetically created a three-month Treasury bill. The return the investor should expect to earn from this synthetic position should be the yield on a three-month Treasury bill. If the yield on the synthetic three-month Treasury bill is greater than the yield on the cash market Treasury bill, the investor can realize an enhanced yield by creating the synthetic short-term security. The fundamental relationship for creating synthetic securities is as follows:

$$\text{RSP} = \text{CBP} - \text{BFP} \tag{60–4}$$

where

CBP = cash bond position
BFP = bond futures position
RSP = riskless short-term security position

A negative sign before a position means a short position. In terms of our previous example, CBP is the long cash bond position, the negative sign before BFP refers to the short futures position, and RSP is the riskless synthetic three-month security or Treasury bill.

Equation (60–4) states that an investor who is long the cash market security and short the futures contract should expect to earn the rate of return on a risk-free security with the same maturity as the futures delivery date. Solving Eq. (60–4) for the long bond position, we have

$$\text{CBP} = \text{RSP} + \text{BFP} \tag{60–5}$$

Equation (60–5) states that a cash bond position equals a short-term riskless security position plus a long bond futures position. Thus a cash market bond can be synthetically created by buying a futures contract and investing in a Treasury bill.

Solving Eq. (60–5) for the bond futures position, we have

$$\text{BFP} = \text{CBP} - \text{RSP} \tag{60–6}$$

Equation (60–6) tells us that a long position in the futures contract can be synthetically created by taking a long position in the cash market bond and shorting the short-term riskless security. Shorting the short-term riskless security is equivalent to borrowing money. Notice that it was Eq. (60–6) that we used in deriving the theoretical futures price when the futures was overpriced. Recall that when the futures price was 107, the strategy to obtain an arbitrage profit was to sell the futures contract and create a synthetic long futures position by buying the bond with borrowed funds. This is precisely what Eq. (60–6) states. In this case, instead of creating a synthetic cash market instrument as we did with Eqs. (60–4) and (60–5), we have created a synthetic futures contract. The fact that the synthetic long futures position was cheaper than the actual long futures position provided an arbitrage opportunity.

If we reverse the sign of both sides of Eq. (60–6), we can see how a short futures position can be synthetically created.

In an efficient market, the opportunities for yield enhancement should not exist very long. Even in the absence of yield enhancement, however, synthetic securities can be used by money managers to hedge a portfolio position that they find difficult to hedge in the cash market either because of lack of liquidity or because of other constraints.

PORTABLE ALPHA

There are two basic approaches to investment management: passive and active. The objective of passive management is to match the performance of a benchmark that represents a defined asset class while the objective of active management is to select individual assets that are likely to perform better than the average. The returns to an active strategy will consist of returns based on market exposure and returns based on selection skill. The returns resulting from superior selection skills are referred to as *alpha*. Pure alpha strategies are those with no market risk and thus returns do not depend on market direction. An example is a long/short strategy that is market neutral.

In a period when equity markets have increased volatility and lower prospects for increasing returns, institutional investors look to reallocate funds to asset classes with lower volatility such as fixed income securities. Moreover, institutional investors confront an environment of funding shortfalls and moderate returns, which necessitates the development of alternative and more efficient sources of returns. *Portable alpha strategies* can be employed to maintain exposure to a lower volatility asset class while producing returns that approach equities.

The portable alpha strategy can either be used as a core investment in an asset class or as an overlay strategy.

Portable alpha strategies refer to an investment methodology or process that blends traditional asset class exposure with alternative investment strategies in order to add returns without assuming additional risk. The concept is "portable" in the sense that the integration of alternative with traditional does not impact management style or acceptable risk parameters adversely, which means it is easily transferred into an existing asset class or benchmark through the application of an overlay program to achieve the targeted asset exposure. Thus, the alpha is created independently of the core portfolio and transferred with the use of derivatives in order to maintain the characteristics of the core portfolio.

The significance of portable alpha strategies is that the asset allocation decision can be separated from the search for alpha within the asset class. Thus, portable alpha is a return enhancement strategy and not an asset substitution strategy. The advantage of the portable alpha approach is its flexibility in terms of adding returns without additional risk.[4] Many portable alpha strategies involve long and short positions. Exchange-traded futures contracts can be integral to a portable alpha strategy either as a means to overlay an existing core portfolio or as a means to synthetically maintain the core exposure to the fixed income asset class.[5]

The basis of "portable" alpha is that it explicitly changes the investment management process by separating the management of market returns and pure alpha returns.[6] Pure alpha strategies are factor or market neutral and have no correlation with market direction. The objective of portable alpha strategies is to improve the efficiency of finding positive incremental returns. For equity strategies it involves stock selection and for fixed income it might involve bond selection or the exploitation of yield-curve inefficiencies. In any case, derivatives including futures and swaps are vital to achieve the strategic asset allocation exposures. This paradigm shift that explicitly separates market returns and alpha has implications for manager selection and risk management.

Since alpha is the total return less market returns, the production of alpha does not depend on market direction and therefore positive alpha is possible in all market environments. The portable alpha strategy can be implemented as an overlay on an existing asset class or as a separate investment that uses swaps and futures to maintain the overall strategic asset allocation mix. Theoretically, portable alpha strategies can be produced from any strategy assuming it contains

4. Furthermore, the implementation of portable alpha strategies significantly expands the universe of managers beyond the limitations imposed by style or orientation.
5. For an example of a portable alpha overlay strategy see, Edgar E. Peters and Perr J. Vieth, "Portable Alpha Overlay Via PanAgora's Fixed Income Active Core Strategy," PanAgora Asset Management, undated.
6. See Adele Kohler, "Implementation Guide for Portable Alpha and Efficient Beta Exposure," State Street Global Advisors, undated.

alpha and there is sufficient liquidity to implement the strategy. Thus, there are three basic ways to develop a portable alpha generating strategy.

1. Identify an alpha generating long portfolios, use futures to eliminate market risk and overlay the strategy on the existing asset class.
2. Identify pure alpha generating investments from the hedge fund or fund of fund communities, sell off a portion of the asset class, and replace with futures and alpha generating investments.
3. Replace entire asset class with pure alpha generating strategies and use derivatives to maintain targeted market exposure.

Portable alpha represents a change in the investment process and a different way to think about risk and return. Futures contracts are an integral part of the implementation of many portable alpha investment programs.

KEY POINTS

- The theoretical futures price is determined by the net financing cost, or carry.
- Carry is the difference between the financing cost and the cash yield on the underlying cash instrument.
- The basic futures pricing model must be modified to account for nuances of specific futures contracts.
- Uses of futures contracts by portfolio managers are altering a portfolio's duration (risk control), asset allocation, creation of synthetic securities to enhance returns, and portable alpha.
- Hedging is a special case of controlling interest-rate risk in which the portfolio wants to alter the portfolio's duration to zero.
- Portable alpha strategies can be employed to maintain exposure to a lower volatility asset class while producing returns that approach equities.

CHAPTER
SIXTY-ONE

CONTROLLING INTEREST-RATE RISK WITH FUTURES AND OPTIONS

FRANK J. FABOZZI, PH.D., CFA
Professor of Finance
EDHEC Business School

SHRIKANT RAMAMURTHY
Consultant

MARK PITTS, PH.D.

In Chapter 59 the features and characteristics of interest-rate futures and options were explained. In this chapter, our focus is on how these derivative instruments can be used to control the interest-rate risk of a portfolio.

CONTROLLING INTEREST-RATE RISK WITH FUTURES

The price of an interest-rate futures contract moves in the opposite direction from the change in interest rates: when rates rise, the futures price will fall; when rates fall, the futures price will rise. By buying a futures contract, a portfolio's exposure to a rate increase is increased. That is, the portfolio's duration increases. By selling a futures contract, a portfolio's exposure to a rate increase is decreased. Equivalently, this means that the portfolio's duration is reduced. Consequently, buying and selling futures can be used to alter the duration of a portfolio.

While managers can alter the duration of their portfolios with cash-market instruments (buying or selling Treasury securities), using interest-rate futures

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instead of trading long-term Treasuries themselves has the following three advantages:

Advantage 1: Transaction costs for trading futures are lower than trading in the cash market.

Advantage 2: Margin requirements are lower for futures than for Treasury securities; using futures thus permits greater leverage.

Advantage 3: It is easier to sell short in the futures market than in the Treasury market.

Futures also can be used in constructing a portfolio with a longer duration than is available with cash-market securities. For example, suppose that in a certain interest-rate environment a pension fund manager must structure a portfolio to have a duration of 15 to accomplish a particular investment objective. Bonds with such a long duration may not be available. By buying the appropriate number and kind of interest-rate futures contracts, a pension fund manager can increase the portfolio's duration to the target level of 15.

General Principles of Interest-Rate Risk Control

The general principle in controlling interest-rate risk with futures is to combine the dollar exposure of the current portfolio and the dollar exposure of a futures position so that the total dollar exposure is equal to the target dollar exposure. This means that the manager must be able to accurately measure the dollar exposure of both the current portfolio and the futures contract employed to alter the exposure.

There are two commonly used measures for approximating the change in the dollar value of a bond or bond portfolio to changes in interest rates: price value of a basis point (PVBP) and duration. PVBP is the dollar price change resulting from a 1 basis point change in yield. Duration is the approximate percentage change in price for a 100 basis point change in rates. (Given the percentage price change, the dollar price change for a given change in interest rates can be computed.) There are two measures of duration: *modified* and *effective*. Effective duration is the appropriate measure that should be used for bonds with embedded options. In this chapter when we refer to duration, we mean effective duration. Moreover, since the manager is interested in dollar price exposure, it is the effective *dollar* duration that should be used. For a 1 basis point change in rates, PVBP is equal to the effective dollar duration for a 1 basis point change in rates.

To estimate the effective dollar duration, it is necessary to have a good valuation model. It is the valuation model that is used to determine what the new values for the bonds in the portfolio will be if rates change. The difference between the current values of the bonds in the portfolio and the new values estimated by the valuation model when rates are changed is the dollar price exposure. Consequently, the starting point in controlling interest-rate risk is the development of a reliable valuation model. A reliable valuation model also is needed to

value the derivative contracts that the manager wants to use to control interest-rate exposure.

Suppose that a manager seeks a *target duration* for the portfolio based on either expectations of interest rates or client-specified exposure. Given the target duration, a target dollar duration for a small basis point change in interest rates can be obtained. For a 50 basis point change in interest rates, for example, the target dollar duration can be found by multiplying the dollar value of the portfolio by the target duration and then dividing by 200. For example, suppose that the manager of a $500 million portfolio wants a target duration of 6. This means that the manager seeks a 3% change in the value of the portfolio for a 50 basis point change in rates (assuming a parallel shift in rates of all maturities). Multiplying the target duration of 6 by $500 million and dividing by 200 gives a target dollar duration of $15 million.

The manager then must determine the dollar duration of the current portfolio. The current dollar duration for a 50 basis point change in interest rates is found by multiplying the current duration by the dollar value of the portfolio and dividing by 200. Thus, for our $500 million portfolio, suppose that the current duration is 4. The current dollar duration is then $10 million (4 times $500 million divided by 200).

The target dollar duration is then compared with the current dollar duration. The difference between the two dollar durations is the dollar exposure that must be provided by a position in the futures contract. If the target dollar duration exceeds the current dollar duration, a futures position must increase the dollar exposure by the difference. To increase the dollar exposure, an appropriate number of futures contracts must be purchased. If the target dollar duration is less than the current dollar duration, an appropriate number of futures contracts must be sold. That is,

If target dollar duration − current dollar duration > 0, buy futures

If target dollar duration − current dollar duration < 0, sell futures

Once a futures position is taken, the *portfolio's dollar duration* is equal to the *current dollar duration without futures* plus the *dollar duration of the futures position*. That is,

Portfolio's dollar return = current dollar duration without futures
+ dollar duration of futures position

The objective is to control the portfolio's interest-rate risk by establishing a futures position such that the portfolio's dollar duration is equal to the target dollar duration. Thus

Portfolio's dollar duration = target dollar duration

Or equivalently,

Target dollar duration = current dollar duration without futures
+ dollar duration of futures position (61–1)

Over time, the portfolio's dollar duration will move away from the target dollar duration. The manager can alter the futures position to adjust the portfolio's dollar duration to the target dollar duration.

Determining the Number of Contracts

Each futures contract calls for delivery of a specified amount of the underlying instrument. When interest rates change, the value of the underlying instrument changes, and therefore, the value of the futures contract changes. How much the futures dollar value will change when interest rates change must be estimated. This amount is called the *dollar duration per futures contract*. For example, suppose that the futures price of an interest-rate futures contract is 70 and that the underlying interest-rate instrument has a par value of $100,000. Thus the futures delivery price is $70,000 (0.70 times $100,000). Suppose that a change in interest rates of 50 basis points results in the futures price changing by about $0.03 per contract. Then the dollar duration per futures contract is $2,100 (0.03 times $70,000).

The dollar duration of a futures position is then the number of futures contracts multiplied by the dollar duration per futures contract. That is,

$$\text{Dollar duration of futures position} = \text{number of futures contracts} \times \text{dollar duration per futures contract} \qquad (61\text{–}2)$$

How many futures contracts are needed to obtain the target dollar duration? Substituting Eq. (61–2) into Eq. (61–1), we get

$$\text{Number of futures contracts} \times \text{dollar duration per futures contract} = \text{target dollar duration} - \text{current dollar duration without futures} \qquad (61\text{–}3)$$

Solving for the number of futures contracts, we have

$$\text{Number of futures contracts} = \frac{\text{target dollar duration} - \text{current dollar duration without futures}}{\text{dollar duration per futures more contract}} \qquad (61\text{–}4)$$

Equation (61–4) gives the approximate number of futures contracts that are necessary to adjust the portfolio's dollar duration to the target dollar duration. A positive number means that the futures contract must be purchased; a negative number means that the futures contract must be sold. Notice that if the target dollar duration is greater than the current dollar duration without futures, the numerator is positive, and therefore, futures contracts are purchased. If the target dollar duration is less than the current dollar duration without futures, the numerator is negative, and therefore, futures contracts are sold.

Dollar Duration for a Futures Position

Now we turn to how to measure the dollar duration of a bond futures position. Keep in mind what the goal is: it is to measure the sensitivity of a bond futures position to changes in rates.

The general methodology for computing the dollar duration of a futures position for a given change in interest rates is straightforward given a valuation model. The procedure is the same as for computing the dollar duration of any cash-market instrument—shock (change) interest rates up and down by the same number of basis points and determine the average dollar price change.

An adjustment is needed for the Treasury bond and note futures contracts. The pricing of the futures contract depends on the cheapest-to-deliver (CTD) issue.[1] Calculation of the dollar duration of a Treasury bond or note futures contract requires determining the impact of a change in interest rates will have on the price of a futures contract, which, in turn, affects how the futures price will change. The dollar duration of a Treasury bond and note futures contract is determined as follows:

$$\text{Dollar duration of futures contract} = \text{dollar duration of the CTD issue} \times \frac{\text{dollar duration of futures contract}}{\text{dollar duration of the CTD issue}}$$

There is a conversion factor for each issue that is acceptable for delivery for the futures contract. The conversion factor makes deliverable equitable to both the buyer and seller of the futures contract. For each deliverable issue, the product of the futures price and the conversion factor is the adjusted futures price for the issue. This adjusted price is called the *converted price*. Relating this to the preceding equation, the second ratio is approximately equal to the conversion factor of the cheapest-to-deliver issue. Thus we can write

$$\text{Dollar duration of futures contract} = \text{dollar duration of the CTD issue} \times \text{conversion factor for the CTD issue}$$

Why did we focus on dollar duration rather than duration? Recall that duration is the approximate percentage change in price. But what is the price of this leveraged instrument? The investor does not put up the full price of the position in order to acquire the position. Only the initial margin need be made in cash or a cash equivalent. Consequently, what is the base investment made by the investor? Rather than debate what should be used as the base investment in order to compute duration, let's simply ask why we are interested in calculating the exposure to changes in rates. As we have emphasized, it is to determine how a futures position will alter the exposure of a portfolio to changes in rates. Once we know how a futures position changes the dollar duration of a portfolio, we can determine for a portfolio its dollar duration. Given the funds invested by the investor in the portfolio, the portfolio's duration can be computed.

1. The cheapest-to-deliver issue is the one issue from among all those that are deliverable to satisfy a contract that has the highest return in a cash and carry trade. This return is called the *implied repo rate*.

Hedging with Interest-Rate Futures

Hedging with futures calls for taking a futures position as a temporary substitute for transactions to be made in the cash market at a later date. If cash and futures prices move together, any loss realized by the hedger from one position (whether cash or futures) will be offset by a profit on the other position. *Hedging is a special case of controlling interest-rate risk. In a hedge, the manager seeks a target duration or target dollar duration of zero.*

A *short hedge* (or *sell hedge*) is used to protect against a decline in the cash price of a bond. To execute a short hedge, futures contracts are sold. By establishing a short hedge, the manager has fixed the future cash price and transferred the price risk of ownership to the buyer of the futures contract. To understand why a short hedge might be executed, suppose that a pension fund manager knows that bonds must be liquidated in 40 days to make a $5 million payment to beneficiaries. If interest rates rise during the 40-day period, more bonds will have to be liquidated at a lower price than today to realize $5 million. To guard against this possibility, the manager can sell bonds in the futures market to lock in a selling price.

A *long hedge* (or *buy hedge*) is undertaken to protect against an increase in the cash price of a bond. In a long hedge, the manager buys a futures contract to lock in a purchase price. A pension fund manager might use a long hedge when substantial cash contributions are expected, and the manager is concerned that interest rates will fall. Also, a money manager who knows that bonds are maturing in the near future and expects that interest rates will fall can employ a long hedge to lock in a rate for the proceeds to be reinvested.

In bond portfolio management, typically the bond or portfolio to be hedged is not identical to the bond underlying the futures contract. This type of hedging is referred to as *cross-hedging*.

The hedging process can be broken down into four steps:

Step 1. Determining the appropriate hedging instrument

Step 2. Determining the target for the hedge

Step 3. Determining the position to be taken in the hedging instrument

Step 4. Monitoring and evaluating the hedge

We discuss each step below.

Determining the Appropriate Hedging Instrument

A primary factor in determining which futures contract will provide the best hedge is the degree of correlation between the rate on the futures contract and the interest rate that creates the underlying risk that the manager seeks to eliminate. For example, a long-term corporate bond portfolio can be better hedged with Treasury bond futures than with Treasury bill futures because long-term corporate bond rates are more highly correlated with Treasury bond futures than Treasury bill futures. Using the right delivery month is also important. A manager trying to lock

in a rate or price for September will use September futures contracts because September futures contracts will give the highest degree of correlation.

Correlation is not, however, the only consideration if the hedging program is of significant size. If, for example, a manager wants to hedge $600 million of a cash position in a distant delivery month, liquidity becomes an important consideration. In such a case, it might be necessary for the manager to spread the hedge across two or more different contracts.

Determining the Target for the Hedge

Having determined the right contract and the right delivery months, the manager then should determine what is expected from the hedge—that is, what rate will, on average, be locked in by the hedge. This is the *target rate* or *target price.* If this target rate is too high (if hedging a future sale) or too low (if hedging a future purchase), hedging may not be the right strategy for dealing with the unwanted risk. Determining what is expected (calculating the target rate or price for a hedge) is not always simple. We'll see how a manager should approach this problem for both simple and complex hedges.

Risk and Expected Return in a Hedge. When a manager enters into a hedge, the objective is to "lock in" a rate for the sale or purchase of a security. However, there is much disagreement about what rate or price a manager should expect to lock in when futures are used to hedge. Here are the two views:

View 1. The manager can, on average, lock in the current spot rate for the security (i.e., current rate in the cash market).

View 2. The manager can, on average, lock in the rate at which the futures contracts are bought or sold.

The truth usually lies somewhere in between these two views. However, as the following cases illustrate, each view is entirely correct in certain situations.

The Target for Hedges Held to Delivery. Hedges that are held until the futures delivery date provide an example of a hedge that locks in the futures rate (i.e., the second view). The complication in the case of using Treasury bond futures and Treasury note futures to hedge the value of intermediate- and long-term bonds is that because of the delivery options the manager does not know for sure when delivery will take place or which bond will be delivered. This is because of the delivery options granted to the short.[2]

To illustrate how a Treasury bond futures held to the delivery date locks in the futures rate, assume for the sake of simplicity that the manager knows which Treasury bond will be delivered and that delivery will take place on the last day of the delivery month. Suppose that for delivery on the September 1999 futures

2. These delivery options are explained in Chapter 59.

contract, the conversion factor for a deliverable Treasury issue is 1.283, implying that the investor who delivers this issue would receive from the buyer 1.283 times the futures settlement price plus accrued interest. An important principle to remember is that at delivery, the spot price and the futures price times the conversion factor must converge. *Convergence* refers to the fact that at delivery there can be no discrepancy between the spot price and futures price for a given security. If convergence does not take place, arbitrageurs would buy at the lower price and sell at the higher price and earn risk-free profits. Accordingly, a manager could lock in a September 1999 sale price for this issue by selling Treasury bond futures contracts equal to 1.283 times the par value of the bonds. For example, $100 million face value of this issue would be hedged by selling $128.3 million face value of bond futures (1,283 contracts).

The sale price that the manager locks in would be 1.283 times the futures price. This is the converted price. Thus, if the futures price is 113 when the hedge is set, the manager locks in a sale price of 144.979 (113 times 1.283) for September 1999 delivery, regardless of where rates are in September 1999. Exhibit 61–1 shows the cash-flows for a number of final prices for this issue and illustrates how cash-flows on the futures contracts offset gains or losses relative to the target price of 144.979.

Let's look at all the columns in Exhibit 61–1 and explain the computations for one of the scenarios—that is, for one actual sale price for the 11¼% Treasury bond. Consider the first actual sale price of 140. By convergence, at the delivery date the final futures price shown in column (2) must equal the Treasury bond's actual sale price adjusted by the conversion factor. Specifically, the adjustment is as follows. We know that

$$\text{Converted price} = \text{Treasury bond's price} \times \text{conversion factor}$$

and by convergence

$$\text{Final futures price} = \text{converted price}$$

so that

$$\text{Final futures price} = \text{Treasury bond's actual sale price} \times \text{conversion factor}$$

Thus, to compute the final futures price in column (2) of Exhibit 61–1 given the Treasury bond's actual sale price in column (1), the following is computed:

$$\text{Final futures price} = \frac{\text{Treasury bonds actual sale price}}{\text{conversion factor}}$$

Since the conversion factor is 1.283 for the 11¼% Treasury issue, for the first actual sale price of 140, the final futures price is

$$\text{Final futures price} = \frac{140}{1.283} = 109.1193$$

Column (3) shows the market value of the Treasury bonds. This is found by multiplying the actual sale price in column (1) by 100 to obtain the actual sale

EXHIBIT 61–1

Treasury Issue Hedge Held to Delivery

Instrument to be hedged: $100 million 11¼% Treasury Bonds of 2/15/15
Conversion factor for September 1999 = 1.283
Price of futures contract when sold = 113
Target price = (1.283 × 113) = 144.979
Par value hedged = $100,000,000
Number of futures contracts = 1,283
Futures position = Target = $144,979,000

(1)	(2)	(3)	(4)	(5)	(6)
Actual Price for 11.25% T-Bonds	**Final Futures Price***	**Market Value of Treasury Bonds**	**Value of Futures Position†**	**Gain or Loss from Futures Position†**	**Effective Sale Price‡**
140	109.1192518	140,000,000	140,000,000	4,979,000	144,979,000
141	109.898675	141,000,000	141,000,000	3,979,000	144,979,000
142	110.6780982	142,000,000	142,000,000	2,979,000	144,979,000
143	111.4575214	143,000,000	143,000,000	1,979,000	144,979,000
144	112.2369447	144,000,000	144,000,000	979,000	144,979,000
145	113.0163679	145,000,000	145,000,000	–21,000	144,979,000
146	113.7957911	146,000,000	146,000,000	–1,021,000	144,979,000
147	114.5752143	147,000,000	147,000,000	–2,021,000	144,979,000
148	115.3546376	148,000,000	148,000,000	–3,021,000	144,979,000
149	116.1340608	149,000,000	149,000,000	–4,021,000	144,979,000
150	116.913484	150,000,000	150,000,000	–5,021,000	144,979,000
151	117.6929072	151,000,000	151,000,000	–6,021,000	144,979,000
152	118.4723305	152,000,000	152,000,000	–7,021,000	144,979,000
153	119.2517537	153,000,000	153,000,000	–8,021,000	144,979,000
154	120.0311769	154,000,000	154,000,000	–9,021,000	144,979,000
155	120.8106002	155,000,000	155,000,000	–10,021,000	144,979,000

*By convergence, must equal bond price divided by the conversion factor.
†Bond futures trade in even increments of 1/32. Accordingly, the futures prices and margin flows are only approximate.
‡Transaction costs and the financing of margin flows are ignored.

price per $1 of par value and then multiplying by the $100 million par value. That is,

$$\text{Market value of Treasury bonds} = (\text{actual sale price}/100) \times \$100{,}000{,}000$$

For the actual sale price of 140, the value in column (3) is

$$\begin{aligned}\text{Market value of Treasury bonds} &= (140/100) \times \$100{,}000{,}000 \\ &= \$140{,}000{,}000\end{aligned}$$

Column (4) shows the value of the futures position at the delivery date. This value is computed by first dividing the futures price shown in column (2) by

100 to obtain the futures price per $1 of par value. Then this value is multiplied by the par value per contract of $100,000 and further multiplied by the number of futures contracts. That is,

Value of futures position

$$= (\text{final futures price}/100) \times \$100,0000 \times \text{number of futures contracts}$$

In our illustration, the number of futures contracts is 1,283. For the actual sale price of the bond of 140, the final futures price is 109.1193. Thus, the value shown in column (4) is

$$\begin{aligned}\text{Value of futures position} &= (109.1193/100) \times \$100,000 \times 113 \\ &= \$140,000,062\end{aligned}$$

The value shown in column (4) is $140,000,000 because the final futures price of 109.1193 was rounded. Using more decimal places, the value would be $140,000,000.

Now let's look at the gain or loss from the futures position. This value is shown in column (5). Recall that the futures contract was shorted. The futures price at which the contracts were sold was 113. Thus, if the final futures price exceeds 113, this means that there is a loss on the futures position—that is, the futures contract is purchased at a price greater than for which it was sold. In contrast, if the futures price is less than 113, this means that there is a gain on the futures position—that is, the futures contract is purchased at a price less than for which it was sold. The gain or loss is determined by the following formula:

$$(113/100 - \text{final futures price}/100) \times \$100,000 \times \text{number of futures contracts}$$

In our illustration, for a final futures price of 109.1193 and 1,283 futures contracts, we have

$$(113/100 - 109.1193/100) \times \$100,000 \times 1,283 = \$4,978,938.1$$

The value shown in column (5) is $4,979,000 because that is the more precise value using more decimal places for the final futures price than shown in Exhibit 61–1. The value is positive which means that there is a gain in the futures position. Note that for all the final futures prices above 113 in Exhibit 61–1, there is a negative value, which means that there is a loss on the futures position.

Finally, column (6) shows the effective sale price for the Treasury bond. This value is found as follows:

Effective sale price for Treasury bond

$$= \text{actual sale price of Treasury bond} + \text{gain or loss on futures position}$$

For the actual sale price of $140 million, the gain is $4,979,000. Therefore, the effective sale price for the Treasury bond is

$$\$140,000,000 + \$4,979,000 = \$144,979,000$$

Note that this is the target price for the Treasury bond. In fact, it can be seen from column (6) of Exhibit 61–1 that the effective sale price for all the actual sale prices for the Treasury bond is the target price. However, the target price is determined by the futures price, so the target price may be higher or lower than the cash (spot) market price when the hedge is set.

When we admit the possibility that bonds other than the deliverable issue used in our illustration can be delivered and that it might be advantageous to deliver other issues, the situation becomes somewhat more involved. In this more realistic case, the manager may decide not to deliver this issue, but if she does decide to deliver it, the manager is still assured of receiving an effective sale price of approximately 144.979. If the manager does not deliver this issue, it would be because another issue can be delivered more cheaply, and thus the manager does better than the targeted price.

In summary, if a manager establishes a futures hedge that is held until delivery, the manager can be assured of receiving an effective price dictated by the futures rate (not the spot rate) on the day the hedge is set.

The Target for Hedges with Short Holding Periods. When a manager must lift (remove) a hedge prior to the delivery date, the effective rate that is obtained is much more likely to approximate the current spot rate than the futures rate the shorter the term of the hedge. The critical difference between this hedge and the hedge held to the delivery date is that convergence generally will not take place by the termination date of the hedge.

To illustrate why a manager should expect the hedge to lock in the spot rate rather than the futures rate for very short-lived hedges, let's return to the simplified example used earlier to illustrate a hedge to the delivery date. It is assumed that this issue is the only deliverable Treasury bond for the Treasury bond futures contract. Suppose that the hedge is set three months before the delivery date, and the manager plans to lift the hedge after one day. It is much more likely that the spot price of the bond will move parallel to the converted futures price (i.e., the futures price times the conversion factor) than that the spot price and the converted futures price will converge by the time the hedge is lifted.

A one-day hedge is, admittedly, an extreme example. Other than underwriters, dealers, and traders who reallocate assets very frequently, few money managers are interested in such a short horizon. The very short-term hedge does, however, illustrate a very important point: *when hedging, a manager should not expect to lock in the futures rate (or price) just because he is hedging with futures contracts.* The futures rate is locked in only if the hedge is held until delivery, at which point convergence must take place. If the hedge is held for only one day, the manager should expect to lock in the one-day forward rate,[3] which will very nearly equal the spot rate. Generally, hedges are held for more than one day but not necessarily to delivery.

3. Forward rates are covered in Chapter 36.

How the Basis Affects the Target Rate for a Hedge. The proper target for a hedge that is to be lifted prior to the delivery date depends on the basis. The *basis* is simply the difference between the spot (cash) price of a security and its futures price; that is:

$$\text{Basis} = \text{spot price} - \text{futures price}$$

In the bond market, a problem arises when trying to make practical use of the concept of the basis. The quoted futures price does not equal the price that one receives at delivery. For the Treasury bond and note futures contracts, the actual futures price equals the quoted futures price times the appropriate conversion factor. Consequently, to be useful, the basis in the bond market should be defined using actual futures delivery prices rather than quoted futures prices. Thus the price basis for bonds should be redefined as

$$\text{Price basis} = \text{spot price} - \text{futures delivery price}$$

For hedging purposes, it is also useful frequently to define the basis in terms of interest rates rather than prices. The *rate basis* is defined as

$$\text{Rate basis} = \text{spot rate} - \text{futures rate}$$

where spot rate refers to the current rate on the instrument to be hedged and the futures rate is the interest rate corresponding to the futures delivery price of the deliverable instrument.

The rate basis is helpful in explaining why the two views of hedges explained earlier are expected to lock in such different rates. To see this, we first define the *target rate basis*. This is defined as the expected rate basis on the day the hedge is lifted. A hedge lifted on the delivery date is expected to have, and by convergence will have, a zero rate basis when the hedge is lifted. Thus the target rate for the hedge should be the rate on the futures contract plus the expected rate basis of zero or, in other words, just the futures rate. When a hedge is lifted prior to the delivery date, one would not expect the basis to change very much in one day, so the target rate basis equals the futures rate plus the current difference between the spot rate and futures rate, that is, the current spot rate.

The manager can set the target rate for any hedge equal to the futures rate plus the target rate basis. That is,

$$\text{Target rate for hedge} = \text{futures rate} + \text{target rate basis}$$

If projecting the basis in terms of price rather than rate is more manageable (as is often the case for intermediate- and long-term futures), it is easier to work with the target price basis instead of the target rate basis. The *target price basis* is just the projected price basis for the day the hedge is to be lifted. For a deliverable security, the target for the hedge then becomes

$$\text{Target price for hedge} = \text{futures delivery price} + \text{target price basis}$$

The idea of a target price or rate basis explains why a hedge held until the delivery date locks in a price with certainty, and other hedges do not. The examples

have shown that this is true. For the hedge held to delivery, there is no uncertainty surrounding the target basis; by convergence, the basis on the day the hedge is lifted is certain to be zero. For the short-lived hedge, the basis probably will approximate the current basis when the hedge is lifted, but its actual value is not known. For hedges longer than one day but ending prior to the futures delivery date, there can be considerable basis risk because the basis on the day the hedge is lifted can end up being anywhere within a wide range. Thus the uncertainty surrounding the outcome of a hedge is directly related to the uncertainty surrounding the basis on the day the hedge is lifted (i.e., the uncertainty surrounding the target basis).

The uncertainty about the value of the basis at the time the hedge is removed is called *basis risk*. For a given investment horizon, hedging substitutes basis risk for price risk. Thus one trades the uncertainty of the price of the hedged security for the uncertainty of the basis. Consequently, when hedges do not produce the desired results, it is customary to place the blame on basis risk. However, basis risk is the real culprit only if the target for the hedge is defined properly. Basis risk should refer only to the unexpected or unpredictable part of the relationship between cash and futures prices. The fact that this relationship changes over time does not in itself imply that there is basis risk.

Basis risk, properly defined, refers only to the uncertainty associated with the target rate basis or target price basis. Accordingly, it is imperative that the target basis be defined properly if one is to assess the risk and expected return in a hedge correctly.

Determining the Number of Futures Contracts

The final step that must be determined before the hedge is set is the number of futures contracts needed for the hedge. This is called the *hedge ratio*. Usually the hedge ratio is expressed in terms of relative par amounts. Accordingly, a hedge ratio of 1.20 means that for every $1 million par value of securities to be hedged, one needs $1.2 million par value of futures contracts to offset the risk. *In our discussion, the values are defined so that the hedge ratio is the number of futures contracts.*

Earlier we defined a cross-hedge in the futures market as a hedge in which the security to be hedged is not deliverable on the futures contract used in the hedge. For example, a manager who wants to hedge the sale price of long-term corporate bonds might hedge with the Treasury bond futures contract, but since non-Treasury bonds cannot be delivered in satisfaction of the contract, the hedge would be considered a cross-hedge. A manger also might want to hedge a rate that is of the same quality as the rate specified in one of the contracts but that has a different maturity. For example, it is necessary to cross-hedge a Treasury bond, note, or bill with a maturity that does not qualify for delivery on any futures contract. Thus, when the security to be hedged differs from the futures contract specification in terms of either quality or maturity, one is led to the cross-hedge.

Conceptually, cross-hedging is somewhat more complicated than hedging deliverable securities because it involves two relationships. First, there is the relationship between the cheapest-to-deliver (CTD) issue and the futures contract.

Second, there is the relationship between the security to be hedged and the CTD. Practical considerations at times may lead a manager to shortcut this two-step relationship and focus directly on the relationship between the security to be hedged and the futures contract, thus ignoring the CTD altogether. However, in so doing, a manager runs the risk of miscalculating the target rate and the risk in the hedge. Furthermore, if the hedge does not perform as expected, the shortcut makes it difficult to tell why the hedge did not work out as expected.

The key to minimizing risk in a cross-hedge is to choose the right number of futures contracts. This depends on the relative dollar duration of the bond to be hedged and the futures position. Equation (61–4) indicated the number of futures contracts to achieve a particular target dollar duration. The objective in hedging is to make the target dollar duration equal to zero. Substituting zero for target dollar duration in Eq. (61–4) we obtain

$$\text{Number of futures contracts} = -\frac{\text{current dollar duration without futures}}{\text{dollar duration per futures contract}} \qquad (61\text{–}5)$$

To calculate the dollar duration of a bond, the manager must know the precise point in time that the dollar duration is to be calculated (because volatility generally declines as a bond matures), as well as the price or yield at which to calculate dollar duration (because higher yields generally reduce dollar duration for a given yield change). The relevant point in the life of the bond for calculating volatility is the point at which the hedge will be lifted. Dollar duration at any other point is essentially irrelevant because the goal is to lock in a price or rate only on that particular day. Similarly, the relevant yield at which to calculate dollar duration initially is the target yield. Consequently, the numerator of Eq. (61–5) is the dollar duration on the date the hedge is expected to be delivered. The yield that is to be used on this date in order to determine the dollar duration is the forward rate.

Let's look at how we apply Eq. (61–5) when using the Treasury bond futures contract to hedge. The number of futures contracts will be affected by the dollar duration of the CTD issue. We can modify Eq. (61–5) as follows:

$$\text{Number of futures contracts} = -\frac{\text{current dollar duration without futures}}{\text{dollar duration of the CTD issue}} \times \frac{\text{dollar duration of the CTD issue}}{\text{dollar duration per futures contract}} \qquad (61\text{–}6)$$

As noted earlier, the conversion ratio for the CTD issue is a good approximation of the second ratio. Thus Eq. (61–6) can be rewritten as

$$\text{Number of futures contracts} = -\frac{\text{current dollar duration without futures}}{\text{dollar duration of the CTD issues}} \times \text{conversion factor for the CTD issue} \qquad (61\text{–}7)$$

An Illustration. An example for a single bond shows why dollar duration weighting leads to the correct number of contracts to use to hedge. The hedge illustrated is a cross-hedge. Suppose that on 6/24/99 a manager owned $10 million par value of a 6.25% Fannie Mae (FNMA) option-free bond maturing on 5/15/29 selling at 88.39 to yield 7.20%. The manager wants to sell September 1999 Treasury bond futures to hedge a future sale of the FNMA bond. At the time, the price of the September Treasury bond futures contract was at 113. The CTD issue was the 11.25% of 2/15/15 issue that was trading at the time at 146.19 to yield 6.50%. The conversion factor for the CTD issue was 1.283. To simplify, assume that the yield spread between the FNMA bond and the CTD issue remains at 0.70% (i.e., 70 basis points) and that the anticipated sale date is the last business day in September 1999.

The target price for hedging the CTD issue would be 144.979 (from 113 × 1.283), and the target yield would be 6.56% (the yield at a price of 144.979). Since the yield on the FNMA bond is assumed to stay at 0.70% above the yield on the CTD issue, the target yield for the FNMA bond would be 7.26%. The corresponding price for the FNMA bond for this target yield is 87.76. At these target levels, the dollar duration for a 50 basis point change in rates for the CTD issue and FNMA bond per $100 of par value is $6.255 and $5.453, respectively. As indicated earlier, all these calculations are made using a settlement date equal to the anticipated sale date, in this case the end of September 1999. The dollar duration for $10 million par value of the FNMA bond is then $545,300 ($10 million/100 times $5.453). Per $100,000 par value for the CTD issue, the dollar duration per futures contract is $6,255 ($100,000/100 times $6.255).

Thus we know

$$\begin{aligned}\text{Current dollar duration without futures}\\ &= \text{dollar duration of the FNMA bond}\\ &= \$545{,}300\\ \text{Dollar duration of the CTD issue} &= \$6{,}255\\ \text{Conversion factor for CTD issue} &= 1.283\end{aligned}$$

Substituting these values into Eq. (61–7), we obtain

$$\text{Number of futures contracts} = \frac{\$545{,}300}{\$6{,}255} \times 1.283 = -112 \text{ contracts}$$

Consequently, to hedge the FNMA bond position, 112 Treasury bond futures contracts must be shorted.

Exhibit 61–2 uses scenario analysis to show the outcome of the hedge based on different prices for the FNMA bond at the delivery date of the futures contract. Let's go through each of the columns. Column (1) shows the assumed sale price for the FNMA bond, and column (2) shows the corresponding yield based on the actual sale price in column (1). This yield is found from the

EXHIBIT 61–2

Hedging a Nondeliverable Bond to a Delivery Date with Futures

Instrument to be hedged: $10 million FNMA 6.25% of 05/15/29
Price of FNMA as of hedge date (6/24/99) = 88.39
Conversion factor for September 1999 = 1.283
Price of futures contract when sold = 113
Target price for FNMA bonds = 87.76
Par value hedged = $10,000,000
Number of futures contracts = 112
Futures position = $12,656,000
Target market value for FNMA bonds = $8,776,000

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Actual Sale Price of FNMA Bonds	Yield at Sale	Yield of 11.25% Treasury Bond*	Price of 11.25% Treasury Bond	Futures Price†	Value of Futures Position	Gain or Loss on Futures Position	Effective Sale Price‡
8,000,000	8.027	7.327	135.813	105.85581	11,855,850	800,150	8,800,150
8,100,000	7.922	7.222	137.031	106.80514	11,962,176	693,824	8,793,824
8,200,000	7.818	7.118	138.234	107.74279	12,067,193	588,807	8,778,807
8,300,000	7.717	7.017	139,422	108.66875	12,170,899	485,101	8,785,101
8,400,000	7.617	6.917	140.609	109.59392	12,274,519	381,481	8,781,481
8,500,000	7.520	6.820	141.781	110.50740	12,376,829	279,171	8,779,171
8,600,000	7.424	6.724	142.938	111.40920	12,477,830	178,170	8,778,170
8,700,000	7.330	6.630	144.094	112.31021	12,578,744	77,256	8,777,256
8,800,000	7.238	6.538	145.250	113.21122	12,679,657	–23,657	8,776,343
8,900,000	7.148	6.448	146.391	114.10055	12,779,261	–123,261	8,776,739
9,000,000	7.059	6.359	147.531	114.98909	12,878,778	–222,778	8,777,222
9,100,000	6.972	6.272	148.656	115.86594	12,976,985	–320,985	8,779,015
9,200,000	6.886	6.186	149.766	116.73110	13,073,883	–417,883	8,782,117
9,300,000	6.802	6.102	150.875	117.59548	13,170,694	–514,694	8,785,306
9,400,000	6.719	6.019	151.984	118.45986	13,267,504	–611,504	8,788,496
9,500,000	6.637	5.937	153.078	119.31255	13,363,005	–707,005	8,792,995

*By assumption, the yield on the cheapest-to-deliver issue is 70 basis points lower than the yield on the FNMA bond.
†By convergence, the futures price equals the price of the cheapest-to-deliver issue divided by 1.283 (the conversion factor).
‡Transaction costs and the financing of margin flows are ignored.

price/yield relationship. Given the assumed sale price for the FNMA bond, the corresponding yield can be determined. Column (3) shows the yield for the CTD issue. This yield is computed based on the assumption regarding the yield spread of 70 basis points between the FNMA bond and the CTD issue. Thus, by subtracting 70 basis points from the yield for the FNMA bond in column (2), the yield on

the CTD issue (the 11.25% of 2/15/15) is obtained. Given the yield for the CTD issue in column (3), the price per $100 of par value of the CTD issue can be computed. This CTD price is shown in column (4).

Now we must move from the price of the CTD issue to the futures price. As explained in the description of the columns in Exhibit 61–1, by dividing the price for the CTD issue shown in column (4) by the conversion factor of the CTD issue (1.283), the futures price is obtained. This price is shown in column (5).

The value of the futures position is found in the same way as in Exhibit 61–1. First, the futures price per $1 of par value is computed by dividing the futures price by 100. Then this value is multiplied by $100,000 (the par value for the contract) and the number of futures contracts. That is,

Value of futures position

$$= (\text{futures price}/100) \times \$100,0000 \times \text{number of futures contracts}$$

Since the number of futures contracts sold is 112,

$$\text{Value of futures position} = (\text{final futures price}/100) \times \$100,0000 \times 112$$

The values shown in column (6) use the preceding formula. Using the first assumed actual sale price for the FNMA of $8 million as an example, the corresponding futures price in column (5) is 105.85581. Therefore, the value of the futures position is

$$\begin{aligned}\text{Value of futures position} &= (105.85581/100) \times \$100,000 \times 112\\ &= \$11,855,850\end{aligned}$$

Now let's calculate the gain or loss on the futures position shown in column (7). This is done in the same manner as explained for Exhibit 61–1. Since the futures price at which the contracts are sold at the inception of the hedge is 113, the gain or loss on the futures position is found as follows:

$$(113/100 - \text{final futures price}/100) \times \$100,000 \times \text{number of futures contracts}$$

For example, for the first scenario in Exhibit 61–2, the futures price is 105.85581, and 112 futures contract were sold. Therefore,

$$(113/100 - 105.85581/100) \times \$100,000 \times 112 = \$800,150$$

There is a gain from the futures position because the futures price is less than 113. Note that for all the final futures prices above 113 in Exhibit 61–2, there is a negative value, which means that there is a loss on the futures position. For all futures prices below 113, there is a loss.

Finally, column (8) shows the effective sale price for the FNMA bond. This value is found as follows:

Effective sale price for FNMA bond

= actual sale price of FNMA bond + gain or loss on futures position

For the actual sale price of $8 million, the gain is $800,150. Therefore, the effective sale price for the FNMA bond is

$$\$8{,}000{,}000 + \$800{,}150 = \$8{,}800{,}150$$

Looking at column (8) of Exhibit 61–2, we see that if the simplifying assumptions hold, a futures hedge using the recommended number of futures contracts (112) very nearly locks in the target price for $10 million par value of the FNMA bonds.

Refining for Changing Yield Spread. Another refinement in the hedging strategy is usually necessary for hedging nondeliverable securities. This refinement concerns the assumption about the relative yield spread between the CTD issue and the bond to be hedged. In the prior discussion, we assumed that the yield spread was constant over time. Yield spreads, however, are not constant over time. They vary with the maturity of the instruments in question and the level of rates, as well as with many unpredictable and nonsystematic factors.

Regression analysis allows the manager to capture the relationship between yield levels and yield spreads and use it to advantage. For hedging purposes, the variables are the yield on the bond to be hedged and the yield on the CTD issue. The regression equation takes the form

$$\text{Yield on bond to be hedged} = a + b \times \text{yield on CTD issue} + \text{error} \qquad (61\text{–}8)$$

The regression procedure provides an estimate of b, which is the expected relative yield change in the two bonds. This parameter b is called the *yield beta*. Our example that used constant spreads implicitly assumes that the yield beta b equals 1.0 and a equals 0.70 (because 0.70 is the assumed spread).

For the two issues in question, that is, the FNMA bond and the CTD issue, suppose that the estimated yield beta was 1.05. Thus yields on the FNMA issue are expected to move 5% more than yields on the Treasury issue. To calculate the number of futures contracts correctly, this fact must be taken into account; thus the number of futures contracts derived in our earlier example is multiplied by the factor 1.05. Consequently, instead of shorting 112 Treasury bond futures contracts to hedge $10 million of the FNMA bond, the investor would short 118 (rounded up) contracts.

The formula for the number of futures contracts is revised as follows to incorporate the impact of the yield beta:

$$\begin{aligned}\text{Number of futures contracts} = &-\frac{\text{current dollar duration without futures}}{\text{dollar duration of the CTD issue}}\\ &\times \text{conversion factor for the CTD issue}\\ &\times \text{yield beta} \qquad (61\text{–}9)\end{aligned}$$

where the yield beta is derived from the yield of the bond to be hedged regressed on the yield of the CTD issue (Eq. 61–8).

The effect of a change in the CTD issue and the yield spread can be assessed before the hedge is implemented. An exhibit similar to that of Exhibit 61–2 can be constructed under a wide range of assumptions. For example, at different yield levels at the date the hedge is to be lifted (the second column in Exhibit 61–2), a different yield spread may be appropriate and a different acceptable issue will be the CTD issue. The manager can determine what this will do to the outcome of the hedge.

Monitoring and Evaluating the Hedge

After a target is determined and a hedge is set, there are two remaining tasks. The hedge must be monitored during its life and evaluated after it is over. Most futures hedges require very little active monitoring during their life. In fact, overactive management poses more of a threat to most hedges than does inactive management. The reason for this is that the manager usually will not receive enough new information during the life of the hedge to justify a change in the hedging strategy. For example, it is not advisable to readjust the hedge ratio every day in response to a new data point and a possible corresponding change in the estimated value of the yield beta.

There are, however, exceptions to this general rule. As rates change, dollar duration changes. Consequently, the hedge ratio may change slightly. In other cases, there may be sound economic reasons to believe that the yield beta has changed. While there are exceptions, the best approach is usually to let a hedge run its course using the original hedge ratio with only slight adjustments.

A hedge normally can be evaluated only after it has been lifted. Evaluation involves, first, an assessment of how closely the hedge locked in the target rate—that is, how much error there was in the hedge. To provide a meaningful interpretation of the error, the manager should calculate how far from the target the sale (or purchase) would have been had there been no hedge at all. One good reason for evaluating a completed hedge is to ascertain the sources of error in the hedge in the hope that the manager will gain insights that can be used to advantage in subsequent hedges. A manager will find that there are three major sources of hedging errors:

1. The dollar duration for the hedged instrument was incorrect.
2. The projected value of the basis at the date the hedge is removed can be in error.
3. The parameters estimated from the regression (a and b) can be inaccurate.

Recall from the calculation of duration in Chapter 7 that interest rates are changed up and down by a small number of basis points and the security is revalued. The two recalculated values are used in the numerator of the duration formula. The first problem just listed recognizes that the instrument to be hedged may be a complex instrument (i.e., one with embedded options) and that the valuation model does not do a good job of valuing the security when interest rates change.

The second major source of errors in a hedge—an inaccurate projected value of the basis—is the more difficult problem. Unfortunately, there are no satisfactory simple models like regression that can be applied to the basis. Simple models of the basis violate certain equilibrium relationships for bonds that should not be violated. On the other hand, theoretically rigorous models are very unintuitive and usually soluble only by complex numerical methods. Modeling the basis is undoubtedly one of the most important and difficult problems that managers seeking to hedge face.

HEDGING WITH OPTIONS

Hedging strategies using options involve taking a position in an option and a position in the underlying bond in such a way that changes in the value of one position will offset any unfavorable price (interest rate) movement in the other position. We begin with the basic hedging strategies using options. Then we illustrate these basic strategies using futures options to hedge the FNMA bond for which a futures hedge was used earlier in this chapter. Using futures options in our illustration of hedging the bond is a worthwhile exercise because it shows how complicated hedging with futures options is and the key parameters involved in the process. We also compare the outcome of hedging with futures and hedging with futures options.

Basic Hedging Strategies

There are three popular hedging strategies: (1) a protective put-buying strategy, (2) a covered call-writing strategy, and (3) a collar strategy. We discuss each strategy below.

Protective Put-Buying Strategy

Consider a manager who has a bond and wants to hedge against rising interest rates. The most obvious options hedging strategy is to buy put options on bonds. This hedging strategy is referred to as a *protective put-buying strategy*. The puts are usually out-of-the-money puts and may be either puts on cash bonds or puts on interest-rate futures. If interest rates rise, the puts will increase in value (holding other factors constant), offsetting some or all of the loss on the bonds in the portfolio.

This strategy is a simple combination of a long put option with a long position in a cash bond. Such a position has limited downside risk, but large upside potential. However, if rates fall, the price appreciation on the bonds in the portfolio will be diminished by the amount paid to purchase the puts. Exhibit 61–3 compares the protective put-buying strategy to an unhedged position.

The protective put-buying strategy is very often compared with purchasing insurance. Like insurance, the premium paid for the protection is nonrefundable

EXHIBIT 61–3

Protective Put-Buying Strategy

and is paid before the coverage begins. The degree to which a portfolio is protected depends on the strike price of the options; thus the strike price is often compared with the deductible on an insurance policy. The lower the deductible (i.e., the higher the strike price for the put), the greater is the level of protection, and the more the protection costs. Conversely, the higher the deductible (the lower the strike price on the put), the more the portfolio can lose in value, but the cost of the insurance is lower. Exhibit 61–4 compares an unhedged position with several protective put positions, each with a different strike price, or level of protection. As the exhibit shows, no one strategy dominates any other strategy, in the sense of performing better at all possible rate levels. Consequently, it is impossible to say that one strike price is necessarily the "best" strike price or even that buying protective puts is necessarily better than doing nothing at all.

Covered Call-Writing Strategy

Another options hedging strategy used by many portfolio managers is to sell calls against the bond portfolio. This hedging strategy is called a *covered call-writing strategy.* The calls that are sold are usually out-of-the-money calls and can be either calls on cash bonds or calls on interest-rate futures. Covered call writing is just an outright long position combined with a short call position. Obviously, this strategy entails much more downside risk than buying a put to protect the value

EXHIBIT 61–4

Protective Put-Buying Strategy with Different Strike Prices

of the portfolio. In fact, many portfolio managers do not consider covered call writing a hedge.

Regardless of how it is classified, it is important to recognize that while covered call writing has substantial downside risk, it has less downside risk than an unhedged long position alone. On the downside, the difference between the long position alone and the covered call-writing strategy is the premium received for the calls that are sold. This premium acts as a cushion for downward movements in prices, reducing losses when rates rise. The cost of obtaining this cushion is that the manager gives up some of the potential on the upside. When rates decline, the call options become greater liabilities for the covered call writer. These incremental liabilities decrease the gains the manager would otherwise have realized on the portfolio in a declining rate environment. Thus the covered call writer gives up some (or all) of the upside potential of the portfolio in return for a cushion on the downside. The more upside potential that is forfeited (i.e., the lower the strike price on the calls), the more cushion there is on the downside. Exhibit 61–5 illustrates this point by comparing an unhedged position to several covered call-writing strategies, each with a different strike price. Like the protective put-buying strategy, there is no "right" strike price for the covered call writer.

EXHIBIT 61–5

Covered Call-Writing Strategy with Different Strike Prices

Collar Strategy

There are other hedging strategies employing options that are used frequently by managers. For example, many managers combine the protective put-buying strategy and the covered call-writing strategy. By combining a long position in an out-of-the-money put and a short position in an out-of-the-money call, the manager creates a long position in a *collar*. Consequently, this hedging strategy is called a *collar strategy*. The manager who uses the collar eliminates part of the portfolio's downside risk by giving up part of its upside potential. A long position hedged with a collar is shown in Exhibit 61–6.

The collar in some ways resembles the protective put, in some ways resembles covered call writing, and in some ways resembles an unhedged position. The collar is like the protective put-buying strategy in that it limits the possible losses on the portfolio if interest rates go up. Like the covered call-writing strategy, the portfolio's upside potential is limited. Like an unhedged position, within the range defined by the strike prices, the value of the portfolio varies with interest rates.

Selecting the "Best" Strategy

Comparing the two basic strategies for hedging with options, one cannot say that the protective put-buying strategy or the covered call-writing strategy is necessarily

EXHIBIT 61–6

Long Position Hedged with a Collar

the better or more correct options hedge. The best strategy (and the best strike price) depends on the manager's view of the market. Purchasing a put and paying the required premium are appropriate if the manager is fundamentally bearish. If, instead, the manager is neutral to mildly bearish, it is better to receive the premium on the covered call-writing strategy. If the manager prefers to take no view on the market at all, and as little risk as possible, then the futures hedge is the most appropriate. If the manager is fundamentally bullish, then no hedge at all is probably the best strategy.

Steps in Options Hedging

Like hedging with futures, there are steps that managers should consider before setting their hedges. These steps include

Step 1. Determine the option contract that is the best hedging vehicle. The best option contract to use depends on several factors. These include option price, liquidity, and correlation with the bond(s) to be hedged. In price-inefficient markets, the option price is important because not all options will be priced in the same manner or with the same volatility assumption. Consequently, some options may be overpriced and some underpriced. Obviously, with other factors equal, it is better to use the underpriced options when buying and the overpriced options when selling.

Whenever there is a possibility that the option position may be closed out prior to expiration, liquidity is also an important consideration. If the particular option is illiquid, closing out a position may be prohibitively expensive, and the manager loses the flexibility of closing out positions early or rolling into other positions that may become more attractive. Correlation with the underlying bond(s) to be hedged is another factor in selecting the right contract. The higher the correlation, the more precisely the final profit and loss can be defined as a function of the final level of rates. Poor correlation leads to more uncertainty.

While most of the uncertainty in an options hedge usually comes from the uncertainty of interest rates themselves, the degree of correlation between the bonds to be hedged and the instruments underlying the options contracts add to that risk. The lower the correlation, the greater the risk.

Step 2. Find the appropriate strike price. For a cross-hedge, the manager will want to convert the strike price on the options that are actually bought or sold into an equivalent strike price for the actual bonds being hedged.

Step 3. Determine the number of contracts. The hedge ratio is the number of options to buy or sell.

Steps 2 and 3, determining the strike price and the number of contracts, can best be explained with examples using futures options.

Protective Put-Buying Strategy Using Futures Options

As explained earlier, managers who want to hedge their bond positions against a possible increase in interest rates will find that buying puts on futures is one of the easiest ways to purchase protection against rising rates. To illustrate a protective put-buying strategy, we can use the same FNMA bond that we used to demonstrate how to hedge with Treasury bond futures.[4] In that example, a manager held $10 million par value of a 6.25% FNMA bond maturing 5/15/29 and used September 1999 Treasury bond futures to lock in a sale price for those bonds on the futures delivery date. Now we want to show how the manager could use futures options instead of futures to protect against rising rates.

4. As explained in Chapter 59, futures options on Treasury bonds are used more commonly by institutional investors. The mechanics of futures options are as follows: If a put option is exercised, the option buyer receives a short position in the underlying futures contract and the option writer receives the corresponding long position. The futures price for both positions is the strike price for the put option. The exchange then marks the positions to market and the futures price for both positions is then the current futures price. If a call option is exercised, the option buyer receives a long position in the underlying futures contract and the option writer receives the corresponding short position. The futures price for both positions is the strike price for the call option. The exchange then marks the positions to market and the futures price for both positions is then the current futures price.

On 6/24/99, the FNMA bond was selling for 88.39 to yield 7.20%, and the CTD issue's yield was 6.50%. For simplicity, it is assumed that the yield spread between the FNMA bond and the CTD issue remains at 70 basis points.

Selecting the Strike Price

The manager must determine the minimum price that he wants to establish for the FNMA bonds. In our illustration, we will assume that the minimum price before the cost of the put options purchased is 84.453. This is equivalent to saying that the manager wants to establish a strike price for a put option on the hedged bonds of 84.453. But the manager is not buying a put option on the FNMA bond. He is buying a put option on a Treasury bond futures contract. Therefore, the manager must determine the strike price for a put option on a Treasury bond futures contract that is equivalent to a strike price of 84.453 for the FNMA bond.

This can be done with the help of Exhibit 61–7. We begin at the top left-hand box of the exhibit. Since the minimum price is 84.453 for the FNMA bond, this means that the manager is attempting to establish a maximum yield of 7.573%. This is found from the relationship between price and yield: given a price of 84.453 for the FNMA bond, this equates to a yield of 7.573%. (This gets us to the lower left-hand box in Exhibit 61–7.) From the assumption that the spread between the FNMA bond and the cheapest-to-deliver issue is a constant 70 basis points, setting a maximum yield of 7.573% for the FNMA bond is equivalent to setting a maximum yield of 6.873% for the cheapest-to-deliver issue. (Now we are at the lower box in the middle column of Exhibit 61–7.) Given the yield of 6.873% for the CTD issue, the minimum price before the cost of the puts purchased can be determined (the top box in the middle column of the

EXHIBIT 61–7

Calculating Equivalent Strike Prices and Yields for Hedging with Futures Options

exhibit). A 6.873% yield for the CTD issue gives us a price of 141.136. (This is determined from the characteristics of the CTD issue.) The corresponding futures price is found by dividing the price of the CTD issue by the conversion factor. This gets us to the box in the right-hand column of Exhibit 61–7. Since the conversion factor is 1.283, the futures price is about 110 (141.136 divided by 1.283). This means that a strike price of 110 for a put option on a Treasury bond futures contract is roughly equivalent to a put option on our FNMA bond with a strike price of 84.453.

The foregoing steps are always necessary to obtain the appropriate strike price on a put futures option. The process is not complicated. It simply involves (1) the relationship between price and yield, (2) the assumed relationship between the yield spread between the bonds to be hedged and the cheapest-to-deliver issue, and (3) the conversion factor for the cheapest-to-deliver issue. As with hedging employing futures illustrated earlier in this chapter, the success of the hedging strategy will depend on (1) whether the cheapest-to-deliver issue changes and (2) the yield spread between the bonds to be hedged and the cheapest-to-deliver issue.

Calculating the Number of Options Contracts

The hedge ratio is determined using the following equation similar to Eq. (61–7) because we will assume a constant yield spread between the bond to be hedged and the cheapest-to-deliver issue:

$$\text{Number of options contracts} = \frac{\text{current dollar duration without options}}{\text{dollar duration of the CTD issue}} \times \text{conversion factor for CTD issue}$$

The dollar durations are as follows per 50 basis point change in rates:

Current dollar duration without options = \$512,320

Dollar duration of the CTD issue = \$6,021

Notice that the dollar durations are different from those used in calculating the number of futures contracts for the futures hedge. This is so because the dollar durations are calculated at prices corresponding to the strike price of the futures option (110) rather than the futures price (113). The number of futures options contracts is then

$$\text{Number of options contracts} = \frac{\$512,320}{\$6,021} \times 1.283 = 109 \text{ put options}$$

Thus, to hedge the FNMA bond position with put options on Treasury bond futures, 109 put options must be purchased.

Outcome of the Hedge

To create a table for the protective put hedge, we can use some of the numbers from Exhibit 61–2. Exhibit 61–8 shows the scenario analysis for the protective

EXHIBIT 61–8

Hedging a Nondeliverable Bond to a Delivery Date with Puts on Futures

Instrument to be hedged: $10 million FNMA 6.25% of 05/15/29
Price of FNMA as of hedge date (6/24/99) = 88.39
Conversion factor for September 1999 = 1.283
Price of futures contract when sold = 113
Target price per bond for FNMA bonds = 84.453
Effective minimum sale price = 83.908
Par value hedged = $10,000,000
Strike price for put = 110
Number of puts on futures = 109
Price per contract = $500.00
Cost of put position = $54,500

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Actual Sale Price of FNMA Bonds	Yield at Sale	Yield of 11.25% Treasury Bond	Price of 11.25% Treasury Bond*	Futures Price	Value of Put Options†	Cost of Put Position	Effective Sale Price‡
8,000,000	8.027	7.327	135.813	105.85581	451,717	54,500	8,397,217
8,100,000	7.922	7.222	137.031	106.80514	348,239	54,500	8,393,739
8,200,000	7.818	7.118	138.234	107.74279	246,036	54,500	8,391,536
8,300,000	7.717	7.017	139.422	108.66875	145,107	54,500	8,390,607
8,400,000	7.617	6.917	140.609	109.59392	44,263	54,500	8,389,763
8,500,000	7.520	6.820	141.781	110.50740	0	54,500	8,445,500
8,600,000	7.424	6.724	142.938	111.40920	0	54,500	8,545,500
8,700,000	7.330	6.630	144.094	112.31021	0	54,500	8,645,500
8,800,000	7.238	6.538	145.250	113.21122	0	54,500	8,745,500
8,900,000	7.148	6.448	145.391	114.10055	0	54,500	8,845,500
9,000,000	7.059	6.359	147.531	114.98909	0	54,500	8,945,500
9,100,000	6.972	6.272	148.656	115.86594	0	54,500	9,045,500
9,200,000	6.886	6.186	149.766	116.73110	0	54,500	9,145,500
9,300,000	6.802	6.102	150.875	117.59548	0	54,500	9,245,500
9,400,000	6.719	6.019	151.984	118.45986	0	54,500	9,345,500
9,500,000	6.637	5.937	153.078	119.31255	0	54,500	9,445,500

*These numbers are approximate because futures trade in 32nds.
†From maximum of [(110/100 – futures price/100) × $100,000 × 109, 0].
‡Does not include transaction costs or the financing of the options position.

put-buying strategy. The first five columns are the same as in Exhibit 61–2. For the put option hedge, column (6) shows the value of the put option position at the expiration date. The value of the put option position at the expiration date will be equal to zero if the futures price is greater than or equal to the strike price of 110.

If the futures price is below 110, then the options expire in the money, and the value of the put option position is

Value of put option position

$$= (110/100 - \text{futures price}/100) \times \$100{,}000 \times \text{number of put options}$$

For example, for the first scenario in Exhibit 61–8 of $8 million for the actual sale price of the FNMA bond, the corresponding futures price is 105.85581. The number of put options purchased is 109. Therefore

$$(110/100 - 105.85581/100) \times \$100{,}000 \times 109 = \$45{,}717$$

The effective sale price for the FNMA bonds is then equal to

Effective sale price = actual sale price + value of put option position
– option cost

Let's look at the option cost. Suppose that the price of the put option with a strike price of 110 is $500 per contract. With a total of 109 options, the cost of the protection is $54,500 (109 × $500, not including financing costs and commissions). This cost is shown in column (7) and is equivalent to 0.545 per $100 par value hedged.

The effective sale price for the FNMA bonds for each scenario is shown in the last column of Exhibit 61–8. This effective sale price is never less than 83.908. This equals the price of the FNMA bonds equivalent to the futures strike price of 110 (i.e., 84.453) minus the cost of the puts (i.e., 0.545 per $100 par value hedged). This minimum effective price is something that can be calculated before the hedge is ever initiated. (As prices decline, the effective sale price actually exceeds the target minimum sale price of 83.908 by a small amount. This is due only to rounding and the fact that the hedge ratio is left unaltered, although the relative dollar durations that go into the hedge ratio calculation change as yields change.) As prices increase, however, the effective sale price of the hedged bonds increases as well; unlike the futures hedge shown in Exhibit 61–2, the options hedge protects the investor if rates rise but allows the investor to profit if rates fall.

Covered Call-Writing Strategy with Futures Options

Unlike the protective put-buying strategy, covered call writing is not entered into with the sole purpose of protecting a portfolio against rising rates. The covered call writer, believing that the market will not trade much higher or much lower than its present level, sells out-of-the-money calls against an existing bond portfolio. The sale of the calls brings in premium income that provides partial protection in case rates increase. The premium received does not, of course, provide the kind of protection that a long put position provides, but it does provide some additional income that can be used to offset declining prices. If, instead, rates fall, portfolio appreciation is limited because the short call position constitutes a

liability for the seller, and this liability increases as rates decline. Consequently, there is limited upside price potential for the covered call writer. Of course, this is not so bad if prices are essentially going nowhere; the added income from the sale of call options is obtained without sacrificing any gains.

To see how covered call writing with futures options works for the bond used in the protective put example, we construct a table much as we did before. With futures selling around 113 on the hedge initiation date, a sale of a 117 call option on futures might be appropriate. As before, it is assumed that the hedged bond will remain at a 70 basis point spread over the CTD issue. We also assume for simplicity that the price of the 117 calls is $500 per contract. The number of options contracts sold will be the same, namely, 109 contracts for $10 million face value of underlying bonds. Thus, the proceeds received from the sale of the 109 call options is $54,500 (109 contracts × $500) or 0.545 per $100 par value hedged.

Exhibit 61–9 shows the outcomes of the covered call-writing strategy given these assumptions. The first five columns of the exhibit are the same as for Exhibit 61–8. In column (6), the liability resulting from the call option position is shown. The liability is zero if the futures price for the scenario is less than the strike price of 117. If the futures price for the scenario is greater than 117, the liability is calculated as follows:

$$(\text{Futures price}/100 - 117/100) \times \$100{,}000 \times \text{number of put options}$$

For example, consider the scenario in Exhibit 61–9, where the actual sale price of the FNMA bond is $9.5 million. The corresponding futures price is 119.31255. The number of call options sold is 109. Therefore

$$(119.31255/100 - 117/100) \times \$100{,}000 \times 109 = \$252{,}068$$

That is,

$$\begin{aligned}\text{Effective sale price} = {} & \text{actual sale price} \\ & + \text{proceeds from sale of the call options} \\ & - \text{liability of call position}\end{aligned}$$

Since the proceeds from sale of the call options is $54,500, then

$$\text{Effective sale price} = \text{actual sale price} + \$54{,}000 - \text{liability of call position}$$

The last column of Exhibit 61–9 shows the effective sale price for each scenario.

Just as the minimum effective sale price could be calculated beforehand for the protective put-buying strategy, the maximum effective sale price can be calculated beforehand for the covered call-writing strategy. The maximum effective sale price will be the price of the hedged bond corresponding to the strike price of the option sold plus the premium received. In this case, the strike price on the futures call option is 117. A futures price of 117 corresponds to a price of 150.111 (from 117 times the conversion factor of 1.283) and a corresponding

EXHIBIT 61–9

Writing Calls on Futures against a Nondeliverable Bond

Instrument to be hedged: $10 million FNMA 6.25% of 05/15/29
Price of FNMA as of hedge date (6/24/99) = 88.39
Conversion factor for September 1999 = 1.283
Price of futures contract when sold = 113
Target maximum price for FNMA bonds per bond = 92.858
Par value hedged = $10,000,000
Strike price for call = 117
Number of calls on futures = 109
Price per contract = 500.00
Value of call position = 54,500
Target maximum value for FNMA bonds = $9,285,800

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Actual Sale Price of FNMA Bonds	Yield at Sale	Yield of 11.25% Treasury Bond	Price of 11.25% Treasury Bond	Futures Price*	Liability of Call Options†	Proceeds from Call Position	Effective Sale Price‡
8,000,000	8.027	7.327	135.813	105.85581	0	54,500.00	8,054,500
8,100,000	7.922	7.222	137.031	106.80514	0	54,500.00	8,154,500
8,200,000	7.818	7.118	138.234	107.74279	0	54,500.00	8,254,500
8,300,000	7.717	7.017	139.422	108.66875	0	54,500.00	8,354,500
8,400,000	7.617	6.917	140.609	109.59392	0	54,500.00	8,454,500
8,500,000	7.520	6.820	141.781	110.50740	0	54,500.00	8,554,500
8,600,000	7.424	6.724	142.938	111.40920	0	54,500.00	8,654,500
8,700,000	7.330	6.630	144,094	112.31021	0	54,500.00	8,754,500
8,800,000	7.238	6.538	145.250	113.21122	0	54,500.00	8,854,500
8,900,000	7.148	6.448	146.391	114.10055	0	54,500.00	8,954,500
9,000,000	7.059	6.359	147.531	114.98909	0	54,500.00	9,054,500
9,100,000	6.972	6.272	148.656	115.86594	0	54,500.00	9,154,500
9,200,000	6.886	6.186	149.766	116.73110	0	54,500.00	9,254,500
9,300,000	6.802	6.102	150.875	117.59548	64,907	54,500.00	9,289,593
9,400,000	6.719	6.019	151.984	118.45986	159,125	54,500.00	9,295,375
9,500,000	6.637	5.937	153.078	119.31255	252,068	54,500.00	9,302,432

*These numbers are approximate because futures trade in 32nds.
†From maximum of [(Futures price/100 − 117/100) × $100,000 × 109, 0].
‡Does not include transaction costs or interest on the option premium received.

yield of 6.159% for the cheapest-to-deliver issue. The equivalent yield for the hedged bond is 70 basis points higher, or 6.859%, for a corresponding price of 92.313. Adding on the premium received of 0.545 per $100 par value hedged, the final maximum effective sale price will be about 92.858. As Exhibit 61–10 shows, if the hedged bond does trade at 70 basis points over the CTD issue as

EXHIBIT 61–10

Comparison of Alternative Strategies

(1) Actual Sale Price of FNMA Bonds	(2) Effective Sale Price with Futures Hedge	(3) Effective Sale Price with Protective Puts	(4) Effective Sale Price with Covered Calls
8,000,000	8,800,150	8,397,217	8,054,500
8,100,000	8.793,824	8,393,739	8,154,500
8,200,000	8,788,807	8,391,536	8,254,500
8,300,000	8.785,101	8,390,607	8,354,500
8,400,000	8,781,481	8,389,763	8,454,500
8,500,000	8,779,171	8,445,500	8,554,500
8,600,000	8,778,170	8,545,500	8,654,500
8,700,000	8,777,256	8,645,500	8,754,500
8,800,000	8,776,343	8,745,500	8,854,500
8,900,000	8.776,739	8,845,500	9,954,500
9,000,000	8,777,222	8,945,500	9,054,500
9,100,000	8,779,015	9,045,500	9,154,500
9,200,000	8,782,117	9,145,500	9,254,500
9,300,000	8,785,306	9,245,500	9,289,593
9,400,000	8,788,496	9,345,500	9,295,375
9,500,000	8,792,995	9,445,500	9,302,432

assumed, the maximum effective sale price for the hedged bond is, in fact, slightly over 92.858. The discrepancies shown in the exhibit are due to rounding and the fact that the position is not adjusted even though the relative dollar durations change as yields change.

Comparing Alternative Strategies

In this chapter we reviewed three basic strategies for hedging a bond position: (1) hedging with futures, (2) hedging with out-of-the-money puts, and (3) covered call writing with out-of-the-money calls. Similar but opposite strategies exist for managers who are concerned that rates will decrease. As might be expected, there is no "best" strategy. Each strategy has its advantages and its disadvantages, and we never get something for nothing. To get anything of value, something else of value must be forfeited.

To make a choice among strategies, it helps to lay the alternatives side by side. Using the futures example and the futures options examples, Exhibit 61–10 shows the final values of the portfolio for the various hedging alternatives. It is

easy to see from Exhibit 61–10 that if one alternative is superior to another alternative at one level of rates, it will be inferior at some other level of rates.

Consequently, we cannot conclude that one strategy is the best strategy. The manager who makes the strategy decision makes a choice among probability distributions, not usually among specific outcomes. Except for the perfect hedge, there is always some range of possible final values of the portfolio. Of course, exactly what that range is, and the probabilities associated with each possible outcome, is a matter of opinion.

Hedging with Options on Cash Instruments

Hedging a position with options on cash bonds is relatively straightforward. Most strategies, including the purchase of protective puts, covered call writing, and buying collars, are essentially the same whether futures options or options on physicals are used. There are some mechanical differences in the way the two types of option contracts are traded, and there may be substantial differences in their liquidity. Nonetheless, the basic economics of the strategies are virtually identical.

Using options on physicals frequently relieves the manager of much of the basis risk associated with a futures options hedge. For example, a manager of Treasury bonds or notes usually can buy or sell options on the exact security held in the portfolio. Using options on futures, rather than options on Treasury bonds, is sure to introduce additional elements of uncertainty.

Given the illustration presented earlier, and given that the economics of options on physicals and options on futures are essentially identical, additional illustrations for options on physicals are unnecessary. The only important difference is the hedge ratio calculation and the calculation of the equivalent strike price. To derive the hedge ratio, we always resort to an expression of relative dollar durations. Thus, for options on physicals assuming a constant spread, the hedge ratio is

$$\frac{\text{Current dollar duration without options}}{\text{Dollar duration of underlying for option}}$$

If a relationship is estimated between the yield on the bonds to be hedged and the instrument underlying the option, the appropriate hedge ratio is

$$\frac{\text{Current dollar duration without options}}{\text{Dollar duration of underlying for option}} \times \text{yield beta}$$

Unlike futures options, there is only one deliverable, so there is no conversion factor. When cross-hedging with options on physicals, the procedure for finding the equivalent strike price on the bonds to be hedged is very similar. Given the strike price of the option, the strike yield is easily determined using the price/yield relationship for the instrument underlying the option. Then, given the projected relationship between the yield on the instrument underlying the option

and the yield on the bonds to be hedged, an equivalent strike yield is derived for the bonds to be hedged. Finally, using the yield-to-price formula for the bonds to be hedged, the equivalent strike price for the bonds to be hedged can be found.

KEY POINTS

- Buying an interest-rate futures contract increases a portfolio's duration; selling an interest-rate futures contract decreases a portfolio's duration.
- The advantages of adjusting a portfolio's duration using futures rather than cash-market instruments are that transaction costs are lower, margin requirements are lower, and short selling in the futures market is easier.
- The general principle in controlling interest-rate risk with futures is to combine the dollar exposure of the current portfolio and that of a futures position so that it is equal to the target dollar exposure. The number of futures contracts needed to achieve the target dollar duration depends on the current dollar duration of the portfolio without futures and the dollar duration per futures contract.
- Hedging with futures calls for taking a futures position as a temporary substitute for transactions to be made in the cash market at a later date, with the expectation that any loss realized by the manager from one position (whether cash or futures) will be offset by a profit on the other position.
- Hedging is a special case of controlling interest-rate risk in which the target duration or target dollar duration is zero.
- Cross-hedging occurs when the bond to be hedged is not identical to the bond underlying the futures contract. A short or sell hedge is used to protect against a decline in the cash price of a bond; a long or buy hedge is employed to protect against an increase in the cash price of a bond.
- The steps in hedging include (1) determining the appropriate hedging instrument, (2) determining the target for the hedge, (3) determining the position to be taken in the hedging instrument, and (4) monitoring and evaluating the hedge.
- The key factor to determine which futures contract will provide the best hedge is the degree of correlation between the rate on the futures contract and the interest rate that creates the underlying risk that the manager seeks to eliminate.
- The manager should determine the target rate or target price, which is what is expected from the hedge. The hedge ratio is the number of futures contracts needed for the hedge.

- The basis is the difference between the spot price (or rate) and the futures price (or rate).
- In general, when hedging to the delivery date of the futures contract, a manager locks in the futures rate or price. Hedging with Treasury bond futures and Treasury note futures is complicated by the delivery options embedded in these contracts. When a hedge is lifted prior to the delivery date, the effective rate (or price) that is obtained is much more likely to approximate the current spot rate than the futures rate the shorter the term of the hedge.
- The proper target for a hedge that is to be lifted prior to the delivery date depends on the basis. Basis risk refers only to the uncertainty associated with the target rate basis or target price basis.
- Hedging substitutes basis risk for price risk.
- Hedging non-Treasury securities with Treasury bond futures requires that the hedge ratio consider two relationships: (1) the cash price of the non-Treasury security and the cheapest-to-deliver issue, and (2) the price of the cheapest-to-deliver issue and the futures price.
- In computing the hedge ratio for nondeliverable securities, the yield beta should be considered; regression analysis is used to estimate the yield beta and captures the relationship between yield levels and yield spreads.
- After a target is determined and a hedge is set, the hedge must be monitored during its life and evaluated after it is over. It is important to ascertain the sources of error in a hedge in order to gain insights that can be used to advantage in subsequent hedges.
- Three popular hedge strategies using options are the protective put-buying strategy, the covered call-writing strategy, and the collar strategy.
- A manager can use a protective put-buying strategy to hedge against rising interest rates. A protective put-buying strategy is a simple combination of a long put option with a long position in a cash bond.
- A covered call-writing strategy involves selling call options against the bond portfolio. A covered call-writing strategy entails much more downside risk than buying a put to protect the value of the portfolio, and many managers do not consider covered call writing a hedge.
- It is not possible to say that the protective put-buying strategy or the covered call-writing strategy is necessarily the better or more correct options hedge. The best strategy (and the best strike prices) depends on the manager's view of the market.
- A collar strategy is a combination of a protective put-buying strategy and a covered call-writing strategy. A manager who implements a collar

strategy eliminates part of the portfolio's downside risk by giving up part of its upside potential.

- The steps in options hedging include determining the option contract that is the best hedging vehicle, finding the appropriate strike price, and determining the number of options contracts. At the outset of options hedging, a minimum effective sale price can be calculated for a protective put-buying strategy and a maximum effective sale price can be computed for a covered call-writing strategy.
- The best options contract to use depends on the option price, liquidity, and correlation with the bond(s) to be hedged.
- For a cross-hedge, the manager will want to convert the strike price for the options that are actually bought or sold into an equivalent strike price for the actual bonds being hedged. When using Treasury bond futures options, the hedge ratio is based on the relative dollar duration of the current portfolio, the cheapest-to-deliver issue, and the futures contract at the option expiration date, as well as the conversion factor for the cheapest-to-deliver issue.
- While there are some mechanical differences in the way options on physicals and options on futures are traded and there may be substantial differences in their liquidity, the basic economics of the hedging strategies are virtually identical for both contracts. Using options on physicals frequently relieves the manager of much of the basis risk associated with an options hedge.

CHAPTER
SIXTY-TWO

INTEREST-RATE SWAPS AND SWAPTIONS

FRANK J. FABOZZI, PH.D., CFA, CPA
Professor of Finance
EDHEC Business School

STEVEN V. MANN, PH.D.
Professor of Finance
Moore School of Business
University of South Carolina

MOORAD CHOUDHRY, PH.D.
MD, Head of Business Treasury, Global Banking & Markets
Royal Bank of Scotland

Swaps and swaptions are also used extensively by market participants to control interest-rate risk. The most prevalent swap contract is an *interest-rate swap*. An interest-rate swap contract provides a vehicle for market participants to transform the nature of cash-flows and the interest-rate exposure of a portfolio or balance sheet. In this chapter we explain how to analyze interest-rate swaps. We will describe a generic interest-rate swap, the parties to a swap, the risk and return of a swap, and the economic interpretation of a swap. Then we look at how to compute the floating-rate payments and calculate the present value of these payments. Next, we will see how to calculate the fixed-rate payments given the swap rate. Before we look at how to calculate the value of a swap, we will see how to calculate the swap rate. Given the swap rate, we will then see how the value of a swap is determined after the inception of a swap. We also will discuss other types of swaps as well as options on swaps called *swaptions*. Swaptions are used ever more frequently as a tool for investors to control their interest-rate risk. These instruments are described in the latter part of the chapter and their valuation is described in Chapter 63.

DESCRIPTION OF AN INTEREST-RATE SWAP

In an *interest-rate swap,* two parties (called *counterparties*) agree to exchange periodic interest payments. The dollar amount of the interest payments exchanged is based on some predetermined dollar principal, which is called the *notional amount*.

The dollar amount each counterparty pays to the other is the agreed-on periodic interest rate times the notional amount. The only dollars that are exchanged between the parties are the interest payments, not the notional amount. Accordingly, the notional principal serves only as a scale factor to translate an interest rate into a cash flow. In the most common type of swap, one party agrees to pay the other party fixed interest payments at designated dates for the life of the contract. This party is referred to as the *fixed-rate payer*. The other party, who agrees to make interest-rate payments that float with some reference rate, is referred to as the *floating-rate payer*.

The reference rates that have been used for the floating-rate in an interest-rate swap are various money market rates: Treasury bill rate, the London Interbank Offered Rate (LIBOR), commercial paper rate, bankers acceptances rate, certificates of deposit rate, the federal funds rate, and the prime rate. The most common is the LIBOR. LIBOR is the rate at which prime banks offer to pay on Eurodollar deposits available to other prime banks for a given maturity. There is not just one rate but a rate for different maturities. For example, there is a one-month LIBOR, three-month LIBOR, and six-month LIBOR.

To illustrate an interest-rate swap, suppose that for the next five years party *X* agrees to pay party *Y* 10% per year, while party *Y* agrees to pay party *X* six-month LIBOR (the reference rate). Party *X* is a fixed-rate payer/floating-rate receiver, while party *Y* is a floating-rate payer/fixed-rate receiver. Assume that the notional amount is $50 million and that payments are exchanged every six months for the next five years. This means that every six months, party *X* (the fixed-rate payer/floating-rate receiver) will pay party *Y* $2.5 million (10% times $50 million divided by 2). The amount that party *Y* (the floating-rate payer/fixed-rate receiver) will pay party *X* will be six-month LIBOR times $50 million divided by 2. If six-month LIBOR is 7%, party *Y* will pay party *X* $1.75 million (7% times $50 million divided by 2). Note that we divide by 2 because one-half year's interest is being paid.

Interest-rate swaps are over-the-counter (OTC) instruments. This means that swaps are not traded on an exchange. An institutional investor wishing to enter into a swap transaction can do so through either a securities firm or a commercial bank that transacts in swaps. These entities can do one of the following. First, they can arrange or broker a swap between two parties that want to enter into an interest-rate swap. In this case, the securities firm or commercial bank is acting in a brokerage capacity.

The second way in which a securities firm or commercial bank can get an institutional investor into a swap position is by taking the other side of the swap. This means that the securities firm or the commercial bank is a dealer rather than a broker in the transaction. Acting as a dealer, the securities firm or the commercial bank must hedge its swap position in the same way that it hedges its position in other securities. Also, it means that the swap dealer is the counterparty to the transaction.

The risks that the two parties take on when they enter into a swap is that the other party will fail to fulfill its obligations as set forth in the swap agreement. That is, each party faces default risk. The default risk in a swap agreement is

called *counterparty risk*. In any agreement between two parties that must perform according to the terms of a contract, counterparty risk is the risk that the other party will default. With futures and exchange-traded options, the counterparty risk is the risk that the clearinghouse will default. Market participants view this risk as small. In contrast, counterparty risk in a swap can be significant.

Because of counterparty risk, not all securities firms and commercial banks can be swap dealers. Several securities firms have established subsidiaries that are separately capitalized so that they have a high credit rating that permits them to enter into swap transactions as a dealer.

Thus it is imperative to keep in mind that any party who enters into a swap is subject to counterparty risk.

INTERPRETING A SWAP POSITION

There are two ways that a swap position can be interpreted: (1) a package of forward/futures contracts and (2) a package of cash-flows from buying and selling cash market instruments.

Package of Forward Contracts

Consider the hypothetical interest-rate swap used earlier to illustrate a swap. Let's look at party *X*'s position. Party *X* has agreed to pay 10% and receive six-month LIBOR. More specifically, assuming a $50 million notional amount, *X* has agreed to buy a commodity called "six-month LIBOR" for $2.5 million. This is effectively a six-month forward contract where *X* agrees to pay $2.5 million in exchange for delivery of six-month LIBOR. The fixed-rate payer is effectively long a six-month forward contract on six-month LIBOR. The floating-rate payer is effectively short a six-month forward contract on six-month LIBOR. There is therefore an implicit forward contract corresponding to each exchange date.

Consequently, interest-rate swaps can be viewed as a package of more basic interest-rate derivative instruments—forwards. The pricing of an interest-rate swap then will depend on the price of a package of forward contracts with the same settlement dates in which the underlying for the forward contract is the same reference rate.

While an interest-rate swap may be nothing more than a package of forward contracts, it is not a redundant contract for several reasons. First, maturities for forward or futures contracts do not extend out as far as those of an interest-rate swap; an interest-rate swap with a term of 15 years or longer can be obtained. Second, an interest-rate swap is a more transactionally efficient instrument. By this we mean that in one transaction an entity can effectively establish a payoff equivalent to a package of forward contracts. The forward contracts would each have to be negotiated separately. Third, the interest-rate swap market has grown in liquidity since its establishment in 1981; interest-rate swaps now provide more liquidity than forward contracts, particularly long-dated (i.e., long-term) forward contracts.

Package of Cash-Market Instruments

To understand why a swap also can be interpreted as a package of cash-market instruments, consider an investor who enters into the transaction below:

- Buy $50 million par value of a five-year floating-rate bond that pays six-month LIBOR every six months
- Finance the purchase by borrowing $50 million for five years at a 10% annual interest rate paid every six months.

The cash-flows for this transaction are set forth in Exhibit 62–1. The second column of the exhibit shows the cash-flows from purchasing the five-year floating-rate bond. There is a $50 million cash outlay and then 10 cash inflows. The amount of the cash inflows is uncertain because they depend on future levels of six-month LIBOR. The next column shows the cash-flows from borrowing $50 million on a fixed-rate basis. The last column shows the net cash-flows from the entire transaction. As the last column indicates, there is no initial cash-flow (the cash inflow and cash

EXHIBIT 62–1

Cash-Flows for the Purchase of a Five-Year Floating-Rate Bond Financed by Borrowing on a Fixed-Rate Basis

Transaction:

- Purchase for $50 million a five-year floating-rate bond:
  Floating-rate = LIBOR, semiannual pay
- Borrow $50 million for five years:
  Fixed-rate = 10%, semiannual payments

Six-Month Period	*Cash-Flow (in Millions of Dollars) from*		
	Floating-Rate Bond*	**Borrowing Cost**	**Net**
0	–$50	+$50.0	$0
1	$+ (\text{LIBOR}_1/2) \times 50$	–2.5	$+ (\text{LIBOR}_1/2) \times 50 - 2.5$
2	$+ (\text{LIBOR}_2/2) \times 50$	–2.5	$+ (\text{LIBOR}_2/2) \times 50 - 2.5$
3	$+ (\text{LIBOR}_3/2) \times 50$	–2.5	$+ (\text{LIBOR}_3/2) \times 50 - 2.5$
4	$+ (\text{LIBOR}_4/2) \times 50$	–2.5	$+ (\text{LIBOR}_4/2) \times 50 - 2.5$
5	$+ (\text{LIBOR}_5/2) \times 50$	–2.5	$+ (\text{LIBOR}_5/2) \times 50 - 2.5$
6	$+ (\text{LIBOR}_6/2) \times 50$	–2.5	$+ (\text{LIBOR}_6/2) \times 50 - 2.5$
7	$+ (\text{LIBOR}_7/2) \times 50$	–2.5	$+ (\text{LIBOR}_7/2) \times 50 - 2.5$
8	$+ (\text{LIBOR}_8/2) \times 50$	–2.5	$+ (\text{LIBOR}_8/2) \times 50 - 2.5$
9	$+ (\text{LIBOR}_9/2) \times 50$	–2.5	$+ (\text{LIBOR}_9/2) \times 50 - 2.5$
10	$+ (\text{LIBOR}_{10}/2) \times 50 + 50$	–52.5	$+ (\text{LIBOR}_{10}/2) \times 50 - 2.5$

*The subscript for LIBOR indicates the six-month LIBOR as per the terms of the floating-rate bond at time *t*.

outlay offset each other). In all 10 six-month periods, the net position results in a cash inflow of LIBOR and a cash outlay of $2.5 million. This net position, however, is identical to the position of a fixed-rate payer/floating-rate receiver.

It can be seen from the net cash-flow in Exhibit 62–1 that a fixed-rate payer has a cash market position that is equivalent to a long position in a floating-rate bond and a short position in a fixed-rate bond—the short position being the equivalent of borrowing by issuing a fixed-rate bond.

What about the position of a floating-rate payer? It can be easily demonstrated that the position of a floating-rate payer is equivalent to purchasing a fixed-rate bond and financing that purchase at a floating-rate, where the floating-rate is the reference rate for the swap. That is, the position of a floating-rate payer is equivalent to a long position in a fixed-rate bond and a short position in a floating-rate bond.

TERMINOLOGY, CONVENTIONS, AND MARKET QUOTES

Here we review some of the terminology used in the swaps market and explain how swaps are quoted. The *trade date* for a swap is the date on which the swap is transacted. The terms of the trade include the fixed interest rate, the maturity, the notional amount of the swap, and the payment bases of both legs of the swap. The date from which floating interest payments are determined is the *reset* or *setting date,* which also may be the trade date. In the same way as for FRAs (discussed in Chapter 59), the rate is fixed two business days before the interest period begins. The second (and subsequent) reset date will be two business days before the beginning of the second (and subsequent) swap periods. The *effective date* is the date from which interest on the swap is calculated, and this is typically two business days after the trade date. In a *forward-start swap,* the effective date will be at some point in the future, specified in the swap terms. The floating interest rate for each period is fixed at the start of the period, so the interest payment amount is known in advance by both parties (the fixed-rate is known, of course, throughout the swap by both parties).

While our illustrations assume that the timing of the cash-flows for both the fixed-rate payer and floating-rate payer will be the same, this is rarely the case in a swap. An agreement may call for the fixed-rate payer to make payments annually but the floating-rate payer to make payments more frequently (semiannually or quarterly). Also, the way in which interest accrues on each leg of the transaction differs. Normally, the fixed interest payments are paid on the basis of a 30/360 day count. Floating-rate payments for dollar and euro-denominated swaps use an actual/360-day count similar to other money market instruments in those currencies. Sterling-denominated swaps use an actual/365-day count.

Accordingly, the fixed interest payments will differ slightly owing to the differences in the lengths of successive coupon periods. The floating payments will differ owing to day counts as well as movements in the reference rate.

The terminology used to describe the position of a party in the swap markets combines cash-market jargon and futures-market jargon, given that a swap position can be interpreted either as a position in a package of cash-market instruments or a package of futures/forward positions. As we have said, the counterparty to an interest-rate swap is either a fixed-rate payer or floating-rate payer.

The fixed-rate payer receives floating-rate interest and is said to be "long" or to have "bought" the swap. The long side has conceptually purchased a floating-rate note (because it receives floating-rate interest) and issued a fixed-coupon bond (because it pays out fixed interest at periodic intervals). In essence, the fixed-rate payer is borrowing at fixed-rate and investing in a floating-rate asset. The floating-rate payer is said to be "short" or to have "sold" the swap. The short side has conceptually purchased a coupon bond (because it receives fixed-rate interest) and issued a floating-rate note (because it pays floating-rate interest). A floating-rate payer is borrowing at floating-rate and investing in a fixed-rate asset.

The convention that has evolved for quoting swaps levels is that a swap dealer sets the floating-rate equal to the reference rate and then quotes the fixed-rate that will apply. To illustrate this convention, consider the following 10-year swap terms available from a dealer:

- *Floating-rate payer:* Pay floating-rate of three-month LIBOR quarterly. Receive fixed-rate of 8.75% semiannually.
- *Fixed-rate payer:* Pay fixed-rate of 8.85% semiannually. Receive floating-rate of three-month LIBOR quarterly.

The offer price that the dealer would quote the fixed-rate payer would be to pay 8.85% and receive LIBOR "flat." (The word *flat* means with no spread.) The bid price that the dealer would quote the floating-rate payer would be to pay LIBOR flat and receive 8.75%. The bid-offer spread is 10 basis points.

In order to solidify our intuition, it is useful to think of the swap market as a market where two counterparties trade the floating reference rate in a series of exchanges for a fixed price. In effect, the swap market is a market to buy and sell LIBOR. Thus, buying a swap (pay fixed/receive floating) can be thought of as buying LIBOR on each reset date for the fixed-rate agreed to on the trade date. Conversely, selling a swap (receive fixed/pay floating) is effectively selling LIBOR on each reset date for a fixed-rate agreed to on the trade date. In this framework, a dealer's bid-offer spread can be easily interpreted. Using the numbers presented earlier, the bid price of 8.75% is the price the dealer will pay to the counterparty to receive three-month LIBOR. In other words, buy LIBOR at the bid. Similarly, the offer price of 8.85% is the price the dealer receives from the counterparty in exchange for three-month LIBOR. In other words, sell LIBOR at the offer.

The fixed-rate is some spread above the Treasury yield-curve with the same term-to-maturity as the swap. In our illustration, suppose that the 10-year Treasury yield is 8.35%. Then the offer price that the dealer would quote to the fixed-rate payer is the 10-year Treasury rate plus 50 basis points versus receiving LIBOR flat. For the floating-rate payer, the bid price quoted would be LIBOR flat versus

the 10-year Treasury rate plus 40 basis points. The dealer would quote such a swap as 40-50, meaning that the dealer is willing to enter into a swap to receive LIBOR and pay a fixed-rate equal to the 10-year Treasury rate plus 40 basis points, and he would be willing to enter into a swap to pay LIBOR and receive a fixed-rate equal to the 10-year Treasury rate plus 50 basis points.

VALUING INTEREST-RATE SWAPS

In an interest-rate swap, the counterparties agree to exchange periodic interest payments. The dollar amount of the interest payments exchanged is based on the notional principal. In the most common type of swap, there is a fixed-rate payer and a fixed-rate receiver. The convention for quoting swap rates is that a swap dealer sets the floating-rate equal to the reference rate and then quotes the fixed-rate that will apply.

Computing the Payments for a Swap

In the preceding section we described in general terms the payments by the fixed-rate payer and fixed-rate receiver, but we did not give any details. That is, we explained that if the swap rate is 6% and the notional amount is $100 million, then the fixed-rate payment will be $6 million for the year, and the payment is then adjusted based on the frequency of settlement. Thus, if settlement is semiannual, the payment is $3 million. If it is quarterly, it is $1.5 million. Similarly, the floating-rate payment would be found by multiplying the reference rate by the notional amount and then scaling based on the frequency of settlement.

It was useful to illustrate the basic features of an interest-rate swap with simple calculations for the payments such as described earlier and then explain how the parties to a swap either benefit or hurt when interest rates change. However, we will show how to value a swap in this section. To value a swap, it is necessary to determine both the present value of the fixed-rate payments and the present value of the floating-rate payments. The difference between these two present values is the value of a swap. As will be explained below, whether the value is positive (i.e., an asset) or negative (i.e., a liability) will depend on the party.

At the inception of the swap, the terms of the swap will be such that the present value of the floating-rate payments is equal to the present value of the fixed-rate payments. That is, the value of the swap is equal to zero at its inception. This is the fundamental principle in determining the swap rate (i.e., the fixed-rate that the fixed-rate payer will make).

Here is a roadmap of the presentation. First, we will look at how to compute the floating-rate payments. We will see how the future values of the reference rate are determined to obtain the floating-rate for the period. From the future values of the reference rate we will then see how to compute the floating-rate payments, taking into account the number of days in the payment period. Next,

we will see how to calculate the fixed-rate payments given the swap rate. Before we look at how to calculate the value of a swap, we will see how to calculate the swap rate. This will require an explanation of how the present value of any cash-flow in an interest-rate swap is computed. Given the floating-rate payments and the present value of the floating-rate payments, the swap rate can be determined by using the principle that the swap rate is the fixed-rate that will make the present value of the fixed-rate payments equal to the present value of the floating-rate payments. Finally, we will see how the value of swap is determined after the inception of a swap.

Calculating the Floating-Rate Payments

For the first floating-rate payment, the amount is known. For all subsequent payments, the floating-rate payment depends on the value of the reference rate when the floating-rate is determined. To illustrate the issues associated with calculating the floating-rate payment, we will assume that

- A swap starts today, January 1 of year 1 (swap settlement date).
- The floating-rate payments are made quarterly based on "actual/360."
- The reference rate is three-month LIBOR.
- The notional amount of the swap is $100 million.
- The term of the swap is three years.

The quarterly floating-rate payments are based on an actual/360-day count convention. Recall that this convention means that 360 days are assumed in a year and that in computing the interest for the quarter, the actual number of days in the quarter is used. The floating-rate payment is set at the beginning of the quarter but paid at the end of the quarter—that is, the floating-rate payments are made in arrears.

Suppose that today three-month LIBOR is 4.05%. Let's look at what the fixed-rate payer will receive on March 31 of year 1—the date when the first quarterly swap payment is made. There is no uncertainty about what the floating-rate payment will be. In general, the floating-rate payment is determined as follows:

$$\text{Notional amount} \times (\text{three-month LIBOR}) \times \frac{\text{no. of days in period}}{360}$$

In our illustration, assuming a nonleap year, the number of days from January 1 of year 1 to March 31 of year 1 (the first quarter) is 90. If three-month LIBOR is 4.05%, then the fixed-rate payer will receive a floating-rate payment on March 31 of year 1 equal to

$$\$100,000,000 \times 0.0405 \times \frac{90}{360} = \$1,012,500$$

Now the difficulty is in determining the floating-rate payment after the first quarterly payment. That is, for the three-year swap, there will be 12 quarterly floating-rate payments. Thus, while the first quarterly payment is known, the next 11 are not. However, there is a way to hedge the next 11 floating-rate payments by using a futures contract. Specifically, the futures contract used to hedge the future floating-rate payments in a swap whose reference rate is three-month LIBOR is the Eurodollar futures contract.

Determining Future Floating-Rate Payments

Now let's determine the future floating-rate payments. These payments can be locked in over the life of the swap using the Eurodollar futures contract. We will show how these floating-rate payments are computed using this contract.

We will begin with the next quarterly payment—from April 1 of year 1 to June 30 of year 1. This quarter has 91 days. The floating-rate payment will be determined by three-month LIBOR on April 1 of year 1 and paid on June 30 of year 1. Where might the fixed-rate payer look today (January 1 of year 1) to project what three-month LIBOR will be on April 1 of year 1? One possibility is the Eurodollar futures market. There is a three-month Eurodollar futures contract for settlement on June 30 of year 1. That futures contract will express the market's expectation of three-month LIBOR on April 1 of year 1. For example, if the futures price for the three-month Eurodollar futures contract that settles on June 30 of year 1 is 95.85, then as explained earlier, the three-month Eurodollar futures rate is 4.15%. We will refer to that rate for three-month LIBOR as the "forward rate." Therefore, if the fixed-rate payer bought 100 of these three-month Eurodollar futures contracts on January 1 of year 1 (the inception of the swap) that settle on June 30 of year 1, then the payment that will be locked in for the quarter (April 1 to June 30 of year 1) is

$$\$100,000,000 \times 0.0415 \times \frac{91}{360} = \$1,049,028$$

Note that each futures contract is for $1 million, and hence 100 contracts have a notional amount of $100 million.

Similarly, the Eurodollar futures contract can be used to lock in a floating-rate payment for each of the next 10 quarters. Once again, it is important to emphasize that the reference rate at the beginning of period t determines the floating-rate that will be paid for the period. However, the floating-rate payment is not made until the end of period t.

Exhibit 62–2 shows this for the three-year swap. Shown in column (1) is when the quarter begins and in column (2) when the quarter ends. The payment will be received at the end of the first quarter (March 31 of year 1) and is $1,012,500. This is the known floating-rate payment, as explained earlier. It is the only payment that is known. The information used to compute the first payment

EXHIBIT 62–2

Floating-Rate Payments Based on Initial LIBOR and Eurodollar Futures

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Quarter Starts	Quarter Ends	Number of Days in Quarter	Current Three-Month LIBOR	Eurodollar Futures Price	Forward Rate	Period = End of Quarter	Floating-Rate Payment at End of Quarter
Jan 1 year 1	Mar 31 year 1	90	4.05%		—	1	1,012,500
Apr 1 year 1	June 30 year 1	91		95.85	4.15%	2	1,049,028
July 1 year 1	Sept 30 year 1	92		95.45	4.55%	3	1,162,778
Oct 1 year 1	Dec 31 year 1	92		95.28	4.72%	4	1,206,222
Jan 1 year 2	Mar 31 year 2	90		95.10	4.90%	5	1,225,000
Apr 1 year 2	June 30 year 2	91		94.97	5.03%	6	1,271,472
July 1 year 2	Sept 30 year 2	92		94.85	5.15%	7	1,316,111
Oct 1 year 2	Dec 31 year 2	92		94.75	5.25%	8	1,341,667
Jan 1 year 3	Mar 31 year 3	90		94.60	5.40%	9	1,350,000
Apr 1 year 3	June 30 year 3	91		94.50	5.50%	10	1,390,278
July 1 year 3	Sept 30 year 3	92		94.35	5.65%	11	1,443,889
Oct 1 year 3	Dec 31 year 3	92		94.24	5.76%	12	1,472,000

is in column (4), which shows the current three-month LIBOR (4.05%). The payment is shown in the last column, column (8).

Notice that column (7) numbers the quarters from 1 through 12. Look at the heading for column (7). It identifies each quarter in terms of the end of the quarter. This is important because we will eventually be discounting the payments (cash-flows). We must take care to understand when each payment is to be exchanged in order to properly discount. Thus, for the first payment of $1,012,500, it is going to be received at the end of quarter 1. When we refer to the time period for any payment, the reference is to the end of quarter. Thus the fifth payment of $1,225,000 would be identified as the payment for period 5, where period 5 means that it will be exchanged at the end of the fifth quarter.

Calculating the Fixed-Rate Payments

The swap will specify the frequency of settlement for the fixed-rate payments. The frequency need not be the same as the floating-rate payments. For example, in the three-year swap we have been using to illustrate the calculation of the floating-rate payments, the frequency is quarterly. The frequency of the fixed-rate payments could be semiannual rather than quarterly.

In our illustration we will assume that the frequency of settlement is quarterly for the fixed-rate payments, the same as with the floating-rate payments. The day-count convention is the same as for the floating-rate payment, actual/360. The equation for determining the dollar amount of the fixed-rate payment for the period is

$$\text{Notional amount} \times (\text{swap rate}) \times \frac{\text{no. of days in period}}{360}$$

It is the same equation as for determining the floating-rate payment except that the swap rate is used instead of the reference rate (three-month LIBOR in our illustration).

For example, suppose that the swap rate is 4.98% and the quarter has 90 days. Then the fixed-rate payment for the quarter is

$$\$100,000,000 \times 0.0498 \times \frac{90}{360} = \$1,245,000$$

If there are 92 days in a quarter, the fixed-rate payment for the quarter is

$$\$100,000,000 \times 0.0498 \times \frac{92}{360} = \$1,272,667$$

Note that the rate is fixed for each quarter, but the dollar amount of the payment depends on the number of days in the period.

Exhibit 62–3 shows the fixed-rate payments based on different assumed values for the swap rate. The first three columns of the exhibit show the same information as in Exhibit 62–2—the beginning and end of the quarter and the number of days in the quarter. Column (4) simply uses the notation for the period.

EXHIBIT 62–3

Fixed-Rate Payments for Several Assumed Swap Rates

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Quarter Starts	Quarter Ends	Number of Days in Quarter	Period = End of Quarter	Fixed-Rate Payment if Swap Rate Is Assumed to Be				
				4.9800%	4.9873%	4.9874%	4.9875%	4.9880%
Jan 1 year 1	Mar 31 year 1	90	1	1,245,000	1,246,825	1,246,850	1,246,875	1,247,000
Apr 1 year 1	June 30 year 1	91	2	1,258,833	1,260,679	1,260,704	1,260,729	1,260,856
July 1 year 1	Sept 30 year 1	92	3	1,272,667	1,274,532	1,274,558	1,274,583	1,274,711
Oct 1 year 1	Dec 31 year 1	92	4	1,272,667	1,274,532	1,274,558	1,274,583	1,274,711
Jan 1 year 2	Mar 31 year 2	90	5	1,245,000	1,246,825	1,246,850	1,246,875	1,247,000
Apr 1 year 2	June 30 year 2	91	6	1,258,833	1,260,679	1,260,704	1,260,729	1,260,856
July 1 year 2	Sept 30 year 2	92	7	1,272,667	1,274,532	1,274,558	1,274,583	1,274,711
Oct 1 year 2	Dec 31 year 2	92	8	1,272,667	1,274,532	1,274,558	1,274,583	1,274,711
Jan 1 year 3	Mar 31 year 3	90	9	1,245,000	1,246,825	1,246,850	1,246,875	1,247,000
Apr 1 year 3	June 30 year 3	91	10	1,258,833	1,260,679	1,260,704	1,260,729	1,260,856
July 1 year 3	Sept 30 year 3	92	11	1,272,667	1,274,532	1,274,558	1,274,583	1,274,711
Oct 1 year 3	Dec 31 year 3	92	12	1,272,667	1,274,532	1,274,558	1,274,583	1,274,711

That is, period 1 means the end of the first quarter, period 2 means the end of the second quarter, and so on. The other columns of the exhibit show the payments for each assumed swap rate.

Calculation of the Swap Rate

Now that we know how to calculate the payments for the fixed-rate and floating-rate sides of a swap where the reference rate is three-month LIBOR given (1) the current value for three-month LIBOR, (2) the expected three-month LIBOR from the Eurodollar futures contract, and (3) the assumed swap rate, we can demonstrate how to compute the swap rate.

At the initiation of an interest-rate swap, the counterparties are agreeing to exchange future payments, and no upfront payments are made by either party. This means that the swap terms must be such that the present value of the payments to be made by the counterparties must be at least equal to the present value of the payments that will be received. In fact, to eliminate arbitrage opportunities, the present value of the payments made by a party will be equal to the present value of the payments received by that same party. *The equivalence (or no arbitrage) of the present value of the payments is the key principle in calculating the swap rate.*

Since we will have to calculate the present value of the payments, let's show how this is done.

Calculating the Present Value of the Floating-Rate Payments

As explained earlier, we must be careful about how we compute the present value of payments. In particular, we must carefully specify (1) the timing of the payment and (2) the interest rates that should be used to discount the payments. We have already addressed the first issue. In constructing the exhibit for the payments, we indicated that the payments are at the end of the quarter. Thus we denoted the time periods with respect to the end of the quarter.

Now let's turn to the interest rates that should be used for discounting. First, every cash-flow should be discounted at its own discount rate using a spot rate. Thus, if we discounted a cash-flow of \$1 using the spot rate for period t, the present value would be

$$\text{Present value of \$1 to be received in period } t = \frac{\$1}{(1 + \text{spot rate for period } t)^t}$$

Second, forward rates are derived from spot rates, so if we discounted a cash-flow using forward rates rather than spot rates, we would come up with the same value. That is, the present value of \$1 to be received in period t can be rewritten as

$$\text{Present value of \$1 to be received in period } t \text{ discounted with forward rates}$$
$$= \frac{\$1}{(1 + \text{forward rate for period } 1)(1 + \text{forward rate for period } 2)\cdots(1 + \text{forward rate for period } t)}$$

We will call the present value of \$1 to be received in period t as the *forward discount factor*. In our calculations involving swaps, we will compute the forward discount factor for a period using the forward rates. These are the same forward rates that are used to compute the floating-rate payments—those obtained from the Eurodollar futures contract. We must make just one more adjustment. We must adjust the forward rates used in the formula for the number of days in the period (i.e., the quarter in our illustrations) in the same way that we made this adjustment to obtain the payments. Specifically, the forward rate for a period, which we will call the *period forward rate,* is computed using the following equation:

$$\text{Period forward rate} = \text{annual forward rate} \times \left(\frac{\text{days in period}}{360}\right)$$

For example, look at Exhibit 62–2. The annual forward rate for period 4 is 4.72%. The period forward rate for period 4 is

$$\text{Period forward rate} = 4.72\% \times \left(\frac{92}{360}\right) = 1.2062\%$$

Column (5) in Exhibit 62–4 shows the annual forward rate for all 12 periods (reproduced from Exhibit 62–3), and column (6) shows the period forward rate for all 12 periods. Note that the period forward rate for period 1 is 4.05%, the known rate for three-month LIBOR.

Also shown in Exhibit 62–4 is the forward discount factor for all 12 periods. These values are shown in the last column. Let's show how the forward discount factor is computed for periods 1, 2, and 3. For period 1, the forward discount factor is

$$\text{Forward discount factor} = \frac{\$1}{(1.010125)} = 0.98997649$$

For period 2,

$$\text{Forward discount factor} = \frac{\$1}{(1.010125)(1.010490)} = 0.97969917$$

For period 3,

$$\text{Forward discount factor} = \frac{\$1}{(1.010125)(1.010490)(1.011628)} = 0.96843839$$

Given the floating-rate payment for a period and the forward discount factor for the period, the present value of the payment can be computed. For example, from Exhibit 62–2 we see that the floating-rate payment for period 4 is \$1,206,222. From Exhibit 62–4, the forward discount factor for period 4 is 0.95689609. Therefore, the present value of the payment is

$$\begin{aligned}\text{Present value of period 4 payment} &= \$1{,}206{,}222 \times 0.95689609 \\ &= \$1{,}154{,}229\end{aligned}$$

EXHIBIT 62–4

Calculating the Forward Discount Factor

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Quarter Starts	**Quarter Ends**	**Number of Days in Quarter**	**Period = End of Quarter**	**Forward Rate**	**Period Forward Rate**	**Forward Discount Factor**
Jan 1 year 1	Mar 31 year 1	90	1	4.05%	1.0125%	0.98997649
Apr 1 year 1	June 30 year 1	91	2	4.15%	1.0490%	0.97969917
July 1 year 1	Sept 30 year 1	92	3	4.55%	1.1628%	0.96843839
Oct 1 year 1	Dec 31 year 1	92	4	4.72%	1.2062%	0.95689609
Jan 1 year 2	Mar 31 year 2	90	5	4.90%	1.2250%	0.94531597
Apr 1 year 2	June 30 year 2	91	6	5.03%	1.2715%	0.93344745
July 1 year 2	Sept 30 year 2	92	7	5.15%	1.3161%	0.92132183
Oct 1 year 2	Dec 31 year 2	92	8	5.25%	1.3417%	0.90912441
Jan 1 year 3	Mar 31 year 3	90	9	5.40%	1.3500%	0.89701471
Apr 1 year 3	June 30 year 3	91	10	5.50%	1.3903%	0.88471472
July 1 year 3	Sept 30 year 3	92	11	5.65%	1.4439%	0.87212224
Oct 1 year 3	Dec 31 year 3	92	12	5.76%	1.4720%	0.85947083

Exhibit 62–5 shows the present value for each payment. The total present value of the 12 floating-rate payments is $14,052,917 Thus the present value of the payments that the fixed-rate payer will receive is $14,052,917, and the present value of the payments that the fixed-rate receiver will make is $14,052,917.

Determination of the Swap Rate

The fixed-rate payer will require that the present value of the fixed-rate payments that must be made based on the swap rate not exceed the $14,052,917 payments to be received from the floating-rate payments. The fixed-rate receiver will require that the present value of the fixed-rate payments to be received is at least as great as the $14,052,917 that must be paid. This means that both parties will require a present value for the fixed-rate payments to be $14,052,917. If this is the case, the present value of the fixed-rate payments is equal to the present value of the floating-rate payments, and therefore, the value of the swap is zero for both parties at the inception of the swap. The interest rates that should be used to compute the present value of the fixed-rate payments are the same interest rates as those used to discount the floating-rate payments.

To show how to compute the swap rate, we begin with the basic relationship for no arbitrage to exist:

$$PV \text{ of floating-rate payments} = PV \text{ of fixed-rate payments}$$

We know the value for the left-hand side of the equation.

If we let

$$SR = \text{swap rate}$$

and

$$\text{Days}_t = \text{number of days in the payment period } t$$

then the fixed-rate payment for period t is equal to

$$\text{Notional amount} \times SR \times \frac{\text{days}_t}{360}$$

The present value of the fixed-rate payment for period t is found by multiplying the previous expression by the forward discount factor. If we let FDF_t denote the forward discount factor for period t, then the present value of the fixed-rate payment for period t is equal to

$$\text{Notional amount} \times SR \times \frac{\text{days}_t}{360} \times FDF_t$$

We can now sum up the present value of the fixed-rate payment for each period to get the present value of the floating-rate payments. Using the Greek

EXHIBIT 62–5

Present Value of the Floating-Rate Payments

(1)	(2)	(3)	(4)	(5)	(6)
Quarter Starts	**Quarter Ends**	**Period = End of Quarter**	**Forward Discount Factor**	**Floating-Rate Payment at End of Quarter**	**PV of Floating-Rate Payment**
Jan 1 year 1	Mar 31 year 1	1	0.98997649	1,012,500	1,002,351
Apr 1 year 1	June 30 year 1	2	0.97969917	1,049,028	1,027,732
July 1 year 1	Sept 30 year 1	3	0.96843839	1,162,778	1,126,079
Oct 1 year 1	Dec 31 year 1	4	0.95689609	1,206,222	1,154,229
Jan 1 year 2	Mar 31 year 2	5	0.94531597	1,225,000	1,158,012
Apr 1 year 2	June 30 year 2	6	0.93344745	1,271,472	1,186,852
July 1 year 2	Sept 30 year 2	7	0.92132183	1,316,111	1,212,562
Oct 1 year 2	Dec 31 year 2	8	0.90912441	1,341,667	1,219,742
Jan 1 year 3	Mar 31 year 3	9	0.89701471	1,350,000	1,210,970
Apr 1 year 3	June 30 year 3	10	0.88471472	1,390,278	1,229,999
July 1 year 3	Sept 30 year 3	11	0.87212224	1,443,889	1,259,248
Oct 1 year 3	Dec 31 year 3	12	0.85947083	1,472,000	1,265,141
TOTAL					14,052,917

symbol sigma (Σ) to denote summation, and letting N be the number of periods in the swap, then the present value of the fixed-rate payments can be expressed as

$$\sum_{t=1}^{N} \text{notional amount} \times SR \times \frac{\text{days}_t}{360} \times FDF_t$$

This also can be expressed as

$$SR \sum_{t=1}^{N} \text{notional amount} \times \frac{\text{days}_t}{360} \times FDF_t$$

The condition for no arbitrage is that the present value of the fixed-rate payments as given by the preceding expression is equal to the present value of the floating-rate payments. That is,

$$SR \sum_{t=1}^{N} \text{notional amount} \times \frac{\text{days}_t}{360} \times FDF_t = PV \text{ of floating-rate payments}$$

Solving for the swap rate,

$$SR = \frac{PV \text{ of floating-rate payments}}{\sum_{t=1}^{N} \text{notional amount} \times \frac{\text{days}_t}{360} \times FDF_t}$$

All the values needed to compute the swap rate are known.

Let's apply the formula to determine the swap rate for our three-year swap. Exhibit 62–6 shows the calculation of the denominator of the formula. The forward discount factor for each period shown in column (5) is obtained from column (4) of Exhibit 62–5. The sum of the last column in Exhibit 62–6 shows that the denominator of the swap-rate formula is $281,764,282. We know from Exhibit 62–5 that the present value of the floating-rate payments is $14,052,917. Therefore, the swap rate is

$$SR = \frac{\$14,052,917}{\$281,764,282} = 0.049875 = 4.9875\%$$

Given the swap rate, the *swap spread* can be determined. For example, since this is a three-year swap, the convention is to use the three-year on-the-run Treasury rate as the benchmark. If the yield on that issue is 4.5875%, the swap spread is 40 basis points (4.9875% – 4.5875%).

The calculation of the swap rate for all swaps follows the same principle: equating the present value of the fixed-rate payments to that of the floating-rate payments.

Valuing a Swap

Once the swap transaction is completed, changes in market interest rates will change the payments of the floating-rate side of the swap. The value of an interest-rate swap

EXHIBIT 62–6

Calculating the Denominator for the Swap-Rate Formula

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Quarter Starts	Quarter Ends	Number of Days in Quarter	Period = End of Quarter	Forward Discount Factor	Days/360	Forward Discount Factor × Days/360 × Notional
Jan 1 year 1	Mar 31 year 1	90	1	0.98997649	0.25000000	24,749,412
Apr 1 year 1	June 30 year 1	91	2	0.97969917	0.25277778	24,764,618
July 1 year 1	Sept 30 year 1	92	3	0.96843839	0.25555556	24,748,981
Oct 1 year 1	Dec 31 year 1	92	4	0.95689609	0.25555556	24,454,011
Jan 1 year 2	Mar 31 year 2	90	5	0.94531597	0.25000000	23,632,899
Apr 1 year 2	June 30 year 2	91	6	0.93344745	0.25277778	23,595,477
July 1 year 2	Sept 30 year 2	92	7	0.92132183	0.25555556	23,544,891
Oct 1 year 2	Dec 31 year 2	92	8	0.90912441	0.25555556	23,233,179
Jan 1 year 3	Mar 31 year 3	90	9	0.89701471	0.25000000	22,425,368
Apr 1 year 3	June 30 year 3	91	10	0.88471472	0.25277778	22,363,622
July 1 year 3	Sept 30 year 3	92	11	0.87212224	0.25555556	22,287,568
Oct 1 year 3	Dec 31 year 3	92	12	0.85947083	0.25555556	21,964,255
TOTAL						281,764,282

is the difference between the present value of the payments of the two sides of the swap. The three-month LIBOR forward rates from the current Eurodollar futures contracts are used to (1) calculate the floating-rate payments and (2) determine the discount factors at which to calculate the present value of the payments.

To illustrate this, consider the three-year swap used to demonstrate how to calculate the swap rate. Suppose that one year later, interest rates change as shown in columns (4) and (6) in Exhibit 62–7. Column (4) shows the current three-month LIBOR. In column (5) are the Eurodollar futures price for each period. These rates are used to compute the forward rates in column (6). Note that the interest rates have increased one year later because the rates in Exhibit 62–7 are greater than those in Exhibit 62–2. As in Exhibit 62–2, the current three-month LIBOR and the forward rates are used to compute the floating-rate payments. These payments are shown in column (8) of Exhibit 62–7.

In Exhibit 62–8, the forward discount factor is computed for each period. The calculation is the same as in Exhibit 62–4 to obtain the forward discount factor for each period. The forward discount factor for each period is shown in the last column of Exhibit 62–8.

In Exhibit 62–9, the forward discount factor (from Exhibit 62–8) and the floating-rate payments (from Exhibit 62–7) are shown. The fixed-rate payments need not be recomputed. They are the payments shown in column (8) of Exhibit 62–3. These are fixed-rate payments for the swap rate of 4.9875% and are reproduced in Exhibit 62–9. Now the two payment streams must be discounted using the new forward discount factors. As shown at the bottom of Exhibit 62–9, the two present values are as follows:

Present value of floating-rate payments	\$11,459,495
Present value of fixed-rate payments	\$9,473,390

The two present values are not equal, and therefore, for one party, the value of the swap increased, and for the other party, the value of the swap decreased. Let's look at which party gained and which party lost.

The fixed-rate payer will receive the floating-rate payments. And these payments have a present value of \$11,459,495. The present value of the payments that must be made by the fixed-rate payer is \$9,473,390. Thus the swap has a positive value for the fixed-rate payer equal to the difference in the two present values of \$1,986,105. This is the value of the swap to the fixed-rate payer. Notice, consistent with what we said earlier, that when interest rates increase (as they did in our illustration), the fixed-rate payer benefits because the value of the swap increases.

In contrast, the fixed-rate receiver must make payments with a present value of \$11,459,495 but will only receive fixed-rate payments with a present value equal to \$9,473,390. Thus the value of the swap for the fixed-rate receiver is –\$1,986,105. Again, as explained earlier, the fixed-rate receiver is adversely affected by a rise in interest rates because it results in a decline in the value of a swap.

EXHIBIT 62–7

Rates and Floating-Rate Payments One Year Later if Rates Increase

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Quarter Starts	Quarter Ends	Number of Days in Quarter	Current Three-Month LIBOR	Eurodollar Futures Price	Forward Rate	Period = End of Quarter	Floating-Rate Payments at End of Quarter
Jan 1 year 2	Mar 31 year 2	90	5.25%			1	1,312,500
Apr 1 year 2	June 30 year 2	91		94.27	5.73%	2	1,448,417
July 1 year 2	Sept 30 year 2	92		94.22	5.78%	3	1,477,111
Oct 1 year 2	Dec 31 year 2	92		94.00	6.00%	4	1,533,333
Jan 1 year 3	Mar 31 year 3	90		93.85	6.15%	5	1,537,500
Apr 1 year 3	June 30 year 3	91		93.75	6.25%	6	1,579,861
July 1 year 3	Sept 30 year 3	92		93.54	6.46%	7	1,650,889
Oct 1 year 3	Dec 31 year 3	92		93.25	6.75%	8	1,725,000

EXHIBIT 62–8

Period Forward Rates and Forward Discount Factors One Year Later if Rates Increase

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Quarter Starts	Quarter Ends	Number of Days in Quarter	Period = End of Quarter	Forward Rate	Period Forward Rate	Forward Discount Factor
Jan 1 year 2	Mar 31 year 2	90	1	5.25%	1.3125%	0.98704503
Apr 1 year 2	June 30 year 2	91	2	5.73%	1.4484%	0.97295263
July 1 year 2	Sept 30 year 2	92	3	5.78%	1.4771%	0.95879023
Oct 1 year 2	Dec 31 year 2	92	4	6.00%	1.5333%	0.94431080
Jan 1 year 3	Mar 31 year 3	90	5	6.15%	1.5375%	0.93001186
Apr 1 year 3	June 30 year 3	91	6	6.25%	1.5799%	0.91554749
July 1 year 3	Sept 30 year 3	92	7	6.46%	1.6509%	0.90067829
Oct 1 year 3	Dec 31 year 3	92	8	6.75%	1.7250%	0.88540505

EXHIBIT 62–9

Valuing the Swap One Year Later if Rates Increase

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Quarter Starts	**Quarter Ends**	**Forward Discount Factor**	**Floating Cash Flow at End of Quarter**	**PV of Floating Cash-Flow**	**Fixed Cash Flow at End of Quarter**	**PV of Fixed Cash-Flow**
Jan 1 year 2	Mar 31 year 2	0.98704503	1,312,500	1,295,497	1,246,875	1,230,722
Apr 1 year 2	June 30 year 2	0.97295263	1,448,417	1,409,241	1,260,729	1,226,630
July 1 year 2	Sept 30 year 2	0.95879023	1,477,111	1,416,240	1,274,583	1,222,058
Oct 1 year 2	Dec 31 year 2	0.94431080	1,533,333	1,447,943	1,274,583	1,203,603
Jan 1 year 3	Mar 31 year 3	0.93001186	1,537,500	1,429,893	1,246,875	1,159,609
Apr 1 year 3	June 30 year 3	0.91554749	1,579,861	1,446,438	1,260,729	1,154,257
July 1 year 3	Sept 30 year 3	0.90067829	1,650,889	1,486,920	1,274,583	1,147,990
Oct 1 year 3	Dec 31 year 3	0.88540505	1,725,000	1,527,324	1,274,583	1,128,523
TOTAL				11,459,495		9,473,390

Summary	Fixed-Rate Payer	Fixed-Rate Receiver
PV of payments received	11,459,495	9,473,390
PV of payments made	9,473,390	11,459,495
Value of swap	1,986,105	–1,986,105

The same valuation principle applies to more complicated swaps. For example, there are swaps whose notional amount changes in a predetermined way over the life of the swap. These include amortizing swaps, accreting swaps, and roller-coaster swaps. Once the payments are specified, the present value is calculated as described earlier simply by adjusting the payment amounts by the changing notional amounts—the methodology does *not* change.

PRIMARY DETERMINANTS OF SWAP SPREADS

The swap spread is determined by the same factors that drive the spread over Treasuries on instruments that replicate a swap's cash-flows, i.e., produce a similar return or funding profile. As discussed below, the swap spread's key determinant for swaps with tenors (i.e., maturities) of five years or less is the cost of hedging in the Eurodollar futures market. Although listed contracts exist with delivery dates out to 10 years, the liquidity of the Eurodollar futures market diminishes considerably after about five years. For longer tenor swaps, the swap spread is largely driven by credit-spreads in the corporate bond market. Specifically, longer-dated swaps are priced relative to rates paid by investment-grade credits in traditional fixed- and floating-rate markets.

Given that a swap is a package of futures/forward contracts, the shorter-term swap spreads respond directly to fluctuations in Eurodollar futures prices. As noted, there is a liquid market for Eurodollar futures contracts with maturities every three months for approximately five years. A market participant can create a synthetic fixed-rate security or a fixed-rate funding vehicle by taking a position in a bundle of Eurodollar futures contracts (i.e., a position in every three-month Eurodollar futures contract up to the desired maturity date).

For example, consider a financial institution that has fixed-rate assets and floating-rate liabilities. Both the assets and liabilities have a maturity of three years. The interest rate on the liabilities resets every three months based on three-month LIBOR. This financial institution can hedge this mismatched asset/liability position by buying a three-year bundle of Eurodollar futures contracts. By doing so, the financial institution is receiving LIBOR over the three-year period and paying a fixed dollar amount (i.e., the futures price). The financial institution is now hedged because the assets are fixed-rate, and the bundle of long Eurodollar futures synthetically creates a fixed-rate funding arrangement. From the fixed dollar amount over the three years, an effective fixed-rate that the financial institution pays can be computed. Alternatively, the financial institution can synthetically create a fixed-rate funding arrangement by entering into a three-year swap in which it pays fixed and receives three-month LIBOR. Other things equal, the financial institution will use the vehicle that delivers the lowest cost of hedging the mismatched position. That is, the financial institution will compare the synthetic fixed-rate (expressed as a percentage over U.S. Treasuries) to the three-year

swap spread. The difference between the synthetic spread and the swap spread should be within a few basis points under normal circumstances.

For swaps with tenors greater than five years, we cannot rely on the Eurodollar futures owing to diminishing liquidity of such contracts. Instead, longer-dated swaps are priced using rates available for investment-grade corporate borrowers in fixed-rate and floating-rate debt markets. Since a swap can be interpreted as a package of long and short positions in a fixed-rate bond and a floating-rate bond, it is the credit-spreads in those two market sectors that will be the primary determinant of the swap spread. Empirically, the swap curve lies above the U.S. Treasury yield-curve and below the on-the-run yield-curve for AA-rated banks.[1] Swap fixed-rates are lower than AA-rated bond yields due to their lower credit risk due to netting and offsetting of swap positions.

In addition, there are a number of other technical factors that influence the level of swap spreads.[2] While the impact of some these factors is ephemeral, their influence can be considerable in the short run. Included among these factors are (1) the level and shape of the Treasury yield-curve, (2) the relative supply of fixed- and floating-rate payers in the interest-rate swap market, (3) the technical factors that affect swap dealers, and (4) the level of asset-based swap activity.

The level, slope, and curvature of the U.S. Treasury yield-curve are important influences on swap spreads at various maturities. The reason is that embedded in the yield-curve are the market's expectations of the direction of future interest rates. While these expectations are sometimes challenging to extract, the decision to borrow at a fixed-rate or a floating-rate will be based, in part, on these expectations. The relative supply of fixed- and floating-rate payers in the interest-rate swap market also should be influenced by these expectations. For example, many corporate issuers—financial institutions and federal agencies in particular—swap their newly issued fixed-rate debt into floating using the swap market. Consequently, swap spreads will be affected by the corporate debt issuance calendar. In addition, swap spreads, like credit-spreads, also tend to increase with the swap's tenor or maturity.

Swap spreads are also affected by the hedging costs faced by swap dealers. Dealers hedge the interest-rate risk of long (short) swap positions by taking a long (short) position in a Treasury security with the same maturity as the swap's tenor and borrowing funds (lending funds) in the repo market. As a result, the spread between LIBOR and the appropriate repo rate will be a critical determinant of the hedging costs. When on-the-run Treasuries go "on special," it is correspondingly

1. For a discussion of this point, see Andrew R. Young, *A Morgan Stanley Guide to Fixed-Income Analysis* (New York: Morgan Stanley, 1997).
2. See Ellen L. Evans and Gioia Parente Bales, "What Drives Interest-Rate Swap Spreads," Chapter 13 in Carl R. Beidleman (ed.), *Interest-Rate Swaps* (Burr Ridge, IL: Irwin Professional Publishing, 1991).

more expensive to use these Treasuries as a hedge. This increase in hedging costs results in wider swap spreads.[3]

Another influence on the level of swap spreads is the volume of asset-based swap transactions. An asset-based swap transaction involves the creation of a synthetic security via the purchase of an existing security and the simultaneous execution of a swap. For example, after the Russian debt default and devaluation in August 1998, risk-averse investors sold corporate bonds and fled to the relative safety of U.S. Treasuries. Credit-spreads widened considerably and liquidity diminished. A contrary-minded floating-rate investor (like a financial institution) could have taken advantage of these circumstances by buying newly issued investment-grade corporate bonds with relatively attractive coupon rates and simultaneously taking a long position in an interest-rate swap (pay fixed/receive floating). Accordingly, the financial institution ends up with a synthetic floating-rate asset with a spread above LIBOR.

By similar reasoning, investors can use swaps to create a synthetic fixed-rate security. For example, during the mid-1980s, many banks issued perpetual floating-rate notes in the Eurobond market. A perpetual floating-rate note is a security that delivers floating-rate cash-flows forever. The coupon is reset and paid usually every three months with a coupon formula equal to the reference rate (e.g., three-month LIBOR) plus a spread. When the perpetual floating-rate note market collapsed in late 1986, the contagion spread into other sectors of the floaters market.[4] Many floaters cheapened considerably. As before, contrary-minded fixed-rate investors could exploit this situation through the purchase of a relatively cheap (from the investor's perspective) floater while simultaneously taking a short position in an interest-rate swap (pay floating/receive fixed) thereby creating a synthetic fixed-rate investment. The investor makes floating-rate payments (say, based on LIBOR) to the counterparty and receives fixed-rate payments equal to the Treasury yield plus the swap spread. Accordingly, the fixed-rate on this synthetic security is equal to the sum of the following: (1) the Treasury bond yield that matches the swap's tenor, (2) the swap spread, and (3) the floater's index spread.

NONGENERIC INTEREST-RATE SWAPS

The swap market is very flexible, and instruments can be tailor-made to fit the requirements of individual customers. A wide variety of swap contracts are traded in the market. Although the most common reference rate for the floating leg of a swap is six-month LIBOR for a semiannual-paying floating leg, other reference rates that have been used include three-month LIBOR, the prime rate

3. Traders often use the repo market to obtain specific securities to cover short positions. If a security is in short supply relative to demand, the repo rate on a specific security used as collateral in a repo transaction will be below the general (i.e., generic) collateral repo rate. When a particular security's repo rate falls markedly, that security is said to be "on special." Investors who own these securities are able to lend them out as collateral and borrow at bargain basement rates.
4. Suresh E. Krishman, "Asset-Based Interest-Rate Swaps," Chapter 8 in *Interest-Rate Swaps*.

(for dollar swaps), the one-month commercial paper rate, the Treasury bill rate, and the municipal bond rate.

The term of a swap need not be fixed; swaps may be *extendible* or *putable*. In an extendible swap, one of the parties has the right but not the obligation to extend the life of the swap beyond the fixed maturity date, whereas in a putable swap one party has the right to terminate the swap prior to the specified maturity date.

It is also possible to transact options on swaps, known as *swaptions*. A swaption is the right to enter into a swap agreement at some point in the future during the life of the option. Essentially a swaption is an option to exchange a fixed-rate bond cash-flow for a floating-rate bond cash-flow structure. Swaptions will be described in more detail later. Other swaps are described below.

Constant-Maturity Swap

In a constant-maturity swap, the parties exchange a LIBOR rate for a fixed swap rate. For example, the terms of the swap might state that six-month LIBOR is exchanged for the five-year swap rate on a semiannual basis for the next five years or for the five-year government bond rate. In the U.S. market, the second type of constant-maturity swap is known as a *constant-maturity Treasury swap*.

Accreting and Amortizing Swaps

In a plain-vanilla swap, the notional principal remains unchanged during the life of the swap. However it is possible to trade a swap where the notional principal varies during its life. An accreting (or step-up) swap is one in which the principal starts off at one level and then increases in amount over time. The opposite, an amortizing swap, is one in which the notional reduces in size over time. An accreting swap would be useful where, for instance, a funding liability that is being hedged increases over time. The amortizing swap might be employed by a borrower hedging a bond issue that featured sinking-fund payments, where a part of the notional amount outstanding is paid off at set points during the life of the bond. If the principal fluctuates in amount, for example, increasing in one year and then reducing in another, the swap is known as a *roller-coaster swap*. Another application of an amortizing swap is as a hedge for a loan that is itself an amortizing one. Frequently this is combined with a forward-start swap to tie in with the cash-flows payable on the loan. The pricing and valuation of an amortizing swap are no different in principle to a vanilla interest-rate swap; a single swap rate is calculated using the relevant discount factors, and at this rate the net present value of the swap cash-flows will equal zero at the start of the swap.

Basis Swap

In a conventional swap, one leg comprises fixed-rate payments and the other floating-rate payments. In a *basis swap,* both legs are floating-rate but linked to

different money market indexes. One leg is normally linked to LIBOR, while the other might be linked to the CD rate or the commercial paper rate. This type of swap would be used by a bank in the United States that had made loans that paid at the prime rate and funded its loans at LIBOR. A basis swap would eliminate the basis risk between the bank's income and interest expense. Other basis swaps are traded in which both legs are linked to LIBOR, but at different maturities; for instance, one leg might be at three-month LIBOR and the other at six-month LIBOR. In such a swap, the basis is different as is the payment frequency: One leg pays out semiannually, while the other would be paying on a quarterly basis.

Off-Market Swap

When a swap is transacted, its fixed-rate is quoted at the current market rate for that maturity. When the fixed-rate is different from the market rate, this type of swap is an *off-market swap,* and a compensating payment is made by one party to the other. An off-market rate may be used for particular hedging requirements, for example, or when a bond issuer wishes to use the swap to hedge the bond as well as to cover the bond's issue costs.

Forward-Start Swap

A *forward-start swap* is an obligation where two counterparties agree to enter into a swap contract at some future date under terms negotiated today.[5] Accordingly, the swap's effective (i.e., start) date is not the usual one or two days after the trade date but some time afterwards, say, six months after the trade date: for example, an interest-rate swap with a tenor of three years that has an effective date one year from today. Once the effective date is reached, a forward-start swap is identical to a normal interest-rate swap. Earlier in the chapter we noted that it is useful to think of the generic interest-rate swap market as one where two counterparties trade the floating reference rate in a series of exchanges for a fixed price. Extending this intuition, the forward-start interest-rate swap market is a forward market for trading the floating reference rate as opposed to the spot market.

A forward-start swap contract will specify the swap's fixed-rate at which the two counterparties agree to exchange cash-flows during the swap's life which begins on some future effective date. This rate is referred to as the *forward swap fixed-rate.*

Overnight Interest-Rate Swaps and Eonia/SONIA Swaps

Overnight-index swaps (OIS) are interest-rate swaps that are traded in the money markets because of their short-term maturity but are generically identically to interest-rate swaps and so also may be considered a capital market instrument.

5. Forward-start swaps are also referred to as *forward swaps, delayed swaps,* and *deferred swaps.*

We saw earlier in this chapter that an interest-rate swap contract, which is generally regarded as a capital market instrument, is an agreement between two counterparties to exchange a fixed-interest-rate payment in return for a floating-interest-rate payment, calculated on a notional swap amount, at regular intervals during the life of the swap. A swap may be viewed as being equivalent to a series of successive forward contracts, with each forward contract starting as the previous one matures. The basis of the floating interest rate is agreed as part of the contract terms at the inception of the trade. Conventional swaps index the floating interest rate to LIBOR; however an exciting recent development in the money markets has been the OIS. In the sterling market they are known as *sterling overnight interest rate average swaps,* or SONIA, while Eurocurrency OIS are known as *Eonia*. In this section we review OIS swaps, which are used extensively by commercial and investment banks.

SONIA is the average interest rate of interbank (unsecured) overnight sterling deposit trades undertaken before 15:30 hours each day between members of the London Wholesale Money Brokers' Association. Recorded interest rates are weighted by volume. A SONIA swap is a swap contract that exchanges a fixed interest rate (the swap rate) against the geometric average of the overnight interest rates that have been recorded during the life of the contract. Exchange of interest takes place on maturity of the swap. SONIA swaps are used to speculate on or to hedge against interest rates at the very short end of the sterling yield-curve; in other words, they can be used to hedge an exposure to overnight interest rates.[6] The swaps themselves are traded in maturities of one week to one year, although two-year SONIA swaps have also been traded.

Conventional swap rates are calculated off the government bond yield-curve and represent the credit premium over government yields of interbank default risk. Essentially, they represent an average of the forward rates derived from the government spot (zero-coupon) yield-curve. The fixed-rate quoted on a SONIA swap represents the average level of the overnight interest rates expected by market participants over the life of the swap. In practice, the rate is calculated as a function of the Bank of England's repo rate. This is the two-week rate at which the Bank conducts reverse repo trades with banking counterparties as part of its open market operations. In other words, this is the Bank's base rate. In theory, one would expect the SONIA rate to follow the repo rate fairly closely, since the credit risk on an overnight deposit is low. However, in practice, the spread between the SONIA rate and the Bank repo rate is very volatile, and for this reason, the swaps are used to hedge overnight exposures.

Overnight-index swaps dealt in U.S. dollars are linked to the federal funds rate. Since this rate is considerably below the overnight LIBOR rate, it means that

6. Traditionally, overnight rates fluctuate in a very wide range during the day, depending on the day's funds shortage, and although volatility has reduced since the introduction of gilt repo, it is still unpredictable on occasion.

the swap is not always used by banks to hedge overnight interest rate liability exposure, especially when the latter is linked to LIBOR.

CANCELING A SWAP

When financial institutions enter into a swap contract in order to hedge interest-rate liabilities, the swap will be kept in place until its expiration. However, circumstances may change, or a financial institution may alter its view on interest rates, and so circumstances may arise such that it may be necessary to terminate the swap. The most straightforward option is for the corporation to take out a second contract that negates the first. This allows the first swap to remain in place, but there may be residual cash-flows unless the two swaps cancel each other out precisely. The terms for the second swap, being nonstandard (and unlikely to be exactly whole years to maturity, unless traded on the anniversary of the first), also may result in it being more expensive than a vanilla swap. Since it is unlikely that the second swap will have the same rate, the two fixed legs will not net to zero. And if the second swap is not traded on an anniversary, payment dates will not match.

For these reasons, an entity may wish to cancel the swap entirely. To do this, it will ask a swap market maker for a quotation on a *cancellation fee*. The bank will determine the cancellation fee by calculating the net present value of the remaining cash-flows in the swap using the relevant discount factor for each future cash-flow. In practice just the fixed leg will be present valued and then netted with LIBOR. The net present value of all the cash-flows is the fair price for canceling the swap. The valuation principles we established earlier will apply; that is, if the fixed-rate payer is asking to cancel the swap when interest rates have fallen, he will pay the cancellation fee, and vice versa if rates have risen.

CREDIT RISK

The rate quoted for swaps in the interbank market assumes that the counterparty to the transaction has a lending line with the swap bank, so the swap rate therefore reflects the credit risk associated with an interbank quality counterparty. This credit risk is reflected in the spread between the swap rate and the equivalent-maturity government bond, although, as noted, the spread also reflects other considerations such as liquidity and supply and demand. The credit risk of a swap is separate from its interest-rate risk or market risk, and arises from the possibility of the counterparty to the swap defaulting on its obligations. If the present value of the swap at the time of default is net positive, then a bank is at risk of loss of this amount. While market risk can be hedged, it is more problematic to hedge credit risk. The common measures taken include limits on lending lines, collateral, and diversification across counterparty sectors, as well as a form of credit value-at-risk to monitor credit exposures.

A bank therefore is at risk of loss due to counterparty default for all its swap transactions. If at the time of default, the net present value of the swap is positive, this amount is potentially at risk and will probably be written off. If the value of the swap is negative at the time of default, in theory this amount is a potential gain to the bank, although in practice the counterparty's administrators will try to recover the value for their client. In this case, then, there is no net gain or loss to the swap bank. The credit risk management department of a bank will therefore often assess the ongoing credit quality of counterparties with whom the swap transactions are currently positive in value.

SWAPTIONS

We conclude this chapter with a discussion of swaptions. A *swaption* is an option to establish a position in an interest-rate swap at some future date. The swaption contract specifies the swaption's expiration date, as well as the fixed-rate and tenor of the underlying swap. The swap's fixed-rate is called the swaption's *strike rate*. There are two types of swaptions—pay fixed or receive fixed. A pay (receive) fixed swaption gives the buyer the right to establish a position in an interest-rate swap where she will pay (receive) the fixed-rate cash-flows and receive (pay) the floating-rate cash-flows.

Let's illustrate a hypothetical swaption with a one-year swaption on a five-year generic interest-rate swap with a $10 million notional principal in which the buyer will receive fixed cash inflows and pay floating-rate cash-flows. Assume the swaption is European and is therefore exercisable only at expiration. Further assume the swap's fixed-rate is 3.35188% while the floating-rate is three-month LIBOR flat. If the swaption is exercised on its expiration date say, January 1, 2012, the five-year swap begins on January 1, 2012 at a fixed-rate of 3.35188% in exchange for floating cash flows and ends on January 1, 2017 ("maturity").

When valuing interest-rate derivatives or bonds with embedded options, it is essential to model expected future interest-rate volatility. Accordingly, the lattice approach discussed in Chapter 40 is a commonly used method to value swaptions. A swaption's value will depend on a few critical parameters that include market inputs (e.g., the current yield-curve) as well as terms of the swaption contract (e.g., time to expiration). To solidify our intuition about how swaptions work, we examine how changes in key factors affect swaption values. In particular, we will consider changes in the following: yield-curve (level and slope), volatility, strike rate, and time to expiration.

Changes in the Yield-Curve

As with conventional call and put options, pay-fixed or receive-fixed swaptions tend to react in an opposite manner to changes in the underlying parameters.

For example, a pay-fixed swaption increases in value with an upward parallel shift in the yield-curve, and a receive-fixed swaption becomes more valuable with a downward parallel shift in the yield-curve. To see this, consider a one-year European pay-fixed swaption on a five-year generic interest-rate swap. The notional principal is $10 million, and the strike rate is 6%. On the expiration date, the buyer will either exercise it (i.e., enter into the five-year swap to pay 6% fixed-rate cash-flows and receive floating-rate cash-flows) or let the swaption expire. If the five-year swap rate is above 6% on the expiration date, the buyer of this pay-fixed swaption will exercise it. Conversely, if the five-year swap rate is below 6%, the pay-fixed swaption will expire worthless. The principle is the same for a receive swaption, only in reverse.

Next, we consider the impact of a change in the yield-curve's shape on swaption values. In particular, we will discuss the impact of a steepening and an inverting yield-curve. If the yield-curve steepens, the value of a pay-fixed swaption increases, and the value of a receive-fixed swaption decreases. The intuition is straightforward. A steepening yield-curve indicates that the implied forward rates are increasing at a faster rate than suggested by the initial yield-curve. The higher rates indicate that the floating-rate cash-flows of the underlying swap contract are going to be higher than previously expected. This effect works to the advantage of the pay-fixed swaption buyer because she will receive higher floating-rate cash-flows if the swaption is exercised. The opposite is true for a receive-fixed swaption buyer. By analogous reasoning, an inverted yield-curve indicates that the implied forward rates are decreasing. If this occurs, the value of a pay-fixed swaption decreases, and the value of a receive-fixed swaption increases.

Volatility

There is a positive relationship between swaption values and the assumed interest-rate volatility. If interest volatility increases, all else held constant, chances are greater that underlying swap's value will move in a favorable direction (i.e., higher floating-rate cash-flows for the pay-fixed swaption and higher fixed-rate cash-flows for the receive-fixed swaption). Vega measures the impact of a change in interest-rate volatility on an option's value. For a swaption, vega tells us the sensitivity of the swaption's value (in basis points) to a 1% change in the assumed interest-rate volatility.

A market convention for calculating implied volatility is to use the Black pricing model for options on commodity futures for translating the price of option-type interest rate derivatives into implied volatility. Most market participants use implied volatility of swaption contracts as their estimate of interest-rate volatility. What is the meaning of an "implied yield volatility of, say, 25%?" To interpret this number, one needs to be cognizant that it is derived from the observed option price based on the Black model. As a result, the meaning of it not only depends on the assumption that the market correctly prices the option, but also the fact that the market prices the option in accordance with the Black model.

Given these assumptions, one may interpret that the option market expects a *constant* annualized yield volatility of 25% for the underlying instrument to the maturity date of the option.

Two major assumptions of the Black model are problematic. First, interest rates are assumed to be constant. Yet, the assumption is used to derive the pricing formula for the option, which derives its payoff precisely from the fact that future interest rates (forward rates) are stochastic. The Black model implies a time evolution path for the term structure that leads to the presence of arbitrage opportunities. In other words, the model itself implicitly violates the no-arbitrage spirit in derivatives pricing.

Second, volatilities of futures prices, or forward interest rates, are assumed to be constant over the life of the contract. This assumption runs counter to the empirical record as well as intuition. For example, a forward contract with one month to maturity is more sensitive to changes in the current term structure than a forward contract with one year to maturity. Accordingly, the volatility of the forward rate is inversely related to the time to maturity.

Strike Rate

The value of a swaption is essentially the difference between the strike rate and prevailing swap rate at the time it is being valued. At expiration, a pay-fixed swaption is only exercised when the swap rate is higher than the strike rate. Conversely, at expiration, a receive-fixed swaption is only exercised when the swap rate is lower than the strike rate. Given this backdrop, it is apparent that as the strike rate changes, a pay-fixed swaption and a receive-fixed swaption will behave in an opposite manner. An increase in the strike rate, all else equal, will decrease the value of a pay-fixed swaption and increase the value of a receive-fixed swaption. The reasoning is as follows: As the strike rate increases, the pay-fixed swaption buyer will pay higher fixed-rate cash-flows over the swap's life if the swaption is exercised. This is obviously less valuable than paying a lower fixed-rate for the same floating-rate cash-flows in return. For the receive-fixed swaption buyer, an increase in the strike rate means that the receive-fixed swaption buyer will receive higher fixed-rate cash-flows over the swap's life if the swaption is exercised. For decreases in the strike rate, the effects are reversed.

Time to Expiration

For most options (calls and puts) traded in the financial markets, increasing the option's time to expiration makes it more valuable. This is not the case for swaptions. Increasing a swaption's time to expiration can either increase or decrease its value. This ambiguity is due to the interaction of increasing the time to expiration and the other variables that drive a swaption's value—the current yield-curve, volatility, and the strike rate.

KEY POINTS

- An interest-rate swap is an agreement between two parties to exchange interest payments at designated times in the future based on a notional principal amount.
- In a generic interest-rate swap, one party agrees to make fixed-rate payments and receive floating-rate payments while the counterparty agrees to make floating-rate payments and receive fixed-rate payments.
- The most common reference rate for the floating-rate payments is LIBOR.
- Interest-rate swaps are over-the-counter instruments.
- The default risk in a swap agreement is called *counterparty risk.*
- A swap position can be interpreted as either a package of forward contracts or a package of cash-flows from buying and selling cash market instruments.
- The convention for quoting swap levels is that a swap dealer sets the floating-rate equal to the reference rate and then quotes the fixed-rate that will apply.
- The swap rate is determined by finding the rate that will make the present value of the cash-flow of both sides of the swap equal.
- In a LIBOR-based swap, the cash-flow of the floating-rate side is determined from the Eurodollar futures contract.
- The discount rates used to calculate the present value of the cash-flows in a swap are forward rates.
- The value of an existing swap is equal to the difference in the present value of the two payments.
- The swap spread is the spread over the Treasury par curve specified at the initiation of the swap that the fixed-rate payer must pay.
- Non-generic swaps include constant maturity, accreting/amortizing, zero-coupon, LIBOR-in-arrears, basis, margin, off-market, differential, and forward-start swaps.
- The net present value of all cash-flows is the fair price for canceling a swap.
- Swaption are options to establish a position in an interest-rate swap at some future date.
- The key factors that impact a swaption's value are the yield-curve, volatility, strike rate, and time to expiration.

CHAPTER
SIXTY-THREE

THE VALUATION OF INTEREST-RATE SWAPS AND SWAPTIONS

GERALD W. BUETOW, JR., PH.D., CFA
Chief Investment Officer
Innealta Capital

BRIAN J. HENDERSON, PH.D., CFA
Assistant Professor of Finance
The George Washington University

An interest-rate swap is an agreement involving two parties who agree to exchange payments at future dates. The cash-flow amounts exchanged in the future are determined by an agreed-upon interest rate and the size, or notional principal, of the agreement. In the most basic interest-rate swap, commonly referred to as a "plain vanilla interest-rate swap," one party agrees to make variable payments that "float" with a short-term rate while the other party makes fixed-rate payments at an agreed-upon fixed-rate.

Swaps are important tools for risk managers, offering a cost-effective means to altering interest rate exposure. This useful tool for controlling interest rates may be customized in a variety of ways. For example, in an amortizing swap the notional principal declines over time. In an accreting swap, the notional principal increases over time. Other swaps, named forward-start swaps, are swap agreements that commence at a specified date in the future. Another variation of the swap agreement is the basis swap that involves the exchange of payments referencing two different interest rates, such as three-month LIBOR and the three-month Treasury bill.

In this chapter, our focus is on more complex swap structures. We assume the reader is familiar with plain vanilla swaps and the traditional valuation method involving the use of implied forward rates from LIBOR futures contracts to value a swap agreement to compute the swap fixed-rate (SFR). In addition to swaps, we cover the valuation of swaptions. A swaption gives its owner the right to enter into a swap agreement at a future time.

Unlike plain vanilla interest-rate swaps, swaptions have cash flows that depend on an interest rate at a future point in time. This feature requires a versatile approach to valuation. The lattice approach to valuation proves useful due to two important features. First, the interest-rate model driving the lattice approach is fit to no-arbitrage conditions, meaning that the pricing fits the arbitrage values for cash flows using forward rates. Second, the interest-rate models behind the

interest-rate lattice incorporate an assumed interest-rate volatility, enabling this approach to handle option-like features.

The balance of the chapter proceeds as follows. We begin by illustrating the lattice approach to valuation with a plain vanilla interest-rate swap. Next, we demonstrate the versatility of the lattice approach through the valuation of forward-start swaps. The chapter proceeds by presenting and pricing swaptions with a focus on the pricing impact of the important parameters (time-to-expiration, strike rate, and volatility). Next, the chapter presents basis swaps and concludes.

SWAP VALUATION USING THE LATTICE APPROACH

The traditional approach to valuing swaps involves obtaining a no-arbitrage value for the swap cash flows by discounting at the implied forward rates. The implied forward rates come from market prices of Eurodollar futures contracts. Unfortunately the traditional approach is not equipped for valuing cash flows that vary depending on interest rates in the future. For this purpose, the lattice model is a useful tool for valuing interest rate derivative instruments such as swaps and swaptions. In contrast to the traditional approach to valuing swaps, the lattice model incorporates the volatility of interest rates to consider how interest rates may change in the future, providing a flexible valuation framework easily adapted to exotic (non–plain vanilla) instruments.

In general, the lattice approach to valuation begins with the construction of the interest-rate lattice.[1] The values on the interest-rate lattice represent possible interest rates in future periods, describing potential evolutions of interest rates through time. After constructing the interest-rate lattice, the swap cash flows are computed at each "node" on the lattice, resulting in the swap cash-flow lattice. The interest rates from the lattice are then used to compute the present value of the possible future cash flows. This process is referred to as *backwardation:* working backward through the tree to discount the expected future cash flows to a present value.

Constructing the interest-rate lattice begins with an interest-rate model to describe the dynamics of interest rates through time. Although many interest-rate models are used by practitioners, the most common models are one-factor models that describe the evolution of the short rate (one period interest rate) through time. The term *one factor* simply means that the short rate is the only interest rate being modeled and it solely determines the *term structure*. An interest-rate model makes important assumptions about the relationship between short-term interest rates and interest-rate volatility, typically measured as the standard deviation.[2] The examples in this chapter employ a version of the Kalotay, Williams, and Fabozzi interest-rate model.[3]

1. The approach employed here applies regardless of whether a lattice (binomial, trinomial), grid (finite differences), or paths (Monte Carlo) are used to generate the evolution of interest rates.
2. The details of term structure modeling are beyond the scope of this chapter.
3. Andrew J. Kalotay, George O. Williams, and Frank J. Fabozzi, "A Model for the Valuation of Bonds with Embedded Options," *Financial Analysts Journal* (May-June 1993), pp. 35–46. See also Chapter 40 in this handbook.

After selecting an interest-rate model to describe the possible evolution of the interest rate through time, it is useful to express that model in a lattice comprising discrete time periods. Each node on the binomial tree represents a possible short rate over that discrete time step. The interest rate may evolve to the next time step by taking two possible values. There are other models allowing for more than two possible rates in each subsequent period; for example, the trinomial model allows for three rates. To avoid complication, we illustrate the lattice valuation procedure using the binomial model. The important feature of the interest-rate models is that they satisfy the "no-arbitrage" condition, meaning the interest rates they produce match the implied spot rates from bond prices. Additionally, interest-rate models incorporate an assumption regarding interest-rate volatility. The volatility of interest rates is a critical component when valuing interest rate contingent claims since the cash flows to the claim are determined by interest rates in the future. We will see later that the volatility assumption has direct effects on the value of swaptions.

To illustrate the lattice model approach to valuation, we begin by pricing a 5-year plain vanilla interest-rate swap with a swap fixed-rate (SFR) of 3%. To simplify the presentation, and without loss of generality, we consider the swap to have semiannual payments instead of quarterly payments.

Exhibit 63–1 presents the interest-rate lattice that will be used in the valuation process. The model is a one-factor model and describes the possible paths of the short rate (one-period interest rate) through time. The current short rate is 0.3850%, and according to the model, the short rate for the next time period will be either 0.7950% or 0.6902%, where each of these values is equally likely. The interest-rate tree has 10 semiannual time periods, covering the five-year tenor of the swap agreement.

The next step in the valuation process is to compute the cash-flow at each node. The swap payments occur in arrears, but are determined at the start of the period. For instance, the first swap payment is determined today, at $t = 0$, and is based on the current short rate of interest. Referring to Exhibit 63–1, the current rate is 0.3850%. At the end of the first period, the swap counterparty making the fixed-rate payment will make a payment of:

$$\text{Fixed-Rate Payment} = \text{SFR} \times \text{NP} \times (\text{Days in Period}/360)$$

where NP is the notional principal and Days in Period is the number of days in the payment period.

To simplify the presentation, we assume semiannual cash flows and that the fraction of the year is 0.5. The other swap counterparty, the floating-rate payer, makes a payment that is equal to:

$$\text{Floating-Rate Payment} = \text{Floating-Rate} \times \text{NP} \times (\text{Days in Period}/360)$$

Since the swap cash flows are typically netted, the swap cash-flow at the end of the period will be:

$$\text{Net Cash-Flow} = (\text{Floating-Rate} - \text{SFR}) \times \text{NP} \times (\text{Days in Period}/360)$$

Note that when the periodic floating-rate is greater than the SFR, the floating-rate payer makes the net cash-flow payment to the fixed-rate payer. Conversely, when the periodic floating-rate is less than the SFR, the fixed-rate payer makes payment of the net cash flow amount to the floating-rate payer. Exhibit 63–2 presents the net cash flows at each node on the lattice in Exhibit 63–1 for the five-year semiannual swap agreement with a SFR of 3% and notional principal of $100. To illustrate the computation, refer to the node on the upper right hand side of the interest-rate lattice in Exhibit 63–1 where the short rate is 9.1446% at time 4.5 years. At that node, the short rate is 9.1446%. Recall the cash-flow is determined at the start of the period but paid in arrears. Thus, the short rate at time 4.5 years determines the cash-flow at $t = 5$ years. The net cash-flow from the swap is:

$$\begin{aligned}\text{Net Cash-Flow} &= (\text{Floating-Rate} - \text{SFR}) \times \text{NP} \times (\text{Days in Period}/360)\\ &= (9.1446\% - 3.0\%) \times 100 \times 0.5 = 3.0723.\end{aligned}$$

The procedure repeats for each node on the tree. Recall that the cash flows to the swap occur in arrears (at the end of the period) but are determined at the beginning of the period based on the interest rate at that time.

At this point in the valuation process, we have used the interest-rate lattice to compute the swap cash flows at each node on the lattice. To arrive at a value for the interest-rate swap, the next step is to construct another lattice referred to as the *cumulative swap valuation lattice*. Each node of the cumulative swap valuation lattice is the present value of the swap cash flows from all nodes on the cash-flow lattice occurring after that time (see Exhibit 63–2) discounted using the rates on the binomial lattice (see Exhibit 63–1). To illustrate the process, refer to the shaded region in the top right portion of Exhibit 63–3. The cumulative swap valuation at the nodes where $t = 4.5$ are the present values of the cash flows at $t = 5$. Note the time reference here – cash flows ($t = 5$) verse present value of cash flows ($t = 4.5$). Since the swap agreement matures at $t = 5$ years, there are no subsequent cash flows to consider. Thus, the values in the shaded region at $t = 4.5$ years are computed as the present values of the $t = 5$ cash flows (see Exhibit 63–3) discounted at the rates in Exhibit 63–1:

$$\begin{aligned}3.0723/(1 + 9.1446\%/2) &= 2.9380\\ 2.4693/(1 + 7.9386\%/2) &= 2.3750\\ 1.9458/(1 + 6.8917\%/2) &= 1.8810.\end{aligned}$$

Working backward to the next time step ($t = 4$) requires discounting the values at $t = 4.5$ plus the arrears cash-flow that take place at $t = 4.5$. At each node, there are two possible values at the next time step and they are equally likely to occur. To illustrate, the values at the shaded $t = 4$ nodes in Exhibit 63–3 are determined as:

$$\begin{aligned}(0.5 \times 2.9380 + 0.5 \times 2.3750 + 2.3104)/(1 + 7.6208\%/2) &= 4.7846\\ (0.5 \times 2.3750 + 0.5 \times 1.8810 + 1.8079)/(1 + 6.6158\%/2) &= 3.8099.\end{aligned}$$

After computing the cumulative swap values at $t = 4$, backwardation continues by computing the values at $t = 3.5$ years. To illustrate, the shaded value in

EXHIBIT 63–1

Interest-Rate Tree

									9.1446%
								7.6208%	
							6.5216%		7.9386%
						5.4226%		6.6158%	
					4.4031%		5.6615%		6.8917%
				3.4300%		4.7075%		5.7433%	
			2.5178%		3.8225%		4.9149%		5.9828%
		1.5968%		2.9776%		4.0867%		4.9859%	
	0.7950%		2.1857%		3.3184%		4.2667%		5.1938%
0.3850%		1.3862%		2.5850%		3.5477%		4.3284%	
	0.6902%		1.8975%		2.8808%		3.7041%		4.5089%
		1.2034%		2.2441%		3.0799%		3.7576%	
			1.6472%		2.5009%		3.2156%		3.9143%
				1.9481%		2.6737%		3.2621%	
					2.1711%		2.7915%		3.3981%
						2.3211%		2.8319%	
							2.4234%		2.9500%
								2.4584%	
									2.5609%
Time in Years	**0.50**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**4.50**

EXHIBIT 63–2

Cash Flow Lattice Illustration; 5-Year Plain-Vanilla Swap, Semiannual Settlement, $100 Notional Principal, SFR = 3%

										3.0723
									2.3104	
								1.7608		2.4693
							1.2113		1.8079	
						0.7016		1.3308		1.9458
					0.2150		0.8537		1.3717	
				–0.2411		0.4112		0.9574		1.4914
			–0.7016		–0.0112		0.5433		0.9930	
		–1.1025		–0.4071		0.1592		0.6334		1.0969
	–1.3075		–0.8069		–0.2075		0.2739		0.6642	
		–1.1549		–0.5513		–0.0596		0.3520		0.7544
			–0.8983		–0.3780		0.0399		0.3788	
				–0.6764		–0.2496		0.1078		0.4571
					–0.5259		–0.1631		0.1310	
						–0.4145		–0.1042		0.1990
							–0.3394		–0.0841	
								–0.2883		–0.0250
									–0.2708	
										–0.2195
Time in Years	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**

EXHIBIT 63–3

Cumulative Swap Valuation Lattice; 5-Year Plain-Vanilla Swap, Semiannual Settlement, $100 Notional Principal, SFR = 3%

Value Lattice

										2.9380
									4.7846	
								5.8667		2.3750
							6.2657		3.8099	
						6.0786		4.5818		1.8810
					5.3698		4.7561		2.9515	
				4.1975		4.4151		3.4469		1.4481
			2.5771		3.6131		3.4203		2.1968	
		0.5799		2.4011		2.9411		2.4468		1.0692
	–1.5892		0.7923		2.0558		2.2411		1.5345	
		–1.1495		0.8084		1.6386		1.5672		0.7378
			–0.7893		0.6788		1.2025		0.9540	
				–0.5999		0.4902		0.7949		0.4484
					–0.5358		0.2893		0.4458	
						–0.5203		0.1177		0.1957
							–0.5122		0.0014	
								–0.4752		–0.0247
									–0.3868	
										–0.2168
Time in Years		**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**

Exhibit 63–3 at $t = 3.5$ is computed as the present value of the nodes at $t = 4$ plus the arrears cash-flow received at $t = 4$:

$$(0.5 \times 4.7846 + 0.5 \times 3.8099 + 1.7608)/(1 + 6.5216\%/2) = 5.8667.$$

The process continues through each node, arriving finally at the present value of the swap. Referring to Exhibit 63–3, the present value of the swap with $100 notional principal, 3% swap fixed-rate, and 5-year tenor is –1.5892. Recall that we computed the cash flows from the perspective of the fixed-rate payer, meaning that the cash-flow is negative (an outflow) when the floating-rate is less than the swap fixed-rate. Thus, the negative value indicates that the present value of the fixed-rate payments (3% SFR) is greater than the present value of receiving the floating-rate payments. At the time the counterparties enter into a plain vanilla swap, the present value is zero, meaning the SFR can be determined in the lattice model by iterating on the SFR until the present value at $t = 0$ of the cumulative swap valuation line equals zero. In this example, a SFR of 2.6650% results in the initial value of the swap equaling zero, illustrating why the swap value is negative to the fixed-rate payer in the example where the SFR is 3%. Interest rates must have declined since the inception of the SFR 3% plain vanilla swap.

It is important to note that the value of the plain vanilla swap obtained through the lattice model is identical to the value obtained through the traditional valuation method. This equivalence is due to the fact that the interest-rate model is derived through no-arbitrage conditions based on forward rates determined by market data. The key advantage to the lattice approach will be clear in later sections when we value interest-rate swaptions and need to account for volatility in the possible paths of future interest rates.

Now that we have introduced the binomial lattice, we proceed by introducing more complicated swap structures and swaptions.

FORWARD-START SWAPS

A forward start swap is a swap agreement commencing at some specified date in the future. An example is a two-year swap that begins three years from today. We refer to a forward start swap by the date at which the swap begins and the maturity date of the swap using the notation (y_{start}, y_{end}). Thus, the two-year swap beginning three years from today is denoted (3,5). In addition to the start date and maturity date, the forward start swap agreement also specifies the swap fixed-rate and the notional principal. The swap fixed-rate for a forward start swap is referred to as the forward swap fixed-rate.

To illustrate the valuation of a forward start swap, we will use the interest-rate lattice presented in Exhibit 63–1 to value the two-year swap that begins three years from today with a fixed-rate of 3.250% and notional principal of 100. The process begins by calculating the swap cash flows at each node on the interest-rate lattice and then constructing the cumulative valuation lattice through the process outlined in the previous section. Exhibit 63–4 presents the cumulative valuation

EXHIBIT 63–4

Cumulative Swap Valuation Lattice for (3,5) Forward-Start Swaps, SFR = 3.250%

									2.8184
								4.5487	
							5.5164		2.2548
						5.8014		3.5722	
					5.4998		4.2283		1.7602
				4.6750		4.2874		2.7123	
			3.3845		3.8305		3.0907		1.3267
		1.6427		2.9115		2.9476		1.9562	
	–0.4794		1.5803		2.3515		2.0883		0.9473
–2.7754		–0.1503		1.3480		1.7650		1.2927	
	–2.2170		–0.0192		1.0445		1.2066		0.6156
		–1.7392		–0.0343		0.7233		0.7111	
			–1.4335		–0.1079		0.4324		0.3258
				–1.2535		–0.1926		0.2020	
					–1.1218		–0.2464		0.0728
						–0.9964		–0.2431	
							–0.8407		–0.1478
								–0.6320	
									–0.3402
Time in Years	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**

lattice for this swap. Note that the swap begins three years from today and the possible values at time $t = 3$ years are highlighted in the lattice.

The cumulative value lattice produces seven possible values for the forward start swap at $t = 3$ years, and these values can be used to determine the value of the swap agreement. At this point, the missing link is the probability of each of the possible lattice values. The probability of reaching any node in the tree is determined by the number of paths through the lattice that arrive at that node. In the binomial lattice, where there are two possible movements for the rate in the next period, the following formula can be used to calculate the number of paths arriving at any given node:

$$\text{Number of Paths} = \frac{n!}{j!(n-j)!},$$

where n is the number of periods and j is the number of down-states. Exhibit 63–5 presents the number of paths arriving at each node. By referring to the paths at time 3 in the tree, we illustrate the computation using the above formula. Since time on the tree at $t = 3$ corresponds to the sixth semiannual time step, $n = 6$. At the very top node, there are no down nodes so $j = 0$. Evaluating the formula, we

EXHIBIT 63–5

The Number of Paths Arriving at Each Lattice Node

										1
									1	
								1		10
							1		9	
						1		8		45
					1		7		36	
				1		6		28		120
			1		5		21		84	
		1		4		15		56		210
	1		3		10		35		126	
0		2		6		20		70		252
	1		3		10		35		126	
		1		4		15		56		210
			1		5		21		84	
				1		6		28		120
					1		7		36	
						1		8		45
							1		9	
								1		10
									1	
Time in Years	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	1

find that the number of paths arriving at the top node is 6!/(0!(6!)) = 1 path, which makes sense since the one and only path arriving at the top node consists solely of up-movements. At the node that is second from the top at $t = 3$, the time periods are still 6 but at this node there is one down-step so $j = 1$. Evaluating the formula, there are 6!/(1!(5!)) = 6 possible paths arriving at this node.

To finish the demonstration, we compute the number of nodes at the third node from the top at $t = 3$. At this node, $n = 6$ and there are two down nodes so $j = 2$. Applying the formula, the number of paths arriving at the third node are 6!/(2!(4!)) = 15 paths.

Across the six nodes at $t = 3$, there are a total of 64 possible paths. The probability of arriving at each node is simply the number of paths to that node divided by the number of possible paths arriving at all nodes at this time. The value of the forward start swap is determined by weighting each of the cumulative swap valuation nodes corresponding to the forward start swap start date by the probability of arriving at that node. This calculation is illustrated in Exhibit 63–6, which presents the seven nodes at $t = 3$ and the corresponding cumulative swap valuation from the $t = 3$ node in Exhibit 63–5. The probability of arriving at each node is computed as the number of paths arriving at that node divided by the total number of paths arriving at any node at this time. The product of the cumulative swap valuation and the probability result in the probability weighted value. Summing the probability weighted values results in the forward start swap value. In this case, the value for 100 notional principal of the (3,5) forward start swap with a 3.250% forward start fixed-rate is 1.87089. Note that this is the value to the fixed-rate payer. Recall that we computed the cash flows at each node as the rate on the interest-rate lattice minus the swap fixed-rate. Thus, the positive value indicates

EXHIBIT 63–6

Calculation of the Probability Weighted Value for Year 3

Node	Cumulative Swap Valuation	Number of Paths Arriving at Node	Probability of Arriving at This Node	Probability Weighted Value
1	5.8014	1	1.56%	0.09065
2	4.2874	6	9.38%	0.40194
3	2.9476	15	23.44%	0.69085
4	1.7650	20	31.25%	0.55156
5	0.7233	15	23.44%	0.16952
6	–0.1926	6	9.38%	–0.01805
7	–0.9964	1	1.56%	–0.01557
TOTAL	14.3356	64	100.00%	1.87089

that the value of the floating-rate payments exceeds the value of the fixed-rate payments, implying a positive value to the fixed-rate payer. The value to this swap for the floating-rate swap payer is the negative of this amount, –1.87089. The SFR that would produce an FSS value of zero is 4.233% and is computed in the same manner as the iterative routine used to compute the SFR of a zero value plain vanilla swap.

Once we understand the process, we can value forward-start swaps with the same SFR that begin at each node on the lattice and end at five years. That is to say we may compute the values of the otherwise identical (0,5), (0.5,5), (1,5), (1.5,5), (2,5), (2.5,5), (3.5,5), (4,5), and (4.5,5) swaps. Exhibit 63–7 illustrates the computation of forward start swap values at each time period on the lattice.

VALUING SWAPTIONS

A swaption is an option contract on an interest-rate swap. The owner of a swaption has the right to initiate a swap agreement on or by a specified future date. The swaption specifies several important features of the swap, including the tenor of the swap and the swap fixed-rate. The swap fixed-rate is the strike rate for the option. Unlike a forward start swap, where both counterparties have the obligation to participate in the swap, the swaption owner has the right, but not the obligation, to enter into the swap. We will demonstrate the valuation procedure for swaptions using the interest-rate lattice and discuss how the important parameters affect the swaption valuation.

A payer's swaption (a pay fixed swaption) gives the owner the right to enter into an interest-rate swap as the fixed-rate payer and receive floating-rate payments. Swaptions may be either European or American style. The difference is that the owner of a European style swaption may exercise their right to enter into the swap at the expiration of the swaption, while the owner of an American style swaption may exercise that right any time up to the expiration date. For our purposes, we will consider European style swaptions.

A receiver's swaption (receive fixed swaption) givers the owner the right to enter into an interest-rate swap as the floating-rate payer and fixed-rate receiver. As an example, consider a swaption with a fixed-rate of 3.650%, option expiration date of two years, and the swap tenor is three years. The buyer of this swaption has the right at the end of two years to enter into a swap in which they make floating-rate payments and receive fixed-rate payments of 3.650%. We introduce the notation ($y_{expiration}$, y_{tenor}) for swaptions to refer to the expiration date of the swaption and the tenor of the swap. Thus, the receiver's swap is a (2,3) swaption.

To illustrate swaption pricing, we will price several payers' swaps with a strike rate of 3.650%. The lattice approach is helpful to value swaptions, and the valuation example uses the interest-rate lattice from Exhibit 63–1. After constructing the interest-rate lattice, the next step in the valuation process is to construct the pay fixed cash-flow lattice for a plain vanilla swap with a notional

EXHIBIT 63–7

Probability Weighted Cumulative Valuation Swap Values (SFR = 3.250%, 100 Notional Principal, Maturing in Five Years) and Value of Forward-Start Swaps

									0.0055
								0.0178	
							0.0431		0.0396
						0.0906		0.1116	
					0.1719		0.2312		0.1238
				0.2922		0.4019		0.2967	
			0.4231		0.5985		0.5071		0.2177
		0.4107		0.7279		0.6908		0.4279	
	–0.2397		0.5926		0.7348		0.5710		0.2331
–2.7754		–0.0751		0.5055		0.5516		0.3535	
	–1.1085		–0.0072		0.3264		0.3299		0.1515
		–0.4348		–0.0086		0.1695		0.1556	
			–0.1792		–0.0169		0.0709		0.0534
				–0.0783		–0.0181		0.0221	
					–0.0351		–0.0135		0.0051
						–0.0156		–0.0076	
							–0.0066		–0.0026
								–0.0025	
									–0.0007
Time in Years	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**
FWD Start Pay Fixed Swaps	–1.3482	–0.0993	0.8293	1.4386	1.7797	1.8709	1.7332	1.3750	0.8265
FWD Start Receive Fixed Swaps	1.3482	0.0993	–0.8293	–1.4386	–1.7797	–1.8709	–1.7332	–1.3750	–0.8265

principal of $100, based on a swap fixed-rate of 3.650%. Recall that at each node on the lattice, the cash-flow is determined by the swap fixed-rate, the notional principal, the corresponding node on the interest-rate lattice:

$$\text{Cash-Flow}_{i,j} = (F_{i,j-1} - SFR) \times NP_j \times 0.5$$

where $F_{i,j-1}$ is the floating-rate at node (i,j-1), indicating the arrears cash-flow at time j. Exhibit 63–8 presents the cash-flow lattice for the plain vanilla swap with a strike rate of 3.650%. To illustrate the computation of the cash flows, refer to the top-right node on the tree. Note that this cash-flow occurs at time $t = 5$, but is determined by the rate at $t = 4.5$. The corresponding rate from the interest-rate lattice is 9.1446%, so the cash-flow at this node is:

$$\text{Cash-Flow}_{1,5} = (9.1446\% - 3.650\%) \times 100 \times 0.5 = 2.7473$$

After constructing the cash-flow lattice in Exhibit 63–8, the next step in the swaption valuation process is to construct the cumulative swap valuation lattice for the plain vanilla pay-fixed swaption. Exhibit 63–9 presents the cumulative valuation lattice. The cumulative swap valuation lattice can then be used to value pay fixed swaptions.

To illustrate the swaption valuation, we price the (3,2) pay fixed swaption, as illustrated in Exhibit 63–10. The option expires in year 3 and the values corresponding to expiration are referred to as the expiration values. The expiration value at each node (here $t = 3$) come from the values in the cumulative valuation lattice (see Exhibit 63–9). Recall that the swaption gives the owner the right, but not the obligation to enter into the pay fixed swap. The owner will only exercise this right when the value of the two-year swap commencing at $t = 3$ is positive. Thus, the expiration values for the swaption are the maximum of zero or the value at the corresponding node on the cumulative valuation lattice. To illustrate, at the bottom node on the tree at $t = 3$, the cumulative valuation for the pay-fixed swap is –0.7711. Intuitively, this makes sense since the bottom nodes correspond to low interest rates that adversely affect the fixed-rate payer.

After determining the expiration values for the swaption, the remaining portion of the lattice is populated using backward induction. The corresponding rates from the interest-rate lattice determine the discount factors. To illustrate the process, the top value at year 2.5 in Exhibit 63–10 is computed as:

$$0.5\ (5.058457 + 3.537322)/(1 + 4.4031\%/2) = 4.205307$$

Repeating this process throughout the lattice in Exhibit 63–10 results in a value of $1.170195 for the (3,2) pay fixed swaption per $100 of notional principal. It is worth noting that the lattice valuation process requires as inputs the interest-rate lattice and the swaps valuation lattice. Once these have been determined, it is straightforward to price any variation of the swaption having the same fixed-rate. The lattice valuation framework is very flexible and handles easily any adjustments such as varying the notional principal (amortizing or accreting). This flexibility makes the lattice approach to valuation attractive.

EXHIBIT 63–8

Pay Fixed Cash Flow Lattice for Plain Vanilla Swap (Strike Rate = 3.65%)

										2.7473
									1.9854	
								1.4358		2.1443
							0.8863		1.4829	
						0.3766		1.0058		1.6208
					−0.1100		0.5287		1.0467	
				−0.5661		0.0862		0.6324		1.1664
			−1.0266		−0.3362		0.2183		0.6680	
		−1.4275		−0.7321		−0.1658		0.3084		0.7719
	−1.6325		−1.1319		−0.5325		−0.0511		0.3392	
		−1.4799		−0.8763		−0.3846		0.0270		0.4294
			−1.2233		−0.7030		−0.2851		0.0538	
				−1.0014		−0.5746		−0.2172		0.1321
					−0.8509		−0.4881		−0.1940	
						−0.7395		−0.4292		−0.1260
							−0.6644		−0.4091	
								−0.6133		−0.3500
									−0.5958	
										−0.5445
Time in Years	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**

EXHIBIT 63–9

Cumulative Swap Valuation Lattices, 5-Year, Semiannual, Plain Vanilla Swap and Strike Rate of 3.65%

Value Lattice

									2.6272
								4.1713	
							4.9558		2.0624
						5.0585		3.1920	
					4.5738		3.6628		1.5669
				3.5634		3.5373		2.3295	
			2.0837		2.8952		2.5209		1.1325
		0.1477		1.7888		2.1913		1.5713	
	–2.1743		0.2672		1.4080		1.5146		0.7524
–4.6732		–1.6585		0.2157		1.0031		0.9058	
	–3.9251		–1.3433		0.0939		0.6295		0.4200
		–3.2589		–1.1752		–0.0434		0.3225	
			–2.7672		–1.0647		–0.1476		0.1296
				–2.4020		–0.9635		–0.1880	
					–2.0842		–0.8289		–0.1239
						–1.7711		–0.6345	
							–1.4255		–0.3449
								–1.0245	
									–0.5377
Time in Years	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**

EXHIBIT 63–10

(3,2) Pay Fixed Swaption, Strike Rate 3.65%

						5.058457
					4.205307	
				3.448802		3.537322
			2.768908		2.81059	
		2.153258		2.158727		2.191292
	1.615948		1.571992		1.571144	
1.170195		1.091484		1.019616		1.003132
	0.728946		0.626107		0.494444	
		0.371439		0.244479		0
			0.121241		0	
				0		0
					0	
						0
Time in Years	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**

VALUING BASIS SWAPS AND NON-LIBOR-BASED SWAPS

To this point, we have focused on the valuation of swap structures involving the exchange of floating and fixed-rate payments in which the floating leg of the swap is based off LIBOR. Next, we generalize our discussion to include swaps in which both legs of the swap float and to swap structures based on interest rates other than LIBOR.

A basis swap is a swap agreement in which both legs of the swap are based on different rates. For example, the spread between the 90-day Treasury bill rate and the three-month LIBOR is referred to as the *TED spread*. In a LIBOR TED swap, one counterparty makes payments based on LIBOR and receives payments based on the 90-day Treasury bill rate plus a spread. This is referred to as a *pay LIBOR TED swap*.

We illustrate the lattice approach to valuation for a one-year pay LIBOR TED swap with a *Spread* of 0.376%. Since each leg of the swap references a floating-rate, the lattice approach requires a lattice for each rate. Exhibit 63–11 presents the one-year interest-rate lattices for LIBOR and the 90-day Treasury bill rate. Note that we assume a 10% volatility for LIBOR and 7.5% for the Treasury bill rate. In previous examples, we assumed semiannual periodicity for payments. In this example we assume quarterly.

After the two interest-rate lattices are in place, the next step in the valuation process is to compute the cash flows for the pay LIBOR TED swap. Each cash-flow at node i in period j is computed as follows. Note that in the example

EXHIBIT 63–11

One-Year Interest-Rate Lattices for LIBOR TED Swap

LIBOR Interest-Rate Lattice, 10% Volatility

			1.01%
		0.68%	
	0.44%		0.91%
0.35%		0.61%	
	0.40%		0.82%
		0.56%	
			0.75%
Time in Years	**0.25**	**0.5**	**0.75**

90-day T-Bill Interest-Rate Lattice, 7.5% Volatility

			0.29%
		0.22%	
	0.17%		0.26%
0.14%		0.20%	
	0.15%		0.24%
		0.18%	
			0.21%
Time in Years	**0.25**	**0.50**	**0.75**

we ignore the exact day count and assume each period is exactly one quarter of the year.

$$CF_{i,j} = (\text{T-Bill}_{i,j-1} + \text{Spread} - \text{LIBOR}_{i,j-1}) \times 0.25 \times NP_j$$

It is important to point out that the *Spread* is the adjustment to the Treasury bill rate such that the present values of the two payment streams are equal. To obtain the spread that equates the two cash-flow streams, we can iterate on the *Spread* value.

Following the two interest-rate lattices in Exhibit 63–11, the next step is the computation of the pay LIBOR TED swap cash flow at each node on the tree. To illustrate, consider the highest node on the tree at maturity of the swap. Referring to Exhibit 63–11, the LIBOR and Treasury bill rate at this node are 1.01% and 0.29%, respectively. Using the *Spread* of 0.376%, the payment on $100 notional principal is:

$$\begin{aligned} CF_{i,j} &= (\text{T-Bill}_{i,j-1} + \text{Spread} - \text{LIBOR}_{i,j-1}) \times 0.25 \times NP_j \\ &= (0.29\% + 0.376\% - 1.01\%) \times 0.25 \times NP_j \\ &= -0.085 \end{aligned}$$

EXHIBIT 63–12

Cash Flows for Pay LIBOR TED Swap, Spread of 0.376%

				–0.0854
			–0.0204	
		0.0258		–0.0683
	0.0415		–0.0095	
		0.0322		–0.0529
			0.0004	
				–0.0389
Time in Years	**0.25**	**0.5**	**0.75**	**1**

The cash flows for the swap at all times are presented in Exhibit 63–12. After constructing the cash flows, the final step for valuing the pay LIBOR TED swap is to compute the cumulative value lattice. This procedure is exactly the same as demonstrated in previous sections. The values are presented in Exhibit 63–13. Note that the present value of the expected payments is zero, indicating that the spread of 0.376% produces zero value for the swap. This means the present value of the LIBOR and the Treasury bill plus *spread* legs are identical. For Spreads greater (smaller) than 0.376%, in this example the pay LIBOR TED swap would have positive (negative) present value. To note the flexibility of the lattice approach to valuation, note that it is straightforward to extend the valuation for a swaption on a basis swap following the procedure outlined in the previous section.

EXHIBIT 63–13

Cumulative Value Lattice for Pay LIBOR TED Swap, Spread of 0.376%

				–0.0852
			–0.0969	
		–0.0576		–0.0682
	0.0000		–0.0699	
		–0.0254		–0.0528
			–0.0454	
				–0.0388
Time in Years	**0**	**0.25**	**0.5**	**0.75**

FACTORS AFFECTING SWAP VALUATION

The flexibility of the lattice approach to valuation facilitates the analysis of a swaption's sensitivity to changes in the swaption terms and changes in market inputs such as volatility. In this section, we illustrate the sensitivity of swaption valuations to interest-rate volatility and the strike rate.

There are two main determinants of the values in the interest-rate lattice: the current term structure and interest-rate volatility. Recall that the interest-rate lattice is the basic building block in the lattice approach to valuing swaptions. Changing the expiration date of a swap changes the value of the swaption, but the directional change in value depends on the current term structure, volatility, and strike price. Interest-rate volatility, however, increases the value of swaptions, holding all else constant.

The chart in Exhibit 63–14 illustrates the effect of interest-rate volatility and the expiration of the swap on the valuation of four different pay fixed swaptions. To construct the example, we use the LIBOR interest-rate lattice from Exhibit 63–1 and consider pay-fixed swaptions each having a strike rate equal to 3.5%. In the figure, there is not a monotonic relation between the swaption expiration and value. Each swaption's value, however, does increase as volatility increases.

We next consider the joint effect of the strike rate and interest-rate volatility on interest-rate swaptions. Exhibit 63–14 illustrates that swaption values increase as interest-rate volatility increases, holding all else constant. The strike rate has an important impact on the value of the swaption. For a pay

EXHIBIT 63–14

Pay Fixed Swaption Values and Volatility, Strike Rate = 3.5%

fixed swaption, in which the option owner has the right to enter into a swap agreement where they pay the fixed-rate and receive floating payments, as the strike rate increases, the value of the pay fixed swaption declines since the value of the fixed-rate payments rises relative to the floating-rate payments that party will receive. Conversely, in a receive fixed swaption, in which the option owner has the right to enter into a swap agreement where they receive fixed-rate payments and make floating-rate payments, the value of that right increases as the strike rate increases.

Exhibit 63–15 illustrates the joint effect of the strike rate and interest-rate volatility on the value of a (2,3) pay fixed swaption. The surface plot of the swaption value is increasing in the volatility (at higher levels of volatility, the swaption's value is greater), and decreasing in the strike rate (at lower strike rates, the pay-fixed swaption's value is greater). Exhibit 63–16 illustrates the receive fixed swaption value across strike rates and levels of volatility. It is important to note that, across the strike rate dimension, the graph in Exhibit 63–16 is the mirror image of Exhibit 63–15, demonstrating that strike rate has the opposite impact on the values of receive fixed swaptions as it has on pay fixed options. The value of the receiver's swaption, is positively related to the level of volatility, in which the receiver's swaption increases in value as the assumed lever of interest-rate volatility increases.

EXHIBIT 63–15

The Effect of Strike Rate and Interest-Rate Volatility on the (2,3) Pay Fixed Value

EXHIBIT 63–16

The Effect of Strike Rate and Interest-Rate Volatility on the (2,3) Receive Fixed Swaption Value

KEY POINTS

- Interest-rate swap agreements involve two parties agreeing to exchange payments in the future at agreed-upon terms.
- Exotic swap agreements are customized contracts. Common variations include forward-start swaps, amortizing notional principal swaps, accreting notional principal swaps, basis swaps, and non-LIBOR swaps.
- Swaptions are option contracts in which the owner has the right, but not the obligation, to enter into a swap agreement in the future.
- The lattice approach to swap and swaption valuation is a powerful, flexible valuation framework easily adapted to handle variations of exotic swaps.
- Swaption values are determined by market inputs such as the term structure of interest rates and interest-rate volatility in addition to contract specifications such as tenor and strike rate. Holding all else constant, volatility increases swaption values. Holding all else constant, increasing the strike rate decreases the value of a pay-fixed swaption but increases the value of a receive-fixed contract.

CHAPTER
SIXTY-FOUR

THE BASICS OF INTEREST-RATE OPTIONS

WILLIAM J. GARTLAND, CFA
Managing Director
Benchmark Solutions

NICHOLAS C. LETICA
Managing Director
Citigroup Global Markets, Inc.

As the sophistication and diversity of investors have grown, the need for derivative instruments such as options has increased accordingly. Knowledge of option strategies, once the province of a few speculators, is now necessary for everyone who wishes to maintain a competitive edge in an increasingly technical market. Moreover, options technology has been applied with increasing success to securities with optionlike characteristics such as callable bonds and mortgage-backed securities.

In Chapter 59, option contracts were described: exchange-traded options on physical securities, exchange-traded options on futures, and over-the-counter (OTC) options. In this chapter we will review how options work, their risk/return profiles, the basic principles of option pricing, and some common trading and portfolio. A more detailed discussion of hedging strategies is provided in Chapter 61.

Throughout most of the discussion, our focus will be on options on physicals. The principles, however, are equally applicable to options on futures or futures options.

HOW OPTIONS WORK

An *option* is the right but not the obligation to buy or to sell a security at a fixed price. The right to buy is called a *call,* and the right to sell is called a *put;* a call makes money if prices rise and a put makes money if prices fall.

If the owner of an option uses the option to buy or to sell the underlying security, we say that the option has been *exercised.* Because the holder is never required to exercise an option, the holder can never lose more than the purchase price of the option—an option is a limited-liability instrument.

An option on a given security can be specified by giving its strike price and its expiration date. The *strike price* is the price on the optional purchase. For example,

a call with a strike price of par is the right to buy that security at par. The *expiration date* is the last date on which the option can be exercised: after that, it is worthless, even if it had value on the expiration date. If an option is allowed to expire, it is said to be *terminated.* On or before the expiration date, the option holder may decide to sell the option for its market value. This is called a *pair-off.*

Some options can be exercised at any time until expiration: they are called *American* options. On the other hand, some options can only be exercised at expiration and are called *European* options. Because it is always possible to delay the exercise of an American option until expiration, an American option is always worth at least as much as its European counterpart. In practice, there are only a limited number of circumstances under which early exercise is advantageous, so the American option rarely costs significantly more than the European.

The easiest way to analyze a position in a security and options on that security is with a *profit/loss graph.* A profit/loss graph shows the change in a position's value between the *analysis date* ("now") and a *horizon date* for a range of security prices at the horizon.

Suppose that a call option struck at par is bought today for 1 point. At expiration, if the security is priced below par, the option will be allowed to expire worthless; the position has lost 1 point. If the security is above par at expiration, the option will be exercised; the position has made 1 point for every point the security is above par, less the initial one-point cost of the option. Exhibit 64–1 shows the resulting profit/loss graph.

EXHIBIT 64–1

Long Call versus Underlying Security Price
Call Struck at Par, at Expiration, with 1-Point Premium

EXHIBIT 64–2

Long Put versus Underlying Security Price
Put Struck at Par, at Expiration, with 1-Point Premium

Note that if the price of the underlying increases by 1 point, the option purchase breaks even. This happens because the value of the option at expiration is equal to the initial purchase price. A price of 101 is the break-even price for the call: the call purchase will make money if the price of the underlying exceeds 101 at expiration.

A put is the reverse of a call. Look at Exhibit 64–2, which is the profit/loss graph of a put option struck at par bought for 1 point. At expiration, the put is worth nothing if the security's price is more than the strike price and is worth one point for every point that the security is priced below the strike price. The break-even price for this trade is 99, so the put purchase makes money if the underlying is priced below 99 at expiration.

Put-Call Parity

A put and a call struck at-the-money split up the profit/loss diagram of the underlying security into two parts. Consider the position created by buying a call and selling a put such that the strike price of the two options is equal to the price of the underlying. If the price of the security goes up, the call will be exercised; if the price of the security goes down, the put will be exercised. In either case, at expiration the underlying is delivered at the strike price. Thus, in terms of profit and loss, owning the call and selling the put are the same as owning the underlying.

Exhibit 64–3 divides the profit/loss graph of the underlying security into graphs for a long call and a short put, respectively. The following three facts

EXHIBIT 64–3

Long Security = Long Call + Short Put

can be deduced:

Long security = long call + short put (Exhibit 64–3)

Long call = long security + long put (Exhibit 64–4)

Long put = short security + long call (Exhibit 64–5)

This relationship is called *put-call parity;* it is one of the foundations of the options markets. Using these facts, a call can be created from a put by buying the underlying, or a put made from a call by selling the underlying. This ability to convert between puts and calls at will is essential to the management of an options position.

Valuing an Option

The first fact to determine about an option is its worth. There are many option valuation models for each class of options, each of which uses different parameters and returns slightly different values. However, the five main determinants of option value are the price of the underlying, the strike price of the option, the expiration of the option, the volatility of the underlying, and the cost of financing the underlying.

The most apparent component of option value is intrinsic value. The *intrinsic value* of an option is its value if it were exercised immediately. An option with

EXHIBIT 64–4

Long Call = Long Security + Long Put

intrinsic value is an *in-the-money* option. When the underlying security trades right at the strike price, the option is called *at-the-money.* Otherwise, an option with no intrinsic value is called *out-of-the-money.*

An option may have value over and above its intrinsic value, called *time value.* The intrinsic value is the value of the option if exercised immediately, whereas the time value is the remaining value in the option due to time expiration. Clearly, the more time there is to expiration, the greater is the time value.

Exhibit 64–6 graphs the value of an option as time to expiration increases. Exhibit 64–7 compares the value of an option at expiration with the values of options with one and three months to expiration. There is a sharp corner in the graph at the strike price that becomes more pronounced as the time to expiration decreases. This sharp corner makes an at-the-money option increasingly difficult to hedge as expiration approaches.

If the option is out-of-the-money, it has some time value because there is a chance that the option will expire in-the-money; as it gets further out-of-the-money, this is less likely and the time value decreases.

If the option is in-the-money, its time value is due to the fact that it is better to hold the option than the corresponding position in the underlying security because if the security trades out-of-the-money the potential loss on the option is

EXHIBIT 64–5

Long Put = Short Security + Long Call

EXHIBIT 64–6

Call Option Value versus Time until Expiration
Three Calls: At-the-Money, 1 Point In-the-Money, 1 Point Out-of-the-Money

EXHIBIT 64–7

Call Option Value versus Underlying Security Price
Call Struck at Par with One and Three Months to Expiration

limited to the value of the option; as the option gets further in-the-money, this possibility becomes more farfetched and the time value decreases.

Either way, the time value depends on the probability that the security will trade through the strike price. In turn, this probability depends on how far from the strike price the security is trading and how much the security price is expected to vary until expiration.

Volatility measures the variability of the price or the yield of a security. It measures only the magnitude of the moves, not the direction. Standard option pricing models make no assumptions about the future direction of prices but only about the distribution of these prices. Volatility is the ideal parameter for option pricing because it measures how wide this distribution will be. We discuss volatility in more detail at the end of this chapter.

The higher the volatility of a security, the higher is the price of options on that security. If a security had no volatility, for example, that security would always have the same price at time of purchase of an option as at its expiration, so all options would be priced at their intrinsic value. Increasing the volatility of a security increases the time value of options on that security as the chance of the security price moving through the strike price increases. Increases in the value of an at-the-money option are approximately proportional to increases in the volatility of the underlying. Exhibit 64–8 shows how the price of an option behaves as the volatility of the underlying security increases.

EXHIBIT 64–8

Call Option Value versus Percent Price Volatility
Three Calls: At-the-Money, 1 Point In-the-Money, 1 Point Out-of-the-Money; Three Months from Expiration

The final factor that influences options prices is the *carry* on the underlying security. Carry is the difference between the value of the coupon payments on a security and the cost of financing that security's purchase price. With the usual upward-sloping yield-curve, most securities have a positive carry.

The effect of the carry can be seen by comparing the price of an at-the-money call with an at-the-money put where the underlying security has a positive carry. The writer of the call anticipates the chance of being required to deliver the securities and thus buys the underlying as a hedge; the put writer hedges by selling the underlying. The call writer earns the carry while the put writer loses the carry, so the call should cost less than the put. When the yield-curve inverts and short-term rates are higher than long-term rates, carry becomes negative and calls cost more than puts.

By put-call parity, selling an at-the-money call and buying an at-the-money put are equivalent to shorting the underlying security. The cash taken out of the option trade, accounting for transaction costs, compensates the option holder for the carry on the position in the underlying until expiration. This trade is called a *conversion,* and it is used frequently to obtain the effect of a purchase or sale of securities when buying or selling the underlying is impossible for accounting reasons.

Exhibit 64–9 compares the cost of an at-the-money call and put for a range of financing rates. The two graphs intersect where the call and the put have the same value: this happens when the cost of financing the underlying is equal to the coupon

EXHIBIT 64–9

Treasury Option Value versus Financing Rate
Long Call, Long Put Struck at Par, Three Months to Expiration

yield on the security, so the carry is zero and there is no advantage to holding the underlying over shorting it.

Exhibit 64–10 summarizes the parameters that affect the value of an option and how much raising each parameter affects that value.

Delta, Gamma, and Theta: Hedging an Option Position

More precise quantitative ways to describe the behavior of an option are needed to manage an option position. Options traders have created the concepts of delta,

EXHIBIT 64–10

The Effect of an Increase of a Factor on Option Values

	Call	Put
Underlying price	Increase	Decrease
Strike price	Decrease	Increase
Carry	Decrease	Increase
Time to expiration	Increase	Increase
Volatility	Increase	Increase

gamma, and theta for this purpose. Delta measures the price sensitivity of an option, gamma the convexity of the option, and theta the change in the value of the option over time.

For a given option, the *delta* is the ratio of changes in the value of the option to changes in the value of the underlying for small changes in the underlying. A typical at-the-money call option would have a delta of 0.5; that means for a 1-cent increase in the price of the underlying the value of the call would increase by 0.5 cents. On the other hand, an at-the-money put would have a delta of –0.5; puts have negative deltas because they decrease in value as the price of the underlying increases (see Exhibit 64–10).

The standard method of hedging an options position is called *delta hedging,* which unsurprisingly makes heavy use of the delta. The idea behind delta hedging is that for small price moves, the price of an option changes in proportion with the change in price of the underlying, so the underlying can be used to hedge the option. For example, 1,000,000 calls with a delta of 0.25 would for small price movements track a position of 250,000 of the underlying bonds, so a position consisting of 1,000,000 of these long calls and 250,000 of the security sold short would be delta-hedged. The total delta of a position shows how much that position is long or short. In the preceding example, the total delta is

$$0.25 \times 1{,}000{,}000 - 1 \times 250{,}000 = 0$$

so the position is neither long nor short.

Intuitively, the delta of an option is the number of bonds that are expected to be delivered into this option. For example, an at-the-money call has a delta of 0.5, which means that one bond is expected to be delivered for every two calls that are held. In other words, an at-the-money call is equally as likely to be exercised as not. An option that is deeply out-of-the-money will have a delta that is close to 0 because there is almost no chance that the option will ever be exercised. An option that is deeply in-the-money almost certainly will be exercised. This means that a deeply in-the-money put has a delta of –1 because it is almost certain that the holder of the option will exercise the put and deliver one bond to the put writer.

Put-call parity tells us that a position in the underlying security may be duplicated by buying a call and selling a put with the same strike price and expiration date. Thus the delta of the call less the delta of the put should be the delta of the underlying. The delta for the underlying is 1, so we get the following equation:

$$\text{Delta}(\textit{call}) - \text{delta}(\textit{put}) = 1$$

where call and put are options on the same security with the same strike price and expiration date. This says that once the call is bought and the put sold, the bond is certain to be delivered; if the call is out-of-the-money, the put is in-the-money. Moreover, as the chance of having the underlying delivered into the call becomes smaller, the chance of having to accept delivery as the put is exercised becomes larger. Exhibit 64–11 compares the deltas for a long and a short put.

Making the position delta-neutral does not solve all hedging problems, however. This is demonstrated in Exhibit 64–12. Each of the three positions

EXHIBIT 64–11

Option Delta versus Underlying Security Price
Long Call, Short Put Struck at Par, Three Months to Expiration

shown is delta-neutral, but position 1 is clearly preferable to position 2, which is, in turn, better than position 3. The difference between these three positions is *convexity*. A position such as position 1 with a profit/loss graph that curves upward has a positive convexity, whereas position 3 has a graph that curves downward and thus has negative convexity.

Gamma measures convexity for options; it is the change in the delta for small changes in the price of the underlying. If a position has a positive gamma, then as the market goes up the delta of the position increases and as it declines the delta increases. Such a position becomes longer as the market trades up and shorter as the market trades down. A position like this is called *long convexity* or *long volatility.* These names come from the fact that if the market moves in either direction this position will outperform a position with the same delta and a lower gamma. Exhibit 64–13 shows this phenomenon.

A long option always has a positive gamma. The delta of a call increases from 0 to 1 as the security trades up, and the delta of a put increases also, moving from −1 to 0. Exhibits 64–1 and 64–2 show that the profit/loss graph of options curves upward. Because of this, options traders often speak of buying or selling volatility as a synonym for buying or selling options.

A position with a zero gamma is called *flat convexity* or *flat gamma.* Here, a change in the underlying security price does not change the delta of the position. Such a position trades like a position in the underlying with no options bought or sold. If the position has in addition a delta of zero, then its value is not affected by

EXHIBIT 64–12

Delta-Neutral Positions with Different Gamma

EXHIBIT 64–13

Profit/Loss Diagram with Convexity
Long Security with Flat and Long Convexity

small changes in the price of the underlying security in either direction. Position 2 in Exhibit 64–12 is a profit/loss graph for a position with no delta or gamma.

A position with negative gamma is called *short volatility* or *short convexity.* The profit/loss curve slopes downward in either direction from the current price on the underlying; thus the position gets longer as the market trades down and shorter as the market trades up. Either way, this position loses money if there are significant price movements. Position 3 demonstrates this behavior.

A position that is long volatility is clearly preferable to an otherwise identical position that is short volatility. The holder of the short-volatility position must be compensated for this. In order to create a position that is long volatility it is necessary to purchase options and spend money; moreover, if the market does not move, the values of the options will decrease as their time to expiration decreases, so the position loses money in a flat market.

Conversely, creating a position that is short volatility involves selling options and taking in cash. As time passes, the value of these options sold decreases because their time value falls, so the position makes money in a flat market. Large losses could be sustained in a volatile market, however.

To describe the time behavior of options, there is one last measure called *theta.* The theta of an option is the overnight change in value of the option if all other parameters (prices, volatilities) stay constant. This means that a long option has a negative theta because as expiration approaches, the time value of the option will erode to zero. For example, a 90-day at-the-money call that costs 2 points might have a theta of –0.45 ticks per day.

Exhibit 64–14 shows the effects of different volatility exposures.

EXHIBIT 64–14

Comparison of Different Volatility Positions (All Positions Are Delta-Neutral)

	Short Volatility	Flat Volatility	Long Volatility
Convexity	Position has negative convexity: gamma < 0	Position has no convexity: gamma = 0	Position has positive convexity: gamma > 0
Options purchased	More sold than bought	Sold as many as bought	More bought than sold
Time value	Position earns value as time passes: theta > 0	Position stays flat as time passes: theta = 0	Position loses value as time passes: theta < 0
Market moves	Position loses money if the market moves in either direction	Position is invariant with respect to market moves	Position makes money if the market moves in either direction

OPTIONS STRATEGIES—REORGANIZING THE PROFIT/LOSS GRAPH

Investors have many different goals: reducing risk, increasing rates of return, or capturing gains under expected market moves. Often these objectives are simply to rearrange the profit/loss graph of a position in accordance with the investor's expectations or desires. By increasing the minimum value of this graph, for example, the investor reduces risk.

Options provide a precise tool to accomplish this rearrangement. Because it is impossible to replicate the performance of an option position using just the underlying, options allow a much broader range of strategies to be used. The following characteristics of options provide an explanation.

Directionality

Both a put and a call are directional instruments. A put, for example, performs only in a decreasing market. This property makes options ideal for reducing directional risk on a position. Take, for example, a position that suffers large losses in a downward market and makes a consistent profit if prices rise. By purchasing a put option, some of these profits are given up in exchange for dramatically increased performance if the market declines.

Convexity

Buying and selling options makes it possible to adjust the convexity of a position in almost any fashion. Because OTC options can be purchased for any strike price and expiration, convexity can be bought or sold at any place in the profit/loss graph. For example, an investor holding mortgage-backed securities priced just over par might anticipate that prepayments on this security would start to increase dramatically if the market traded up, attenuating possible price gains. In other words, the investor feels that the position is short convexity above the market. To adjust the profit/loss graph, calls could be purchased with strike prices at or above the market. This trade sells some of the spread over Treasuries in exchange for increased performance in a rising market.

Fee Income

An investor who wishes to increase the performance of a position in a stable market can sell convexity by writing options and taking in fees. This increases the current yield of the position, at the cost of increasing volatility risk in some area of the profit/loss graph. A typical example of this is the venerable covered call strategy, where the manager of a portfolio sells calls on a portion of the portfolio, forgoing some profits in a rising market in exchange for a greater return in a stable or decreasing market.

Leveraged Speculation

Investors with a higher risk/reward profile wish to increase their upside potential and are willing to accept a greater downside risk. In this case, options can be used as a highly leveraged position to capture windfall profits under a very specific market move. A strongly bullish investor might purchase 1-point out-of-the-money calls with 30 days to expiration for 1/2 point. If the market traded up 2 points by expiration, the option then would be worth 1 point, and the investor would have doubled the initial investment; a corresponding position in the underlying would have appreciated in value by only about 2%. Of course, if the market did not trade up by at least 1 point, the calls would expire worthless.

CLASSIC OPTION STRATEGIES

This section gives a brief explanation of some of the simplest pure options strategies.

Straddle

The most pure convexity trade is called a *straddle,* composed of one call and one put with the same strike price. Exhibit 64–15 shows the profit/loss graph of a straddle struck at-the-money at expiration and with three months to expiration.

EXHIBIT 64–15

Profit/Loss Diagram for a Long Straddle
Struck at Par, at Expiration, and Three Months Out

This position is delta-neutral because it implies no market bias. If the market stays flat, the position loses money as the options' time value disappears by expiration. If the market moves in either direction, however, either the put or the call will end up in-the-money, and the position will make money. This strategy is most useful for buying convexity at a specific strike price. Investors who are bearish on volatility and anticipate a flat market could sell straddles and make money from time value.

Strangle

A *strangle* is the more heavily leveraged cousin of a straddle. An at-the-money strangle is composed of an out-of-the-money call and an out-of-the-money put. The options are struck so that they are both equally out-of-the-money, and the current price of the security is halfway between the two strikes. The profit/loss graph is found in Exhibit 64–16.

Just like a straddle, a strangle is a pure volatility trade. If the market stays flat, the position loses time value, whereas if the market moves dramatically in either direction the position makes money from either the call or the put. Because the options in this position are both out-of-the-money, the market has to move significantly before either option moves into the money. The options are much cheaper, however, so it is possible to buy many more options for the same money.

EXHIBIT 64–16

Profit/Loss Diagram for a Long Strangle
Struck at Par, at Expiration, and Three Months Out

This is the ideal position for the investor who is heavily bullish on volatility and wants windfall profits in a rapidly moving market.

Writing strangles is a very risky business. Most of the time the market will not move enough to put either option much into the money, and the writer of the strangle will make the fee income. Occasionally, however, the market will plummet or spike, and the writer of the strangle will suffer catastrophic losses. This accounts for the picturesque name of this trade.

Spread Trades

Spread trades involve buying one option and funding all or part of this purchase by selling another. A *bull spread* can be created by owning the underlying security, buying a put struck below the current price, and selling a call above the current price. Because both options are out-of-the-money, it is possible to arrange the strikes so that the cost of the put is equal to the fee for the call. If the security price falls below the put strike or rises above the call strike, the appropriate option will be exercised and the security will be sold. Otherwise, any profit or loss will just be that of the underlying security. In other words, this position is analogous to owning the underlying security except that the final value of the position at expiration is forced to be between the two strikes. Exhibit 64–17 shows the profit/loss graph of this position at expiration and with three months left of time value.

EXHIBIT 64–17

Profit/Loss Diagram for a Bull Spread
Struck at Par, at Expiration, and Three Months Out

EXHIBIT 64–18

Profit/Loss Diagram for a Bear Spread Struck at Par, at Expiration, and Three Months Out

The other spread trade is a *bear spread:* It is the reverse of a bull spread. It can be created by selling a bull spread. Using put-call parity, it also can be set up by holding the underlying security, buying an in-the-money put, and selling an in-the-money call. A bear spread is equivalent to a short position in the underlying, where the position must be closed out at a price between the two strike prices. Exhibit 64–18 shows the profit/loss graph of a bear spread.

PRACTICAL PORTFOLIO STRATEGIES

The strategies discussed in the preceding section are the basic techniques used by speculators to trade options. The usual fixed income investor has a lower risk/reward profile than the speculator and specific objectives that must be accomplished; a floor on rate of return or an increase in current yield, for example. Such investors need a class of strategies different from that needed by speculators; even though the same strategies are often used, the risk is carefully controlled.

Portfolio Insurance

This is the most obvious and one of the most commonly used options strategies. An investor with a portfolio of securities who fears a decreasing market buys puts on

some or all of the portfolio; if the market falls, the puts are exercised, and the securities are sold at the strike price. Alternatively, the investor may keep the underlying security and pair off the in-the-money puts, receiving cash in compensation for the decreased value of the security. Either way, the investor has limited losses on the portfolio in exchange for selling off return in a stable or rising market.

As the strike price of the put increases, so does its cost and the resulting impact on the stable market rate of return. Often, out-of-the-money options are used; the floor on returns is lower because the strike price is lower, but the lower cost of the options means that less return is given up if the market is flat or rises. By put-call parity, such a position is equivalent to holding a call option struck at or in-the-money.

Another popular strategy is to buy at-the-money options on a portion of the portfolio. This reduces but does not eliminate downside risk: Exhibit 64–19 shows the profit/loss graphs at expiration for positions with different percentages of the portfolio hedged with an at-the-money put. Note that all the graphs intersect at a single point. This is the point where the initial cost of the option is equal to the value of the option at expiration, which is the break-even price for this trade.

It is not possible to buy options on many classes of securities that may well be held in a portfolio. Perfect insurance for such securities is unattainable, but cross-market hedging often will permit a reduction in downside risk to acceptable levels.

EXHIBIT 64–19

Hedged Underlying Security with Puts
Long Puts Struck at Par, at Expiration

Covered Calls

Writing covered calls is a strategy that sells volatility in return for fees. An investor who holds a portfolio sells calls on some or all of the portfolio in return for fees. If the market stays the same or falls, the investor pockets the option fees. If the market increases until the calls are in-the-money, the investor is called out by the option holder. In other words, possible gains on the portfolio are sold for fee income.

Often the investor wishes to preserve some upside potential. Just as in the portfolio insurance example, there are two different ways to do this. The calls can be struck out-of-the-money, that is, above the current market price. This strategy allows all gains up to the strike price to be captured. If the bonds in the portfolio are currently trading below the original purchase price, a popular strategy is to sell calls struck at this purchase price. This provides fee income and increased current yield but prevents the possibility that the bonds will be called at a price below the original purchase price and the portfolio will book a capital loss.

Otherwise, calls can be sold on a portion of the portfolio. This allows unlimited price gains to be captured on the remainder. Exhibit 64–20 shows the profit/loss graph of a covered call program where different portions of the portfolio have calls sold against them.

EXHIBIT 64–20

Covered Call Writing Program
Short Calls Struck at Par, at Expiration

Buy-Writes and Writing Puts

Buy-writes and writing puts are two very closely related strategies for selling volatility that most investors think of as entirely different. To execute a buy-write, a bond is purchased, and simultaneously, a call is written on this bond to the same dealer for the fee income. If the security is trading above the strike price at expiration, the security is called, and the investor is left with just the option fee. If the price of the security has fallen, the investor is left holding the security, but the total cost of the security is reduced by the fee from the call. By put-call parity, this trade is identical to writing a put struck at-the-money. In both cases, the investor is delivered the security only if the price of the security is lower than the price of the original sale.

In the MBS market, a buy-write is composed of forward purchases and short calls on forward delivery contracts (standard TBA transactions). If the call is exercised, it offsets the forward sale, and the buyer never takes delivery of the security, keeping the fee income. Otherwise, the buyer will receive the security on the forward settlement date for the original forward sale price, although the total price is decreased by the value of the option fee.

Put writing is a more general strategy that applies to all fixed income options markets. The investor writes a put for the fee income and receives the underlying instrument at expiration if the security trades below the strike price. This can be a very effective strategy if carefully structured. An investor may feel that a security offers real value if bought at a certain price below the market. The investor could then write puts struck at that price. If the security falls below the strike, it is delivered at a price that is more agreeable than the current price. Otherwise, the investor simply pockets the fee income.

VOLATILITY

Volatility plays a key role in the valuation of options and in option strategies. In this section we focus on methods for estimating volatility.

Statistically, volatility is a measure of the dispersion or spread of observations around the mean of the set of observations. If volatility seems strangely like a standard deviation, then you remember your statistics. When people speak of volatility, all they really are talking about is a standard deviation.

For fixed income securities, volatility is expressed in yield or price units, either on a percentage or on an absolute basis. Price volatilities can be computed for any security. Yield volatilities should be computed only for those securities with a consistent method for computing yield. Given the complexity of calculating a yield on a MBS and the variation of results, the predominant volatility measure in the MBS market is price volatility. The government bond market, where yields are easily calculated, favors yield volatility.

There are two types of volatility: empirical volatility and implied volatility. Each is described below.

Empirical Volatility

Empirical volatility is the actual, historical market volatility of a specific security. These numbers typically are calculated for various time periods (10 days, 30 days, 360 days) and usually are annualized.[1] Calculating an empirical volatility is nothing more than calculating the standard deviation of a time series. Thus an absolute volatility is the annualized standard deviation of daily price or yield changes, assuming a normal distribution.

Percentage volatility is the annualized standard deviation of the daily change in the log of prices or yields, assuming a lognormal distribution of prices or yields. Similar to the daily absolute yield changes, the logs of the daily yield changes have a slight bias toward lower yields. The intuitive approach to calculating a percentage volatility is to find the standard deviation of daily *returns,* assuming a normal distribution. This approach is equivalent to the lognormal assumption as long as the distribution can be characterized as being equally normal and log normal and, the changes in prices are taken on a small interval, such as daily.

As mentioned previously, empirical volatility can be measured over various time periods. The most common interval on which the standard deviation is taken is 30 days; other common intervals are 10 days and 360 days. The choice of interval determines how quickly and to what degree an empirical volatility responds to deviations. As the time period shortens, volatility increasingly reflects current conditions but is more unstable as each sample asserts greater influence in the deviation. Conversely, as the interval increases, more of a lag and a smoothing are introduced into the calculation.

The interval used to calculate an empirical volatility should be chosen to match the length of the option contract. This provides the investor with an indication of how volatile the underlying security has been recently and how this relates to the volatility employed to price the option.

With no industry standard for volatility units, converting between the price and yield expression of absolute or percentage volatility is a useful skill. The path to follow to convert from one unit to the next is shown in Exhibit 64–21. The modified duration of a security provides the link between price and yield volatilities. Modified duration is defined as the percentage change in price divided by the absolute change in yield.

Implied Volatility

Implied volatility is merely the market's expectation of future volatility over a specified time period. An option's price is a function of the volatility employed, so where an option's price is known, the implied volatility can be derived. Although it sounds straightforward, calculating an implied volatility is far more

1. When annualizing a volatility, certain assumptions are inherent to the calculation. To convert from daily to yearly volatility, for example, the daily volatility is multiplied by the square root of the number of business days in the year, approximately 250.

EXHIBIT 64–21

Converting Volatility Measures

complicated than calculating an empirical volatility because expectations cannot be observed directly. An option pricing model along with a mathematical method to infer the volatility must be employed. The result of this calculation is a percentage price volatility that can be converted to the various types of volatility measures discussed previously (see Exhibit 64–21).

Owing to the existence and liquidity of fixed income options, proxies for implied volatilities can be derived from Treasuries. Options on Treasury futures listed on the Chicago Board of Trade (CBOT) are often the best vehicles for implied volatility calculations. The resulting implied volatility provides a good indication of the market's expected volatility for the Treasuries with maturities similar to that of the particular bond futures contract in question. The implied volatility on the 10-year bond futures contract, for example, is a useful proxy for the market's expected volatility on intermediate-term Treasury securities.

KEY POINTS

- An option is the right but not the obligation to buy (a call option) or to sell (a put option) a security at a fixed price (strike price or exercise). The expiration date is the last date on which the option can be exercised. Some options can be exercised at any time until expiration (American options); some options can only be exercised at expiration (European options).

- The relationship among the price of a security, the price of a put, and the price of a call is called the put-call parity and is one of the foundations of the options markets.
- The price of an option is the sum of its intrinsic value and time value.
- Volatility measures the variability of the price or the yield of a security. It measures only the magnitude of the moves, not the direction. Standard option pricing models make no assumptions about the future direction of prices but only about the distribution of these prices. Volatility is the parameter used for option pricing because it measures how wide this distribution will be. The higher the volatility of a security, the higher is the price of options on that security.
- To manage an option position, quantitative ways to describe the behavior of an option are needed. These include an options delta, gamma, and theta.
- Any investor with specific goals can use option strategies to tailor the performance of a portfolio.
- Because it is impossible to obtain the effects of options by using only the underlying securities, a whole new universe of strategic possibilities is opened up. In particular, investors with contingent liabilities cannot create an adequate hedge without the use of options.
- Increased liquidity in the options markets and a better understanding of the properties of options make option strategies more accessible to the average investor and allow these strategies to be used for a wider range of securities. In particular, the over-the-counter options markets allow the purchase and sale of options with any desired strike price and expiration date.
- Refinements to option valuation technology continue to improve cross-market arbitrage trades where securities and options in one market can duplicate securities in another. As options trading removes the arbitrages, the relationships among the various markets are reinforced.

CHAPTER
SIXTY-FIVE

INTEREST-RATE CAPS AND FLOORS

GEORGE L. ALBOTA
Director
Capital Markets/Market Risk Manager
Bank of America Merrill Lynch, London

RADU S. TUNARU, PH.D.
Professor of Quantitative Finance
University of Kent, Business School

Caps and floors and their twin instrument swaptions have become the main interest rate derivatives in fixed income markets. In this chapter, we discuss these important derivatives, trying to offer some insights without delving into complex mathematical modeling. We start by first describing caps and floors, their hybrid products and their potential applications. Then we consider some simple but still robust pricing considerations based on Black's formula for caplets and floorlets, the main components of caps and floors. The importance of the forward curve volatility and skew for calibration is pointed out through examples in the last part of the chapter. The market for caps/floors is different from the swaptions market, but since both types of products are related intrinsically to the forward rates and their volatilities, they can be combined to define advanced trading strategies.

CAPS AND FLOORS DEFINED

By design, a *cap* creates a ceiling on a floating interest rate. If market rates move above the cap rate, the buyer will receive the difference between the strike rate of the cap and the underlying index rate, accrued over the corresponding period. This option can only be exercised on specific settlement dates agreed between the buyer and the seller. For instance, the bank that borrows money on a floating-rate basis can purchase a cap to protect against a rate rise above the strike. Consequently, the borrower's interest rate costs will never exceed the cap's strike rate.

A *floor* is the opposite of a cap. If market rates move below the floor rate, the buyer receives the difference between the floor's strike and the underlying rate. It is common for treasurers and asset managers to buy floors as a way of locking in a minimum rate of return on floating-rate assets. The following example illustrates this point. Anticipating that market rates will stay low for a period of time, an asset

EXHIBIT 65–1

Example of a Floor Option

Data obtained from Bloomberg Financial L.P.

manager decides to buy a floor at 1.5% against the return on a floating-rate asset linked to three-month EURIBOR. On February 11, 2009, the asset manager contacts a bank and agrees to buy a EUR 10 million notional, four-year maturity, 1.5% strike floor on three-month EURIBOR. Exhibit 65–1 shows the three-month forward curve on the trading day, the realized three-month EURIBOR rates, the actual payoff of the floor, and the potential payoff for the remaining fixing dates based on the forward curve as of February 14, 2011. On each of the floor's reset dates when three-month EURIBOR fixes below the 1.5% strike, the loss on the asset is offset by the floor's positive payoff. The actual floor on the asset's return is lower than 1.5% because of the premium paid by the asset manager to enter the floor. This cost can be regarded as a running spread over the life of the floor and subtracted from the floor's strike. If in our example the premium would have been 40 basis points (bps), then, disregarding any discounting effects from funding, the average cost per year would be 10 bps and the actual floor level would be 1.40%. (The correct approach is to divide the premium by the annuity covering the life of the floor.)

COLLARS AND CORRIDORS

A *collar* is a trading strategy created by simultaneously purchasing a cap (floor) and selling a floor (cap) with identical maturities, reference rates, and notionals but different strikes. Usually, the cap and the floor are out-of-the-money.

Because the premium paid on the cap (floor) is partially offset by the premium received on the floor (cap), the collar is a cheaper way of hedging risk. This cost reduction comes at the price of giving up the potential benefit of favorable rate movements outside the range defined by the two strikes. A borrower entering a collar is hedged against a rise in the interest rates above the cap strike but gives up any benefit when the rates move below the floor strike. In between the two strikes, the borrower continues to pay the index rate. Unlike a cap or a floor, a premium payment may or may not be necessary depending on the two strikes, volatilities and notional amounts. When the premium of the cap and that of the floor are equal, a "zero cost collar" can be structured. Outside the range defined by the two strikes, a collar is equivalent in terms of cash flows to an interest rate swap paying a fixed-rate and receiving a floating-rate.

A *corridor* is a strategy in which the cost of purchasing a cap is offset by the simultaneous sale of another cap with a higher strike. The buyer is hedged against an increase in the index rate between the two strikes, but loses this protection if the rates go above the higher strike. It is possible to offset entirely the cost of the lower strike cap by increasing the notional of the higher strike cap. However, if the index rate goes through the higher strike, the buyer will no longer be protected because of the notional mismatch between the two caps.

HYBRID TYPE INSTRUMENTS

Following the success of the caps and floors market, a wide range of hybrid type instruments have appeared, trying to tailor the risk to clients' specifications. We describe a few of the more popular ones below.

A *conditional premium cap/floor* is a contract between two parties in which the seller agrees to pay the buyer if the underlying interest rate index is above/below the fixed strike rate (cap/floor) on the specified fixing dates. The seller pays the difference in interest (i.e., between the index and the strike rates) adjusted for the relevant day count fraction. The buyer pays the seller a premium, as a percentage of the notional, only on those occasions when the option is in-the-money. Thus, if the index never fixes above/below the strike rate, the buyer will never have to pay a premium.

A *chooser cap/floor* is an interest rate cap/floor with a fixed number of possible exercises out of the total market fixing times. If the interest rate index fixes above the cap strike/below the floor strike, more times than the agreed number of exercises, then the buyer will lose the protection. This contract is cheaper than a vanilla cap/floor as its premium is related to the number of activation periods. The premium is paid upfront.

Another hybrid product is a *reset strike cap/floor,* which is just a standard cap/floor that has a secondary strike rate. If the underlying index rate is higher/lower than this secondary strike level, then the cap/floor strike is changed to the reset strike level for that period. The premium is quoted as a percentage of the initial notional and it can be paid up front or pay-as-you-go.

POTENTIAL APPLICATIONS OF CAPS AND FLOORS

Here are a few examples of the potential use of caps and floors:

- *Hedging of options embedded in assets/liabilities:* It is common for insurance companies and pension funds to use caps/floors to hedge the risk arising from guaranteed-payoff annuity products.
- *Hedging floating-rate assets/liabilities:* Debt managers can buy floors to protect against potential losses on outstanding fixed-rate debt when rates fall (fixed coupon debt can also be swapped into floating-rate debt and a cap can be added to fix the maximum rate).
- *Create synthetic positions:* Using caps and floors alone or in combination with other derivatives, investors can achieve a wide variety of payoff profiles.
- *Enhance returns:* Hedge funds frequently use caps/floors to express views on the level of interest rates at different points in time. By purchasing options, they have a limited downside (the paid premium), but a virtually unlimited upside if their views prove correct. In general, these positions are not hedged. If these strategies are profitable, hedge funds can put hedges in place to lock in their profits or they can unwind the positions before expiry. Sometimes, these funds sell caps and floors to enhance the return on investments.

CAPLETS AND FLOORLETS

When purchasing a cap or a floor, the buyer is actually entering a collection of sequentially maturing European style options with the same strike called, respectively, *caplets* or *floorlets*. A caplet/floorlet payoff is positive if the underlying rate is higher/lower than the strike, essentially allowing the buyer to receive the underlying rate floored at the strike or pay the underlying rate capped at the strike.

A typical caplet/floorlet uses the reference rate, for instance three-month LIBOR/EURIBOR. Usually, the rate (L) is observed at the beginning of the caplet/floorlet calculation period on the reset date (D_R), which, for the major currencies, is two business days before the actual start date of the caplet/floorlet (D_S). At expiry (D_E) the rate is compared with the strike rate (K) and the payoff is accrued for the duration of the calculation period (from D_S to D_E). The payoff of a caplet on the payment date can be written as:

$$\max\left[L_R(tenor) - K, 0\right] cvg(D_S, D_E)$$

where $cvg(D_S, D_E)$ is the accrual period expressed as a year fraction calculated using the day count convention dictated by the respective currency (usually Actual/360; number of days during the period from time D_S to D_E normalized by the number of days in a year).

EXHIBIT 65–2

Black's Pricing Formulae for the Normal Model and Log-normal Model

Model	Caplet Price	Floorlet Price
Normal	$\sigma_{bp}\sqrt{t_R}[n(d)+dN(d)]cvg(D_S, D_E)df(0, t_E)$	$\sigma_{bp}\sqrt{t_R}[n(d)-dN(-d)]cvg(D_S, D_E)df(0, t_E)$
LN	$[FN(d_1)-KN(d_2)]cvg(D_S, D_E)df(0, t_E)$	$[-FN(-d_1)+KN(-d_2)]cvg(D_S, D_E)df(0, t_E)$
	$d=\dfrac{F-K}{\sigma_{bp}\sqrt{t_R}}$	$d_{1,2}=\dfrac{\ln\left(\dfrac{F}{K}\right)}{\sigma_{LN}\sqrt{t_R}}\pm\dfrac{1}{2}\sigma_{LN}\sqrt{t_R}$
	$N(d)=\int_{-\infty}^{d}\dfrac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}dx$	$n(d)=\dfrac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}d^2}$
Forward rate	$F=F(0, t_S, t_E)=\left[\dfrac{df(0, t_S)}{df(0, t_E)}-1\right]\dfrac{1}{cvg(t_S, t_E)}$	

t_R and t_E represent the time (in years) from the valuation date.
$F(t, t_S, t_E)$ - forward rate spanning the period from t_S to t_E observed at time t (t = 0 is the current time).
$df(t, t_S)$ - discount factor from time t to time t_S.

The market convention is to use the Black formula (the log-normal model or sometimes the normal model) to price caplets/floorlets.[1] Exhibit 65–2 summarizes the pricing formulae for each of the two versions of the model:

We present a numerical example based on the log-normal model for the calculation of the price of a caplet-floorlet straddle. The details of the option are presented below for a valuation date of February 14, 2011, that is equivalent to $t_R = 4.99421$:

Start Date	End Date	Fixing Date	cvg	Forward	Strike	DFs	Vol	Price (bps)
16/02/16	16/08/16	12/02/16	0.50556	3.94234%	4.234%	0.84913	23.29%	72.73

$$d_{1,2}=\frac{\ln\left(\dfrac{3.94234\%}{4.234\%}\right)}{23.29\%\sqrt{4.99421}}\pm\frac{1}{2}23.29\%\sqrt{4.99421}$$

$$\text{Caplet}=(3.94234\%N(0.1230)-4.234\%N(-0.3975))\times 0.50556\times 0.84913=0.3010\%$$

$$\text{Floorlet}=(-3.94234\%N(-0.1230)+4.234\%N(0.3975))\times 0.50556\times 0.84913=0.4263\%$$

Because caplets/floorlets are essentially calls/puts on interest rates, put-call parity holds. A long position in a caplet combined with a short position in a floorlet is equivalent to a position in a forward rate agreement (FRA):

$$\text{Caplet}-\text{Floorlet}=(F-K)\,cvg\,(t_S, t_E)\,df\,(0, t_E)=FRA$$

Hence, for pricing purposes, only the caplet or the floorlet needs to be priced.

1. Fischer Black, "The Pricing of Commodity Contracts," *Journal of Financial Economics*, 3 (1976), pp. 167–179.

The validity of Black's model has been discussed in Hull.[2] If interest rates over the contract's life are assumed to be either constant or deterministic, the forward price equals the futures price, making Black's log-normal model appropriate. Furthermore, Black's model holds when interest rates are stochastic, provided that the discounting is done at today's maturity t_E zero-rate, given by $df(0, t_E)$. To summarize, Black's model for interest rates exhibits the same shortcomings as the Black-Scholes model for equities, namely that it assumes constant volatility.

INSIGHTS ON TRADING CAPS AND FLOORS

Caps/floors trade in the market either *spot starting* (i.e., as an A-year maturity trade), or *forward starting,* in which case the market convention is to name the trade as an A × B cap/floor, meaning the contract kicks-in after A-years and matures in B-years' time from the spot time. When the underlying rate is a LIBOR rate, the number of caplets and floorlets is usually determined by the tenor of the rate; that is, if the tenor is three months, the trade will have four caplet/floorlets per year.

The distinction in quotation is very important for the calibration of models using market data. The array of prices with various maturities imply a volatility surface and various models are judged in terms of performance depending on how well they can fit this surface without introducing arbitrage.

Exhibit 65–3 shows the prices of some at-the-money (ATM) forward starting cap/floor straddles for EUR, GBP, and USD (as of February 14, 2011) that could have been seen on different broker screens in financial markets.

The most common reference *rates* for these contracts are LIBOR or equivalent rates for the most liquid currencies: EUR, USD, GBP, and JPY. However, there is a large market for caps and floors on constant maturity swaps (CMS) rates and CMS spreads. These latter instruments can trade as *single look options* (one caplet/floorlet resetting and paying in arrears) or as regular spot or forward starting with quarterly or semiannual coupons. The difference with the CMS cap/floor contract is that the interest rate index is a swap rate, the forward rates are calculated from the forward swap rates plus a convexity adjustment. The premium is quoted as a percentage of the initial notional amount and it is generally paid either up front or pay-as-you-go, being spread over the life of the contract.

Since caps (floors) are collections of caplets/floorlets, the ATM strike rate is chosen such that all the caplets/floorlets are close to ATM. The convention is to define it as a weighted average of the ATM strikes (forward rates) of the individual caplets/floorlets. The weights are the discount factors corresponding to the expiry of each caplet/floorlet. The ATM strike satisfies the following equality ('*cvg*' here denotes the difference between the two times):

$$\sum_{i=\text{start}}^{\text{end}-1} F(0, t_i, t_{i+1}) cvg(t_i, t_{i+1}) df(0, t_{i+1}) = \sum_{i=\text{start}}^{\text{end}-1} K_{ATM} cvg(t_i, t_{i+1}) df(0, t_{i+1})$$

2. John C. Hull, *Options, Futures and Other Derivatives*, 5th ed. (Upper Saddle River, NJ: Prentice Hall, 2003).

EXHIBIT 65–3

Cap/Floor Straddles Market Prices (as of February 14, 2011)

Caps/Floors	*At-the-Money Premium*		
Straddle	**EUR**	**USD**	**GBP**
1×2	86	101	110
2×3	116	148	152
3×4	136	169	169
4×5	144	183	171
5×6	146	192	171
6×7	148	190	164
7×8	148	189	156
8×9	144	183	150
9×10	142	177	144
2×4	255	325	325
5×7	295	383	335
5×10	732	937	788
10×15	669	794	634
10×20	1,276	1,408	1,171

Data obtained from Bloomberg Finance L.P.

where $t_{\text{start/end}}$ are the start/end dates of the cap/floor. If the strike of a cap is higher than the ATM strike then the cap is said to be in-the-money, otherwise the cap is out-of-the-money (OTM). The converse holds for a floor.

Because the ATM strike is calculated as a weighted average of the forward rates, in an environment with steep forward curves, some of the caplets will be deep in-the-money and hence they will be very expensive. In these instances, one solution to get a similar hedging performance at a reduced cost is to use a *step-up cap*. This product is a variation of the standard cap which uses progressively higher strikes (instead of a single fixed strike for all the caplets) to account for the higher forward rates along the forward curve. A similar product is a flexible cap/floor where the range of strikes is pre-agreed at given levels, not necessarily increasing or decreasing.

Using the put-call parity relationship for caplets/floorlets, we can easily verify that a long position in a cap combined with a short position in a floor with the same features is equivalent with paying fixed in a spot, or forward

starting swap, where the two legs have the same reset frequency and day counting convention.

The convention for reset and payment for caps and floors is reset in advance and payment in arrears. That is, the payoff rate is observed at the beginning of the caplet/floorlet period and payment occurs at the end of each caplet/floorlet period. Because of this feature, spot starting contracts do not have the first caplet/floorlet, since the reset of the payoff rate would happen on the trading date and hence the payoff would be known exactly. For instance, a spot starting two-year cap with quarterly observations will only have seven caplets. Other variations like reset in arrears and payment in arrears are also quoted and traded in the marketplace.

Furthermore, the usual characteristics of options apply to caps and floors. The buyer pays the premium, which is a function of the strike rate, the period covered, and the volatility of the underlying rates. The cost of a cap/floor is the sum of the premiums of each individual component caplet/floorlet. A bank's/dealer's book is made of a large number of caps/floors with different start and maturity dates. Each of these trades is priced using a different volatility depending on the specific features of the product. To this end, banks/dealers construct caplet/floorlet volatility curves. For the same underlying rate, these curves show the caplet/floorlet volatility for different expiry dates. These volatilities are bootstrapped from the prices of the quoted caps/floors (ATM cap/floor straddles; a straddle is a simultaneous position in a cap and a floor with the same notional, strike, maturity, and underlying rate). Information about the volatility of the rates can be also inferred from the prices of options on short rate futures (for instance EURIBOR or EURO-dollar futures). In general, the liquidity of these futures contracts is concentrated in the short expiries. As a result, many traders' bootstrapping procedures use both types of instruments as inputs (i.e., options on futures for short expiries and forward starting caps/floors for longer expiries). Missing points are inferred based on different interpolation schemes, which are beyond the scope of this chapter. An example of the EUR cap/floor volatility curve is illustrated in Exhibit 65–4.

The market convention is to quote cap/floor prices in terms of the implied volatility which sets the Black's model price equal to the market premium. This is a matter of convenience, as implied volatilities are more stable over time than premiums, but it should not be interpreted to mean that market participants view the Black model as being a correct depiction of reality.

Broker screens show prices (quoted as implied volatilities) for both ATM and OTM caps/floors for different tenors. A snapshot of the EUR cap/floor market smile/skew for different maturities is depicted in Exhibit 65–5. Depending on the currency, the conventions for the underlying index rate can differ. For instance, the EUR cap/floor market uses three-month EURIBOR for maturities of up to two years and six-month EURIBOR for higher tenors.

The presence of volatility smiles/skews is a clear indication that Black's model is just a pricing convention rather than rigorously inferred valuation. When it comes to modeling the volatility smile, the market standard (for both caps/floors and swaptions) is the stochastic alpha, beta, and rho (SABR) model

EXHIBIT 65–4

Example of EUR Cap/Floor Implied Volatility as a Function of Maturity Date

Note: Implied volatility obtained from the Black Model.

Data obtained from Bloomberg Finance L.P.

EXHIBIT 65–5

Example of EUR Cap/Floor Volatilities as a Function of Strike Rate

Data obtained from Bloomberg Finance L.P.

developed by Hagan and his associates.[3] For caps/floors there is an added level of complexity because one needs to model the smiles for the underlying caplets/floorlets.

The convention in the market is to refer to each caplet indicating when it will start and when it will end. For example a 6M×9M caplet will kick in after 6M and will mature in 9M. In an idealized world in which caps/floors are available for sequential maturities (i.e., every three months in the case of USD), one possible approach to calibrating the caplet/floorlet smiles could be the following. Start with the 3M×6M caplet for which prices for different strikes are available and calibrate the SABR model. Select one particular strike, say K, and move to the nine-month cap/floor struck at K. Using the price for the 3M×6M caplet/floorlet struck at K (from the previous step) determine the price of a 6M×9M caplet/floorlet struck at K and its implied volatility. By repeating this procedure for all the available strikes/prices for the nine-month cap/floor one can build the smile/skew for the 6M×9M caplet/floorlet and calibrate the SABR model to it. The process continues until all the caplets/floorlets up to a certain tenor (usually 30 year, giving 119 caplets/floorlets) have been calibrated. Exhibit 65–6 illustrates this procedure.

In reality the calibration procedure is more difficult. One issue is the difference in underlying index rates for different tenors (e.g., for EUR caps/floors reference three-month EURIBOR up to two-year and six-month EURIBOR thereafter). Another is the fact that the maturity grid is coarser, which makes interpolation necessary for working out intermediate caplets/floorlets volatilities. Some remedies are possible and banks/dealers use different methods to overcome these problems.

EXHIBIT 65–6

Caplet/Floorlet Smile/Skew Calibration

Tenor (Cap/Floor)	Caplet/Floorlet Calibration				
6 months	3M×6M				
9 months	3M×6M	6M×9M			
1 year	3M×6M	6M×9M	9M×12M		
15 months	3M×6M	6M×9M	9M×12M	12M×15M	
18 months	3M×6M	6M×9M	9M×12M	12M×15M	15M×18M
...					

3. See Patrick S. Hagan, "Convexity Conundrums: Pricing CMS Swaps, Caps and Floors," *Wilmott Magazine* (March 2003), pp. 38–44; Patrick S. Hagan, Deep Kumar, Andrew S. Lesniewski, and Diana E. Woodwar, "Managing Smile Risk," *Wilmott Magazine* (Autumn 2002), pp. 84–108, and; Patrick S. Hagan, Andrew S. Lesniewski, and Diana E. and Woodward, "Probability Distribution in the SABR Model of Stochastic Volatility," Working Paper, 2004.

Information about the three-month forward rates smiles/skews can be retrieved from options on short rate futures (EURO-dollar or EURIBOR futures). In the past, when the basis three-month to six-month was small and less volatile, one approach was to use the relationship between two successive three-month EURIBOR rates and a six-month EURIBOR (compounding) and the autocorrelation for the three-month EURIBORs. This could then be used to derive rules that linked three-month with six-month volatility. Once the SABR parameters for each caplet/floorlet are available, any cap/floor can be priced using the normal/log-normal volatilities implied by the SABR model for a particular strike. Exhibit 65–7 provides an example of a cap/floor straddle pricing for EUR 5×10 ATM cap/floor straddle (CFS) priced as of February 14, 2011. The quotation means that the straddle will start in five years and will end in 10 years' time.

CAPS AND FLOORS VERSUS SWAPTIONS WEDGE

A *swaption* is a European option that allows the buyer to enter a swap upon exercise. The convention is to describe a swaption as an A-year into B-year trade; that is, upon the option expiring at A the parties will enter into a swap lasting B more years. Swaptions are divided into two types: payer and receiver swaptions, namely, the buyer of a swaption enters a B-years swap upon exercise (in A-years' time) where he will pay/receive the fixed side at a level equal to the strike of the swaption.

Since swaps can be defined as portfolios of forward rates weighted by the discount factors, swaptions can be regarded as options on portfolios of forward rates.

$$SR = \sum_{i=1}^{nr.flt\ coupons-1} \frac{cvg(t_i, t_{i+1})df(0, t_{i+1})}{\sum_{j=1}^{nr.fxd\ coupons-1} cvg(t_j, t_{j+1})df(0, t_{j+1})} F(0, t_i, t_{i+1})$$

where SR denotes the par swap rate and all the notation is as before.

In the beginning of this chapter we stated that caps/floors and swaptions are the building blocks of the interest rates derivatives market. On the other hand, we saw that caps/floors are portfolios of options on individual forward rates, whereas swaptions are options on portfolios of forward rates. The question which naturally arises is whether there is a relationship between the prices of caps/floors on one side and swaptions on the other side. A long/short position in a cap/floor combined with a short/long position in a swaption, both sharing the same set of spanning forward rates, is called a *wedge*. Some of the most common wedges are 2×4 cap/floor straddle (CFS) versus 2Y2Y P/R/S payer/receiver straddle (P/R/S) and 5×10 versus 5Y5Y.

If we assume that the caplets/floorlets determine the volatility of the forward rates, then it becomes clear that the driving force behind the price difference between caps/floors and swaptions is the correlation between the forward rates. In addition, the payoff functions of the two instruments impose constraints on the

EXHIBIT 65–7

A Pricing Example of a EUR 5×10 ATM Cap/Floor Straddle on February 14, 2011

Start Dates	End Dates	Pay Dates	Fixing Dates	cvg	Forwards	Strikes	DFs	Vols	Price (bp)
16-Feb-16	16-Aug-16	16-Aug-16	12-Feb-16	0.50556	3.942%	4.234%	0.84913	23.290%	72.73
16-Aug-16	16-Feb-17	16-Feb-17	12-Aug-16	0.51111	4.098%	4.234%	0.83171	23.290%	76.31
16-Feb-17	16-Aug-17	16-Aug-17	14-Feb-17	0.50278	4.082%	4.234%	0.81498	22.190%	73.15
16-Aug-17	16-Feb-18	16-Feb-18	14-Aug-17	0.51111	4.198%	4.234%	0.79786	22.190%	76.57
16-Feb-18	16-Aug-18	16-Aug-18	14-Feb-18	0.50278	4.216%	4.234%	0.78130	20.850%	72.13
16-Aug-18	18-Feb-19	18-Feb-19	14-Aug-18	0.51667	4.308%	4.234%	0.76429	20.850%	75.82
18-Feb-19	16-Aug-19	16-Aug-19	14-Feb-19	0.49722	4.347%	4.234%	0.74813	20.020%	71.23
16-Aug-19	17-Feb-20	17-Feb-20	14-Aug-19	0.51389	4.419%	4.234%	0.73151	20.020%	74.86
17-Feb-20	17-Aug-20	17-Aug-20	13-Feb-20	0.50556	4.385%	4.234%	0.71565	19.150%	70.62
17-Aug-20	16-Feb-21	16-Feb-21	13-Aug-20	0.50833	4.439%	4.234%	0.69986	19.150%	71.82
								Total	735.247

relationship between their premiums. Because of the convexity of the payoff we have the following inequality (here we made the assumption that the underlying swap of the swaption has the same day count convention and payment frequency on the two legs):

$$\sum_{i=1}^{nr.forward\ rates} df(t_1, t_{i+1}) \max(F(t, t_i, t_{i+1}) - K, 0)\, cvg(t_i, t_{i+1})$$
$$\geq \max\left(\sum_{i=1}^{nr.forward\ rates} df(t, t_{i+1})(F(t, t_i, t_{i+1}) - K, 0)\, cvg(t_i, t_{i+1}), 0\right)$$

The above inequality implies that the value of a payer swaption will always be less than the value of a cap (both defined on the same set of forward rates).

In reality, the two products behave rather independently of each other and the implied correlation between the forward rates can at times exceed normal limits or what can be deemed as cheap/expensive given the market stance. Some market participants, banks and hedge funds, have tried to exploit these discrepancies and put on arbitrage plays on the correlation level. In general, these strategies require a long holding period and hence exposure to the mark to market fluctuations. On several occasions in financial markets the unwinding of such positions (which did not performed as expected) caused severe dislocations in the wedge.

The relatively high volatility of the wedge can be explained by the fact that the two products belong to two different markets with different supply/demand dynamics. In the cap/floor market, banks are natural suppliers of cap/floor volatility from their issuance of exotic structures such as snowballs, capped/floored floating-rate notes (FRNs), range accruals, callable trades, and the like. In contrast, banks may decide to buy caps perhaps as a "cheaper" alternative protection against inflation and floors for general asset/liability management. The swaptions market is usually accessed by more sophisticated investors such as banks, pension funds, and hedge funds.

The spread between caps/floors and swaptions volatilities is mean-reverting. As such, one can take directional views on wedges. The interplay between the future shape of the yield-curve (bull/bear steepening, or flattening) and volatility is a major factor affecting the dynamics of the wedge. The "carry and roll" are very important issues when one decides to enact such a trade. Another important aspect is the fact that caps/floors will have on "average" more gamma[4] than a swaption (both trades sharing the same driving forward rates).

We mentioned earlier that the future shape of the curve and the volatility are important factors in the behavior of the wedge. Based on the historical analysis of yield curves, one can expect to see certain behavior of the correlation between the forward rates and volatility under different curve scenarios. From an

4. The gamma is the sensitivity of changes in the value of the caps/floors with respect to large changes in the interest yield. It is measured by the second derivative of the caps/floors price with respect to yield.

EXHIBIT 65–8

Example of EUR 2×4 CFS versus 2y2y Swaption Straddle Wedge against the 5y-2y Swap Spread

Data obtained from Bloomberg Finance L.P.

intuitive point of view, a decrease in correlation would imply more independence in the move of the forward rates and hence, potentially higher values for the caps/floors. On the other hand, since a swap is a portfolio of forward rates with positive weights, one would expect to see a lower volatility and hence a lower value for a swaption. Under such a scenario, a cap/floor would be more valuable on a relative basis. Several studies on the shape of the yield curves have documented a decrease in correlation in steepening environments in which the forward rate curve becomes progressively steeper and the forwards more de-correlated. Based on such observations, market participants can take positions on the wedge. Exhibit 65–8 shows the evolution of the EUR 2×4 CFS versus 2y-2y swaption straddle wedge against the curve of slope (5y-2y). The exhibit seems to reinforce the observation that the steepening causes the correlation between the forward rates to drop and makes the wedge a better hold.

KEY POINTS

- Caps and floors are portfolio of European options and they offer a suitable solution for hedging interest rate risk across time.
- Hybrid type caps and floors include conditional premium cap/floor, chooser cap/floor, and reset strike cap/floor.
- Pricing is done for each individual caplet or floorlet and there is a put-call parity relationship.

- Cheaper hedging solutions can be obtained by giving up some upside opportunity and creating trading strategies such as corridor and collar. Swaptions are another viable alternative for hedging interest rate risk but in general the swaptions market is different from the caps/floors market.
- Black's model is used for price quotation by convenience. The SABR model is used by most banks for calibration of implied volatilities with various maturities.
- Advanced trading strategies such as wedges can be implemented to take advantage of understanding how volatility affects the forward rates.

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CHAPTER
SIXTY-SIX

CREDIT DERIVATIVES

DOMINIC O'KANE, D.PHIL. (OXON)
Affiliated Professor of Finance
EDHEC Business School

Since the turn of the century, the credit derivatives market has become the main destination for those wishing to hedge credit risk and those looking for credit-based investments not available in the traditional cash credit markets. Two products dominate. The first is the single-name credit default swap (CDS), which transfers the default risk of a specific corporate or sovereign. The second is the CDS index, essentially a portfolio of CDS packaged into a single transaction. Together they constitute over 90% of all credit derivative transactions.

The purpose of this chapter is to set out a comprehensive description of the CDS contract, and specifically the detailed mechanics of how it works. We follow this with a detailed description of the mechanics of the CDS indices. We defer a detailed discussion of the pricing and risk-management of CDS and CDS indices to Chapter 67. However, we begin with a history of the evolution of the credit derivatives market.

EVOLUTION OF THE CREDIT DERIVATIVES MARKET

The credit derivatives market began in the early 1990s as a branch of structured finance that involved creating highly bespoke transactions customized to a particular requirement. These included hedging a credit risk, creating a structured investment product, or managing the regulatory capital of both sovereign and corporate credit risk.

By the mid 1990s the concept of a CDS contract had been established. However, the market lacked standardized legal definitions for the credit events that trigger the contract, and for the protected debt obligations. This meant that pretrade negotiations between parties often required legal assistance in order to ensure that the triggering events and the hedged debt obligations were clearly defined and understood. In addition to increasing transaction costs, this meant that trades could take several days to approve and settle.

The significant growth phase of the CDS market therefore only started following the publication of the first *Credit Derivative Definitions* by the International

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Swaps and Dealers Association (ISDA) in 1999. This document, which became known as ISDA '99, was a response to the legal disputes that arose following the Asian crisis of 1997 and the Russian default of 1998. In addition to the new definitions, ISDA '99 also created a short-form confirmation document that required parties to simply tick a box in order to specify the characteristics of their trade. This made it possible for the market to develop a standard contract, i.e., a contract that has a certain number of characteristics that a majority of buyers and sellers can agree on and which therefore attracts the greatest liquidity. Following its adoption of ISDA '99, the CDS market began a period of very rapid expansion, growing from a total outstanding notional of $632 billion in 2001 to $62 trillion by the end of 2007.[1]

A number of important changes were made to the credit derivatives market between 2000 and 2003. Many of these changes were in response to some of the credit events that had occurred[2] after the end of the dot.com boom and the events of September 11, 2001, and addressed such issues as reference entity specification, guarantees, debt restructuring, deliverability, and successors. Of these, perhaps the most problematic, since it led to a regional split in the market standard, was in relation to the treatment of restructuring as a credit event. This is discussed in detail later.

The period from 2004 to 2007 saw the arrival of the CDS indices. These were adopted very rapidly by the market and became highly traded and highly liquid. They were particularly favored by credit investors who viewed them as a simple and cheap way to take a macro-level exposure to the credit markets, in much the same way as equity index futures permit investors to take a macro-level exposure to the equity markets.

In late 2003, the credit derivatives market established an automatic trade confirmation system at the Depository Trust and Clearing Corporation (DTCC) in New York, the aim being to speed up the confirmation of trades and to remove the backlog of unsigned confirmations that had built up. Then in late 2007, the DTCC also established itself as the keeper of the comprehensive trade database—the official legal record for all confirmed trades. It also set an infrastructure to automate and standardize post-trade processing.

The period 2008–2010 saw a considerable upheaval in the CDS market as regulators responded to the aftermath of the Lehman bankruptcy and the financial crisis. Despite the fact that there were $72 billion of CDS linked to Lehman Brothers registered at the DTCC at the time of its bankruptcy, settlement of the credit event went smoothly as it used a market-wide auction procedure.[3] Nevertheless, this event caused regulators to become very concerned about

1. These numbers come from the ISDA which conducts a semiannual survey of its members who are distributed around the world.
2. These included Argentina, Armstrong, Conseco, Enron, Marconi, National Power, Railtrack, Worldcom, and Xerox.
3. The Trade Information Warehouse at the DTCC, which handled the bulk of the triggered Lehman referenced CDS contracts, reported no failures to perform.

systemic risk in the financial sector caused by the large number of outstanding contracts and a lack of transparency with respect to where the actual credit risk was sitting.[4]

In an attempt to reduce counterparty risk, regulators decided to require standard credit derivatives trades to be assigned to a centralized counterparty (CCP). To prepare the ground for these changes, the market introduced some new legal protocols. The first protocol, known as "Big Bang," was introduced in April 2009 and made the following changes:

1. Creation of a market-wide determinations committee (DC) charged with determining whether or not a credit event has occurred.
2. An automatic market-wide auction mechanism for the settlement of triggered CDS contracts following all credit events with the exception of restructuring.
3. Moving the date on which the CDS credit event protection[5] begins to the date 60 days before the date on which the request to consider whether a credit event has occurred is made to the determinations committee. This change was made in order to ensure that all existing contracts are triggered by a credit event even if the contract was initiated after the credit event occurred, but before the credit event had been determined.

At the same time, there was also a recouponing process in which the market switched to trading all CDS contracts on each credit with the same coupon irrespective of when the trade was done. This differed from the previous convention in which the coupon on a CDS was set at trade initiation in order to ensure that the contract had zero initial value. The market has also changed so that standard contracts now trade with a full first coupon, i.e., the first coupon starts accruing on the previous coupon payment date even if it is traded mid-period. Both changes have been made in order to increase the fungibility of contracts and to facilitate contract netting as a precursor to the centralized clearing of CDS contracts.

In late 2009, a second protocol known as "Small Bang" was adopted. This extended the "Big Bang" protocol to deal with the restructuring event as a trigger for the CDS. This protocol was intended for the European CDS market since restructuring is not a standard credit event in the North American CDS market

At the start of 2010, the DTCC formally linked itself to the Federal Reserve System where it is expected to fall under a global oversight framework involving U.S. and international regulators. The initiative to move credit derivative trades

4. It is worth noting that of the more than 900,000 OTC derivative contracts on Lehman's trading books, only one has been challenged due to an open confirmation. See *Report of the Financial Crisis Inquiry Commission* at http://www.fcic.gov/report.
5. For a succession event, the legal protection begins 90 days before the request.

onto CCPs was well underway, especially for CDS indices, with over fifteen trillion dollars of index trades already cleared by ICE in North America and Europe by early 2011. The first CDS to be cleared via a CCP and in compliance with the new Dodd-Frank regulations was traded in February 2011. Although most CCPs are based at exchanges, trading in the CDS market trades continue to be executed in the OTC market. The CCP then steps into the trade, placing itself between the two initial parties.

As of 2011, the size of the CDS market and CDS index markets is roughly half what it was at the market peak in 2007. A significant part of this decline can be attributed to the numerous compression cycles (discussed below) that have been carried out in the last two years. Some of it may also be due to the decrease in CDS-based and CDS index–based hedging activities of more exotic credit derivatives, in particular synthetic CDOs. Indeed a snapshot of the credit derivatives market in early 2011 shows that CDS made up 57% of the gross notional of credit derivatives, whereas CDS indices made up 34%, leaving just 9% to other transaction types.[6]

Market Participants

Since its inception, the credit derivatives market has been dominated by commercial and investment banks. Commercial banks have used CDS to hedge the credit risk of their loan book. The advantage of CDS is that they permit the bank to hedge the risk of a specific loan privately and bilaterally. This is often preferred to selling the loan because the sale of a loan by a bank usually requires the bank to notify the borrower and such a sale may be considered to be a negative signal by the borrower and as such may be damaging to the bank–borrower relationship. Surveys of the credit derivatives market have generally found that commercial banks buy more protection than they sell as their loan book hedging requires them to be net protection buyers. Their reason for selling protection is to earn income and diversify their portfolio credit exposure.

Investment banks and the dealer arms of commercial banks play an important role in the credit derivatives markets where they act as dealers. Overall they tend to run balanced books with equal amounts of protection bought and sold.

Insurance companies are also an important user of credit derivatives, primarily as a form of investment on the asset side of their business where they tend to be net sellers of protection. Hedge funds are an important market participant as they are able to play the credit markets from a long or short position and they also tend to buy roughly as much protection as they sell. They are particularly attracted by the ability to go short and the ability to leverage as the upfront payment needed to enter a CDS contract is typically much smaller than the contract notional.

Other users of the market with a lower market share include pension funds, mutual funds and companies. Funds may be more interested in CDS indices in

6. These numbers are based on a snapshot of market positions on February 11, 2011 taken from the DTCC Trade Information Warehouse Reports.

particular, as they provide a quick way to establish a diversified macro credit exposure onto which they can then add specific credit exposures.

The use of credit derivatives by companies is generally quite bespoke as it may be connected with a need to hedge or assume a very specific credit exposure that they may not wish to sell or cannot find in the bond market. For example, a company may use a CDS to hedge the credit risk of future receivables from a specific company.

Uses of Credit Derivatives

The considerable growth in the size of the CDS and CDS index market has been driven by its various uses. These are as follows:

- *Transferring credit risk:* CDS are first and foremost a tool used to transfer credit risk from one party to another. For example, banks can use CDS to transfer loan credit risk off their balance sheets into the capital markets where this risk may be assumed by an investor. This creates new loan capacity on their balance sheet.
- *Hedge credit risk:* Before the advent of CDS, it was difficult to hedge an existing credit risk by shorting corporate bonds. Buying protection using a CDS is a much easier way to achieve the same objective. CDS indices can also be used as a hedge against changes in the market-wide pricing of credit risk and also the default of individual reference entities.
- *Customization:* As the CDS market is a bilateral OTC market, parties can structure the features of a CDS in almost any way they wish. Features that can be varied include the currency, maturity, and seniority. The more the customization deviates from the market standard, the greater the associated cost and the lower the subsequent liquidity.
- *Ease*: A CDS index makes it simpler for an investment manager to assume an exposure to a diversified portfolio of credits in one transaction. The tight bid/offer spread also makes the cost of unwinding the position cheaper than the cash equivalent.
- *Leverage and yield enhancement:* A CDS and a CDS index typically require only a small upfront payment. This makes it easier to leverage the underlying risk and return compared to a fully funded cash bond.
- *Pure credit play:* The CDS and CDS index are almost a pure credit play since unlike fixed-rate corporate bonds, they have very little interest-rate sensitivity. This isolation of the credit risk is attractive for credit fund managers.
- *Risk decomposition:* CDS can be used to hedge out specific risks in securities with multiple risks. For example, they can be used to hedge

out the credit risk of convertible bonds in an attempt to isolate the economics of the embedded equity option.

- *Speculation:* CDS enable market participants to express a positive or negative view on an underlying credit while a CDS index makes it possible to go long or short macro-level credit.
- *Structured credit investments:* CDS can be used as the building blocks for more exotic structured credit investments that are created to provide a more tailored risk-return profile to specific types of investor.
- *Manage regulatory capital:* Banks can use CDS to hedge credits that have a high regulatory capital charge, provided such a hedge is recognized as being economically effective by regulators.

THE CREDIT DEFAULT SWAP

The simplest way to think of the CDS is as an insurance contract in which one party, the "protection buyer," pays a premium to be protected against a credit loss on a specific face amount of bonds or loans issued by a specified corporate or sovereign reference entity. The other party, known as the "seller of protection," receives the premium and takes on the credit risk. Since there is a buyer and a seller of the credit risk, a CDS contract does not create credit risk, it simple transfers it from the protection buyer to the protection seller as shown in Exhibit 66–1. However, unlike an insurance contract, a CDS is a traded contract that can be valued at any time. The protection seller is any investor who takes a view that the premium is attractive given his or her view of the risk of default of the reference entity.

Care needs to be taken when trading CDS to be clear about to which side of the contract we are referring. In the market, "buying" a CDS contract is usually associated with buying protection. However, buying protection is economically equivalent to shorting credit risk or selling a corporate bond issued by the reference entity. Equally, "selling" a CDS contract is economically equivalent to assuming credit risk and so is akin to buying a corporate bond issued by the

EXHIBIT 66–1

A CDS is a Bilateral Contract between a Protection Buyer and a Protection Seller

reference entity. Indeed we will demonstrate this equivalence in Chapter 67. To avoid misunderstandings, the term *buying a CDS* should always be qualified with the word *protection;* that is, *buying CDS protection*. Equally *selling a CDS* should be qualified as *selling CDS protection*. Note that this differs from the CDS index market, in which the "buyer" is usually an investor who is selling protection on the underlying portfolio of CDS. This is another reason why clarity is essential in order to prevent confusion.

CDS MECHANICS

As just stated, the purpose of the contract is to transfer the *credit event* risk of a specified face value amount of debt obligations issued by a stated *reference entity* (a corporate or sovereign) from the protection buyer to the protection seller.

The debt obligations covered by the contract are known as the *deliverable obligations* and these are usually bonds and loans of a specified seniority. This seniority is defined by specifying a *reference obligation* of the issuer with respect to which the deliverable obligations should be senior or *pari passu*. If a credit event occurs, then the protection buyer will receive a payment which is economically equal to the difference between the price of the impaired deliverable obligations and par.

The reason for protecting a basket of deliverable obligations rather than a specific obligation is that it enhances the liquidity of the market because the same contract can be used by hedgers to protect themselves against any one of many obligations of the issuer. If the market were to trade CDS on each specific debt obligation of the issuer, then liquidity and fungibility would be reduced and the cost of protection would almost certainly increase. However, there is a negative side effect because the protection buyer has the right to choose which bond is protected by the contract. He is therefore long a *delivery option*. The effect of this and how it is treated is discussed below in the section on restructuring-type credit events.

To enter into a CDS, a party trades via a dealer. This is done via the telephone or an electronic trading system. At initiation, the party usually makes an upfront payment that (depending on various factors discussed below) can be positive or negative, i.e., the payment could be from the protection seller to the protection buyer or vice versa. The model used to determine the upfront value is set out in detail in Chapter 67.

Credit protection starts on the *effective date*. Prior to the 2009 "Big Bang" protocols, this was the calendar date immediately following the trade date. However, under the new protocols, protection now begins 60 days before any request to consider whether a credit event occurred is made to the determinations committee. This change was made to ensure that all existing contracts would cancel out irrespective of whether they were traded yesterday or last year. This can create a rather strange scenario in which a protection buyer can buy protection *after the credit event* and be paid out. However, this is not as anachronistic as it may seem since the protection would have to be purchased before the credit event

was determined. Also, if the information that a likely credit event had occurred was already public at the time of the purchase then the cost of the protection would have been high and close to its post-credit event determination value.

Credit protection lasts until the scheduled termination date, more commonly known as the CDS maturity date. This will fall on one of the following dates: March 20, June 20, September 20, or December 20 of a specified year. These dates are not adjusted for holidays if they fall on a weekend. They are known as the *CDS Dates*. What this means is that at any moment in time, the scheduled termination date of the most liquid T-year CDS contract will be on the first CDS Date which falls after the date exactly T years in the future. So, for example, on April 3, 2011, the standard five-year CDS contract has a scheduled termination date of June 20, 2016. The most liquid contracts have terms of one, three, five, seven, and ten years, with greatest liquidity focused on the five-year contract.

The Premium Leg

To pay for the credit protection, the protection buyer pays the protection seller a combination of an upfront payment (which may be negative) plus a regular fixed coupon. These payments are known as the *premium leg* of the CDS. Here we will discuss the fixed coupon, deferring the discussion of the upfront payment to the end of this section.

The fixed coupon is specified at contract initiation and determines the size of the quarterly regular payments from the protection buyer to the protection seller. The size of each actual cash payment is calculated by multiplying the fixed coupon by the contract notional. This is then multiplied by the year fraction between the current and previous coupon date calculated according to an actual 360 day count convention.

Before 2009, the size of this coupon depended not just on the reference entity but also on when the CDS trade was initiated. This was because the coupon was set such that the value of the CDS contract at inception was zero, thereby requiring no upfront payment. However since 2009, contracts linked to each issuer now have a fixed coupon irrespective of when they were traded. As a result, the price of the credit risk is not reflected in the size of the coupon, but in the size of the upfront payment.

The exact details of how the premium schedule is calculated are beyond the scope of this section, although more information can be found in Chapter 67. However, it is worth noting that since 2008, the market standard is for contracts to trade with a full first coupon even if they are traded between two coupon payment dates. This enables a new contract to always have exactly the same cash flows as another existing contract with the same maturity date. This is discussed with specific examples in Chapter 67.

EXHIBIT 66–2

The Premium and Protection Legs of a CDS

Note: In this example we have a three-year CDS contract with quarterly coupon payments on the premium leg.

A key feature of the premium leg is that the payments terminate following a credit event. This is shown in Exhibit 66–2. All that is paid by the protection buyer on the premium leg is the amount of coupon that has accrued between the previous coupon payment date and the credit event. This feature of a CDS means that once a credit event has occurred, the premium leg terminates and the contract can be closed out.

The Protection Leg

The other leg of the CDS is the *protection leg,* also known as the contingent leg. This is the payment from the protection seller to cover the loss on the face value of debt, which is only triggered if there has been a credit event. Economically, the value of the payment equals par minus the recovery price of the deliverable obligations. Determination of the size of the recovery price or value is now done using a market-wide auction process that is discussed in detail below.

The market provides two mechanisms for the protection seller to effect the payment of protection. Either the protection seller can choose to pay a cash amount equal to par minus the recovery price determined by an auction, or the protection seller can request physical settlement, which means that they will pay the contract notional in cash and receive the corresponding face value of deliverable obligations at the price determined by the auction.

There are also two mechanisms for the protection buyer to receive the payment of protection. Either the protection buyer can choose to receive a cash amount equal to par minus the recovery price determined by the auction, or the protection buyer can request physical settlement, which means they will receive the notional amount in cash and deliver the corresponding face value of deliverable obligations at the price determined by the auction.

The protection buyer who elects for physical settlement can choose which deliverable obligations to deliver. They are long a "delivery option" whose value depends on the range of prices of the deliverable obligations. The protection seller who has chosen physical settlement has to accept what is delivered. This is discussed in more detail below.

The Upfront Payment

The cost of protection is paid for through both the payment of the fixed coupon on the premium leg of the CDS and through upfront payment. This is the cost which has to be paid in order to enter into the CDS contract and may be positive or negative. Whether it is positive or negative depends primarily on whether the party is buying or selling protection and how the market perceived credit quality of the reference credit compares with the fixed coupon on the CDS. The market perceived credit quality of the reference credit is captured by the CDS "quoted" spread, which is defined in detail in Chapter 67.

For example, consider a short protection CDS position on a credit that trades with a fixed coupon of 100 bp, but whose credit quality has recently deteriorated so that its CDS market quoted spread is currently 160 bp. This will require an upfront payment as the protection buyer will pay cash to the protection seller in order to offset the fact that the coupon is not high enough to compensate the protection seller for the market perceived credit risk of the reference credit. Before 2009, this contract would have had no upfront cost, as it would have paid a coupon of 160 bp.

Once a CDS has been traded, its mark-to-market value begins to change due to changes in the market view of the credit risk of the reference entity as expressed by the quoted spread and changes in interest rates.

For those familiar with the valuation of CDS contracts before the introduction of fixed coupons, the valuation and risk-management has not changed in any significant way. Once the contract has traded and the upfront payment made, the value of the contract looking forward is identical to before. For example, consider a long protection CDS contract with a coupon of 100 bp in which the current quoted spread is 160 bp. This will have a positive value for the protection buyer as he is paying only 100 bp for protection, which the market now considers to be worth 160 bp. However we do not have enough information to determine whether the position has a positive P&L (ignoring for a moment the impact of coupons paid) since this depends on the upfront value when the contract was entered into. Before the arrival of fixed coupons, the coupon on the CDS would have told us the spread when the

contract was initiated and as the initial cost would have been zero, the mark to market of the CDS would, excluding coupons, be the P&L of the position.

The valuation and risk-management of a CDS is covered in Chapter 67.

CREDIT EVENTS

The *credit event* is the term used by the credit derivative market to define each of the events that can trigger the payment of the CDS protection. Companies can default or enter into a restructuring. The situation is even more complicated for sovereign debt since countries do not formally file for bankruptcy. Instead they can default in a number of different ways, for example, by repudiating their debt or by re-denominating their foreign currency debt. The standard credit events used in CDS need to be broad enough to encompass this range of scenarios. A list of the main such credit events is provided in Exhibit 66–3.

In Exhibit 66–3 we have stipulated which credit events are "hard" and which are "soft." This designation refers to what happens to the debt obligations of the reference entity following the credit event. For most credit events, the debt becomes immediately due and payable. This means that all debt obligations, irrespective of maturity and coupon, which are *pari passu* with each other have an equal claim on the remaining value of the company and so should trade at the same price. These are what we call *hard credit events*.

EXHIBIT 66–3

The Main Credit Events Used in the CDS Market

Credit Event	Hard or Soft	Description
Bankruptcy	Hard	Corporate becomes insolvent or is unable to pay its debts.
Failure to pay	Hard	Failure of the reference entity to make due payments, taking into account some grace period.
Obligation acceleration	Hard	Obligations have become due and payable earlier than they would have due to default and have been accelerated. This event is used mainly in the case of emerging market sovereigns.
Obligation default	Hard	Obligations have become due and payable prior to maturity. This event is used rarely.
Repudiation/ Moratorium	Hard	A reference entity or government authority rejects the validity of the obligations. This is used for sovereign credits.
Restructuring	Soft	Changes in the debt obligations of the reference entity which result in a credit deterioration for the debt holders.

The Restructuring Credit Event

There is only one soft credit event. This is the event of restructuring in which a company does not file for bankruptcy but agrees with its creditors a consensual restructuring of its debt obligations, but in a way that has a negative impact for the creditors.

The restructuring credit event refers to out-of-court pre-insolvency restructuring that usually requires the unanimous approval of all impaired creditors. Since the company continues to trade as a going concern, debt does not become immediately due and payable. Therefore, a restructuring credit event does not cause all *pari passu* debt to trade at the same price and so the debt obligations continue to trade with prices that take into account a term structure, and coupon effects (i.e., higher coupon bonds trade at a higher price than lower coupon bonds of the same maturity.

The reason why we single out soft credit events is that they present a delivery option for the protection buyer. Recall that the protection buyer can choose which obligations they wish to deliver from a basket of possible deliverables. As the deliverable obligations continue to trade at different prices caused by different coupons and maturities, there may be some value in the delivery option, and the protection buyer will always be motivated to deliver the cheapest bond or loan he can find.

As a result, if the debt obligations held by the protection buyer are not the cheapest to deliver, it will be economically preferable to sell these in order to buy the cheapest to deliver, gaining the price difference as a windfall gain. The act of always delivering the cheapest deliverable causes the protection seller to take a larger loss than if another deliverable had been chosen.

Such a situation occurred following the restructuring of the debt of the U.S. insurer Conseco Inc. in 2000. In this case, banks which held short-maturity loans that were not particularly impaired by the restructuring, and who had bought CDS protection on these loans, were able to sell these loans for close to par and use the proceeds to purchase deep discount bonds trading in the $65 to $80 range, which they could then deliver in return for par. They were therefore able to make a windfall gain at the expense of the protection sellers.

Following this, complaints were made by Conseco protection sellers. This resulted in the introduction of a new clause that formed part of the revised CDS documentation released in 2001. Called the *modified-restructuring (Mod-Re) clause,* it was intended to reduce the value of the delivery option following a restructuring by reducing the range of deliverable obligations in the basket. This was done by restricting the maturity of the deliverable obligations. This clause only applied to the North American CDS market.

In 2003, Europe followed by introducing its own restructuring clause. As it was a variation of the North American clause, it was known as *modified-modified restructuring (Mod-Mod Re).* These regional differences were due to the differing requirements of the local financial regulators and the differing importance of banks versus investors in the different regions.

We now have three different restructuring clauses, each with its own restrictions on the maturity of the deliverables. These are as follows:

- *Old-Restructuring (Old-Re):* This is the pre-2003 standard which only imposes a 30-year maturity limit on deliverables.
- *Modified-Restructuring (Mod-Re):* The exact maturity limits of the Mod-Re deliverable obligations are quite complicated. A rough and ready approximation is that the deliverable obligations cannot have a maturity longer than the greater of the scheduled termination date of the CDS and the restructuring date plus 30 months. If we use RMLD to denote the restructuring maturity limitation date then

  $$\text{RMLD} = \text{Max}\ [\text{TD}, \text{RD} + 30 \text{ months}]$$

  where TD is the scheduled termination date of the CDS contract and RD is the date of the restructuring event.
- *Modified-Modified Restructuring (Mod-Mod Re):* This is similar to modified restructuring. The difference is that the formula for the restructuring maturity limitation date is given by

  $$\text{RMLD} = \text{Max}\ [\text{TD}, \text{RD} + \text{A}]$$

  where A equals 60 months for restructured obligations and 30 months for nonrestructured obligations.

There is a fourth alternative which is to remove restructuring from the list of credit events. This is simply called No-Restructuring (No-Re). The situation as of early 2011 is summarized in Exhibit 66–4.

EXHIBIT 66–4

The Standard Credit Events by Region for CDS and CDS Indices

Geographic Region	Credit Events in Standard CDS and CDS Index Contracts
North America*	Bankruptcy
	Failure to pay
Europe	Bankruptcy
	Failure to Pay
	Restructuring according to Mod-Mod Re
Asia	Bankruptcy
	Failure to Pay
	Restructuring according to Old-Re

*The Standard North American Contract is known as SNAC.

Settlement of a Credit Event

Ultimately, the post-credit event settlement of a CDS contract is all about determining the final recovery price for the deliverable obligations. This is done via an auction. The main objectives of the auction process are as follows:

1. To be able to handle cases in which the notional of protection bought approaches or exceeds the total outstanding notional of deliverable obligations. In this case there can be a short squeeze as protection buyers who do not own deliverables attempt to buy these obligations in order to settle their contracts. In the past this has led to the prices of deliverable obligations to rise after the credit event as protection buyers rush to buy them in order to deliver them.
2. To ensure that the recovery price is the same across the entire CDS market. This is necessary if market participants who are both long and short protection to the same maturity on a reference credit are to be sure that they will be hedged. This requires a common recovery price to be set via a public auction procedure described below.
3. To handle the soft restructuring credit event. Recall that hard credit events cause all of the *pari passu* debt obligations to trade at the same price. However following restructuring credit events the debt obligations continue to trade with a term structure and the value of this delivery option led to the introduction of the Mod-Re and Mod-Mod Re restructuring clauses as described earlier. The auction needs to be able to handle these restructuring clauses.

As we shall see, these requirements have all been met by the procedure that we now describe in detail.

THE CDS SETTLEMENT TIMELINE

We now set out the mechanics of settlement of a CDS contract once a credit event has occurred. Many important changes have been made to these mechanics over the past few years. To provide an overview, Exhibit 66–5 shows a timeline of the different stages that begin with credit event determination.

Credit Event Determination

Until 2009, the determination of whether a credit event had occurred was a bilateral decision that involved the protection buyer sending the protection seller evidence that a credit event had occurred. This evidence would consist of publicly available information such as newspaper or wire service reports of a bankruptcy,

EXHIBIT 66–5

Timeline for a Credit Event

failure to pay, or restructuring.[7] In most cases in which the source of the information was reputable and the events described clearly satisfied one of the specified credit events, the contract would trigger.

However, in cases in which the information was not public, was unclear, or was contested, there was a risk that different pairs of parties could come to different conclusions. This would be a problem for hedged intermediaries who would find

7. Or any other form of credit event included in the contract.

that one contract might be triggered but the offsetting contract would not, or that the recovery rate on one contract was not the same as the recovery rate on the offsetting contract, generating an unexpected gain or loss.

To address this concern, the market introduced a new credit event determination procedure as part of the legal protocols ushered in by the 2009 Big Bang. This introduced a new body known as the *determinations committee* (DC) that is tasked with the job of determining whether a credit event has occurred. In actual practice there are five such DCs, one for each of the following: the Americas, Asia (excluding Japan), Japan, Australia-New Zealand, and EMEA (Europe, the Middle East, and Africa).

In order to remove any bias and to ensure that decisions are not finely balanced, the membership of each committee consists of both buy-side and sell-side representatives, and the approval of decisions of the committee requires an 80% supermajority.

The credit event determination process begins when any market participant who has signed up to the new credit derivative protocols introduced in 2009 makes a request to the secretary of the DC to investigate whether a specific reference credit has experienced a credit event. This request should be accompanied by a notice of publicly available information reporting that a credit event may have occurred. The DC then has two business days to meet, investigate, and then vote on whether a credit event has occurred. If more time is needed, they can vote to extend this time period.

Once the credit event has been determined and it is a hard credit event, all CDS contracts linked to this reference credit are automatically triggered. This is a change from the pre-Big Bang procedure in which one of the parties to the CDS would choose to trigger the contract.

However if the credit event is determined to be a restructuring, either the protection buyer or the protection seller must choose to trigger the contract. Furthermore, the exact constituents of the basket of deliverable obligations depend on which party triggered first. This is discussed in more detail below.

The rationale for not making the triggering automatic is that restructuring is not a bankruptcy event but could be a precursor to one. As a result, a protection buyer may prefer not to trigger, thereby keeping the CDS protection "alive" for a later and possibly lower recovery hard credit event.

The Compression Cycle

One of the recent innovations of the credit derivatives market has been the use of what has become known as the "compression cycle." This is a procedure designed to enable groups of counterparties to cancel out mutually offsetting positions. This process is run periodically (typically once a quarter) across the entire credit derivatives market.

Although previously a rather ad-hoc procedure, it has also become an important stage in the settlement of a credit event, where it is run across the relevant CDS contracts after it has been determined that a credit event has

occurred and before the auction begins. However, this is only done for those contracts held by dealers who choose to participate in the compression cycle. The effect of running the compression cycle is to reduce the number of contracts that have to participate in the subsequent auction. This will reduce the amount of physical assets needed to settle the credit event.

The main provider of this compression service is a company called TriOptima. A third party is used to provide this service because compression is all about the cancellation of sets of contracts between three or more dealers. To do this, the parties either need to reveal their full positions list to each other or they need to involve a neutral third party. Dealers prefer the latter, and so introduce a third party to collect the information on the condition that they do not disclose position data to the other parties.

An algorithm is run that calculates the specific set of transactions that if executed would most reduce the outstanding number of contracts. These transactions are then reported back to the dealers who then can choose whether or not to execute them. Between 2008 and 2010, this compression process eliminated around $14.5 trillion of credit derivative contracts from the market.

Deliverables for a Nonrestructuring Credit Event

Within a short period of the credit event being determined by the DC to be a hard credit event, the DC publishes a timetable of when the credit event was determined, when the auction will be held and when the auction will be settled. A list of the deliverable obligations is also published.[8] For hard credit events, there is just one auction as there is just one basket of deliverables for all CDS contracts since the maturity limitation is at 30 years.

Deliverables for a Restructuring Credit Event

When the credit event is a restructuring, the situation depends on the region. In North America, there is no restructuring credit event in standard contracts and so there is only one auction. In Asia, the use of the old-restructuring convention means that there is only one basket for all contracts. In Europe, the situation is more complicated. The market standard is to include a restructuring credit event. However the standard restructuring clause is modified-modified restructuring in which the basket of deliverables depends on the scheduled termination date of the CDS contract.

The purpose of the standard modified-modified restructuring clause found in European CDS contracts is to limit the basket of deliverables in order to reduce the value of the delivery option. In approximate terms, the restructuring maturity limitation date for a deliverable into a CDS contract with a scheduled termination date (TD) is given by

$$\text{RMLD} = \text{Max}\ [\text{TD}, \text{RD} + 60\ \text{Months}]$$

8. All of this information is publicly available on the ISDA website: http://www2.isda.org/.

for restructured obligations, and

$$\text{RMLD} = \text{Max [TD, RD + 30 Months]}$$

for nonrestructured obligations. In both cases the basket of deliverables depends mainly on the TD of each CDS contract.

Reconciling this restructuring clause with an auction mechanism presents an immediate difficulty. If the reference credit has a large number of deliverable obligations distributed across the maturity spectrum, it is possible that there will be a different basket of deliverable obligations for each possible CDS scheduled termination date. Given that the longest maturity CDS contracts have a scheduled termination date in around ten years, and given that CDS scheduled termination dates are quarterly, this implies that we could have more than 30 distinct baskets of deliverables[9] for a given reference entity. However, holding this many auctions in parallel would be organizationally burdensome. It would also split the universe of relevant contracts across many auctions, resulting in a loss of liquidity and price competition in each auction.

To overcome this problem, the market has decided to run a maximum of eight different auctions by assigning each CDS contract to one of eight maturity buckets. The buckets and what they contain are listed in Exhibit 66–6. In practice, fewer than eight buckets may be used if a lack of deliverables across the maturity spectrum means that two or more buckets are identical. In this case only the earliest of these buckets will have an auction. In addition, a minimum liquidity requirement states that an auction will only be held if 300 or more contracts

EXHIBIT 66–6

The Maximum Set of Auction Buckets Used after a Restructuring Credit Event

Bucket
Nonrestructured debt obligations out to 30 months and restructured debt obligations out to 5 years;
All deliverable obligations to 5 years;
All deliverable obligations to 7.5 years;
All deliverable obligations to 10 years;
All deliverable obligations to 12.5 years;
All deliverable obligations to 15 years;
All deliverable obligations to 20 years; and
All deliverable obligations to 30 years.

9. Out to 30 months there is just one bucket according to Mod-Mod Re. Beyond 30 months, the remaining deliverable buckets depend on the contract scheduled termination date. These are quarterly so for example could be in 33, 36, 39, …, 120 months giving a total of 1 + 30 = 31 buckets.

linked to that bucket are triggered and if there are five or more dealers who are party to these transactions.

If a bucket is not used, then the protection buyer and seller have a *movement option*. This allows the protection buyer to choose to move the contract to use the next earliest maturity bucket. The protection seller also has a movement option and can also choose to move the contract to the longest maturity 30-year bucket. If both parties wish to exercise the movement option, then the protection buyer's decision is the one that takes priority.

Prior to the auction, each CDS contract must be assigned to one of these buckets. To simplify matters, one of the duties performed by the DC is to calculate and publish a table that maps ranges of scheduled termination dates to specific buckets. However, there is one final step before CDS holders know which maturity bucket, and hence which auction, is relevant to their contract. This is the triggering decision.

Restructuring: Triggering a Credit Default Swap

Unlike hard credit events, the triggering of a contract following a restructuring credit event is not automatic. In fact it is actually asymmetric in the sense that the basket of deliverable obligations depends on which party, if any, is the first to trigger the contract. The rules are as follows:

- If the contract is triggered by the protection buyer, then the basket that applies is the one that corresponds to the scheduled termination date of the CDS contract.
- If the contract is triggered by the protection seller, then the basket that applies is the longest maturity (30-year) basket.

The consequence of these rules is that each party wants the other to trigger. To see why, consider the holder of five-year CDS protection. He will prefer the protection seller to trigger because the 30-year bucket contains more deliverable obligations than the five-year bucket, and so the value of the delivery option is greater. At the same time the protection seller wants the protection buyer to trigger since he does not wish to be delivered a long-dated obligation.

However, the protection buyer also knows that if he fails to trigger within the specified period, the ability to trigger for this credit event is lost. This is known as *use it* or *lose it*. Suffice to say that both protection buyers and sellers will usually wait until the last moment to trigger. However, great care needs to be taken not to miss the triggering deadline altogether.

There is another complicating factor, which is that the decision period for the protection buyer and seller are not always the same. Typically these periods begin together, but the protection buyer has five days, whereas the protection seller has three days to decide.[10]

10. A discussion of all of the issues is beyond the scope of this chapter. For more information, see Dominic O'Kane, "Testing the Protocols," Nomura International Fixed Income Research, March 2010.

If the contract is not triggered by either party, it does not follow that the protection is lost altogether. It just means that it cannot be used for this credit event but can be used for any subsequent credit event.

The Auction Process

Before the auction, holders of CDS contracts need to decide whether they wish to use cash or physical settlement. A protection buyer who elects for physical settlement will end up with par in cash and a short position in the deliverable obligation after the auction. This replicates the economics of delivering a bond to the protection seller in return for par. Equally a protection seller who elects for physical settlement will end up paying par in cash and owning a deliverable obligation. This replicates the economics of paying par and taking delivery of a deliverable obligation from the protection buyer.

The auction breaks the link between the protection buyer and seller since each party to a CDS can each choose a settlement mechanism that may be different to that of their counterparty.

Prior to the auction, market participants who wish to have physical settlement are able to submit physical settlement requests via their dealers. These must arrive before 5 p.m. on the day before the auction. Each request must be in line with the market participant's net CDS position (i.e., a net long protection position must correspond with a request to sell bonds, and vice versa).

A protection seller will choose physical rather than cash settlement in order to realize a view that the current recovery price is too low and will rise after the auction. This view requires the protection seller to hold the physical asset.

The auction is a two-stage process that is administered by Creditex and Markit. It is carried out via the Creditex inter-dealer electronic trading platform. This means that non-dealers cannot participate directly but must do so via their chosen dealer. Both stages occur on the same auction date, with stage one usually occurring in the morning and stage two in the afternoon.

Auction: Stage One

Stage one of the auction is used to determine an indicative recovery price for the deliverable obligations and the net open interest to buy or sell physical assets that will be used in stage two of the auction. Stage one is limited to parties who have CDS positions and have submitted physical settlement requests.

The process is short, lasting only 15 minutes. In this time, the participating dealers submit two-way bid/offer prices for the deliverable obligations. At the same time, the dealers submit physical settlement requests on behalf of their customers and on their own behalf. Note that there is a maximum limit on the bid/offer spread submitted by dealers that prevents dealers from making uncompetitive markets. There is also a minimum trade size. Both of these constraints are set in advance by the DC and are a function of the liquidity and market outstanding notional of the reference credit.

At the end of this 15-minute period, the auction administrator has a further 15-minute period during which they calculate and then publish the indicative recovery price. This is more formally known as the internal market midpoint price (IMMP) and is calculated using an algorithm that rejects outlying price combinations (to prevent manipulation) and averages the remaining bid/offer spreads that are then rounded to the nearest 1/8th of a point. The internal market midpoint price will then be used in stage two of the auction procedure to constrain the final auction price.

The final calculation is the net open interest, which is simply the aggregation of the physical settlement requests. This establishes the size and direction of the demand of market participants to use physical settlement, i.e., the total amount of deliverable obligations to be traded in stage two of the auction and whether the net open interest is to buy or sell these deliverable obligations.[11]

Auction: Stage Two

Stage two of the auction occurs when the parties bid to satisfy the net open interest determined in stage one. This process results in a market-wide recovery price that is then used to settle all CDS contracts, including both those that are cash and physically settled.

Stage two begins two or three hours after the end of stage one, thereby giving market participants time to decide how to respond to the results of stage one. Unlike stage one it is an auction that is open to all parties who have signed up to the ISDA protocol, not just those who hold a CDS position in the relevant reference entity. This maximizes the number of participants and should maximize the chances of a competitive auction.

If the net open interest of stage one of the auction is to sell bonds, then the aim of stage two is to match this open interest with those who wish to buy the bonds. If the net open interest of stage two of the auction is to buy bonds, then the aim of stage two of the auction is to find bond sellers.

At the start of stage two, auction participants have a 15-minute window during which they submit limit orders of a size that is only limited by the size of the net open interest. The order prices can be at whatever price they decide. To do so, they have to commit that they will be willing to transact the limit order size of deliverable obligations at the final auction price.

When this period is over, an order matching algorithm is run on all of the submitted orders. If the open interest was to buy bonds, then the auction is one in which participants submit offer prices to sell bonds. The open interest is then filled starting at the lowest price until all of the open interest has been filled. The price at which this happens is the final auction price. If the open interest was to sell bonds, then the auction is one in which participants submit bid prices to buy bonds. The open interest is then filled starting at the highest price

11. The open interest, the various bids and offers and the calculated internal market midpoint price are all published on the www.creditfixings.com website.

until all of the open interest has been filled. The price at which this happens is the final auction price.

This final auction price may not become the official final auction price, as there is a condition that requires that the final price be within a certain range, known as the *cap amount,* of the IMMP calculated in stage one. If the final auction price is above the IMMP by more than the cap amount, then it is set equal to the IMMP plus the cap amount. If the final auction price is below the IMMP by more than the cap amount, then it is set equal to the IMMP minus the cap price.

After the auction, dealers are paired off with each other so that the demand to buy or sell deliverable obligations that were submitted in the first stage of the auction can be satisfied by the demand to satisfy the open interest that was filled by the orders submitted in the second stage of the auction. The dealers then in turn enter into trades with their customers to satisfy their physical settlement requests, and the settlement procedure is then complete.

CDS INDICES

Following the CDS, the most important product in the credit derivatives market is the CDS index. Unlike CDS, CDS indices are primarily used by investors to easily obtain a diversified credit exposure as they enable an investor to take a broad exposure to the credit market in a single transaction. The upfront cost required to enter into a CDS index is usually a small percentage of the notional and this makes it possible to leverage the risk of a CDS position. CDS indices are also used as a way to hedge the credit risk associated with a broad portfolio of credit names. This can be useful for credit funds, hedge funds, or banks wishing to hedge the so-called systemic market credit risk.

The first CDS indices appeared in 2002 to the extent that there were competing index providers in each regional market. This situation persisted until the middle of 2004. At this time the North American indices fell under the name CDX, while their European and Asian equivalents fell under the name iTraxx. The main CDS indices that now trade are listed in Exhibit 66–7. Of these the most liquid are the North American and European investment-grade indices, known as CDX IG and iTraxx Europe, respectively.

Note that in the CDS index market, "buying the index" means assuming the credit risk by selling protection and receiving the coupon. This differs from the CDS market, in which "buying" generally means buying protection. It is worth noting that the CDS indices are equally weighted when issued. This differs from stock indices, which are either market cap-weighted or price-weighted. It also differs from the traditional fixed income benchmark indices found in the credit markets, which are almost always weighted by the outstanding debt of each issuer. This was done for reasons of simplicity and to maximize diversification. However, this can change during the life of an index if one or more companies in the index splits (de-merges) or two or more of the companies in the index merge.

CDS Index Constituents

A CDS index is essentially a portfolio of CDS in which the credits in the index satisfy a certain set of inclusion criteria. For example, the CDX IG index is the CDS index, which contains the 125 most liquid investment-grade (IG) credits that trade in the CDS market and are domiciled in North America. The main inclusion criteria for the main CDS indices are shown in Exhibit 66–7.

At any moment in time, there is not just one of each of the CDS indices trading in the market but several series. This is because a new series of each CDS index is issued every six months. Although the new version of the index will have the same credit inclusion criteria as the whole series, the actual credit names of each series of the index may differ if certain credits were upgraded or downgraded, defaulted, or became less liquid since the previous issue date. The most recently issued series of any index is known as the "on-the-run" and is usually the most liquid.

There is also a further subdivision of a CDS index series by maturity. On the issue date, new series of a specific index are issued with terms which will typically include one, three, five, seven, and ten years. The maturity date of the *T*-year index will be on one of the standard CDS Dates—March 20, June 20, September 20, and December 20.

EXHIBIT 66–7

The Standard CDS Indices Showing the Type and Number of Credits in Each

Name	Domicile and Type of Credits	Number of Credits
CDX.NA.IG	North American investment-grade	125
CDX.NA.HY	North American high-yield	100
CDX.NA.XO	North American crossover[12]	35
CDX.EM	Emerging market sovereign	15
CDX.EM.Diversified	Emerging market sovereign/corporate	40
iTraxx Europe	European investment-grade	125
iTraxx Europe Crossover	European crossover	40
iTraxx Japan	Japanese investment-grade	50
iTraxx Asia ex-Japan	Asian non-Japanese investment-grade	50
iTraxx Australia	Australian investment-grade	25

12. The term *crossover* refers to credits that were initially investment-grade but have since been downgraded to subinvestment-grade.

For a series that rolls on March 20 and September 20 each year, the corresponding maturity dates will be June 20 and December 20 T years later. This means that the time to maturity of the term T index will actually be T years plus three months at issue and this will have fallen to T years minus three months by the time the next series of the index is issued six months later. This allows an investor to continuously roll his index position into the next "on-the-run" index and so be able to maintain his average maturity at close to T years.

CDS Index Mechanics

To enter into a CDS index, the buyer (or protection seller) pays an upfront cost. The value of this may be positive or negative, and so may actually result in a payment to the index buyer. This depends on the size of the fixed coupon paid by the index and the current trading level of the index.

Each series of a CDS index has its coupon set on the issue date, and this coupon is fixed thereafter. It is usually set at a value that makes the initial upfront value of the index close to zero. Once the index series has been issued, changes in the market perceived credit quality of the index causes the upfront value to change. This is exactly analogous to the mechanics of the CDS market, in which contracts linked to each specific reference entity adopted a fixed coupon in 2009.

The economics of a CDS index are identical to those of a portfolio of CDS contracts where the coupons on the CDS contracts equal the index coupon. As with a CDS, there is both a premium leg and a protection leg.

The Premium Leg

The premium leg of a CDS index is the payment of the coupon to the buyer of the index. The actual payment amounts are determined by multiplying the index fixed coupon by the day count fraction[13] that has elapsed since the previous coupon date and then by the *surviving notional* of the index reference portfolio. The surviving notional at initiation is the contract notional. However, over time this may change if there are credit events.

As credits in the reference portfolio experience credit events, the surviving notional of the index is reduced in proportion to the number of credits remaining. So if two credits in a reference portfolio of initially 125 credits experience a credit event, the surviving notional of the index is 123/125 times the initial notional and the size of the coupon is also reduced to 123/125 times the initial coupon. Note that the notional does not depend on the size of the recovery rate of the defaulted credits, just the number of credit events.

The economics of a CDS index premium leg are therefore equivalent to that of a portfolio of CDS premium legs linked to each of the reference credits in the index, which all pay a fixed coupon equal to the index coupon. The premium leg

13. The day count fraction is usually calculated according to an Actual 360 basis convention.

is paid until the end of the contract, the exception being the unlikely case of all of the credits in the reference portfolio experiencing a credit event.

The Protection Leg

The protection leg of the CDS index is identical to that of an equally weighted portfolio of CDS protection legs on the reference portfolio. If a credit event occurs on a reference credit in the index, the index buyer must pay the index seller the loss on that credit. The process is as follows:

1. The credit is immediately removed from that index series across all maturities.
2. The new index without the credit is thereafter assigned a new version number to distinguish it from earlier versions of the index series.
3. The reference credit that was removed then becomes a standalone CDS position with the notional corresponding to its notional size in the index, e.g., if the index position size was $10 million and there were 125 credits in the index, then the notional of the standalone CDS contract will be $80,000.

The standalone CDS position then takes part in the standard auction procedure as described earlier. In economic terms, this will result in the index buyer having to pay the index seller par minus the auction recovery rate on the CDS notional.

There is an added complication if the credit event was a restructuring. In this case, the index buyer and seller have the option to trigger the standalone contract. If they both choose not to trigger, then the standalone CDS position continues to sit on their respective books until maturity or until it is triggered by a subsequent credit event. However, this is usually only a consideration for European and Asian index holders since, as shown in Exhibit 66–4, the standard for North American indices is to exclude restructuring as a credit event.

IMPORTANCE OF THE CDS MARKET

The credit derivatives market has become an important branch of the credit markets. The ease with which a single-name CDS can be traded has made it an invaluable hedging tool for many, most notably bank loan risk managers. The CDS index has also become an important investment tool for credit investors seeking to quickly and easily obtain a macro-level credit exposure.

In the aftermath of the financial crisis of 2008, the market quickly responded with a number of fundamental changes in the format and mechanics of the contract to increase fungibility and so decrease counterparty risk. The triggering and settlement of credit events were revised to ensure that there is a common market-wide process and to minimize the risk of failing to settle.

Many of the changes were intended to facilitate making all market participants face centralized counterparties (CCPs) rather than dealers in an attempt to reduce the systemic risk associated with the default of a major dealer. This process began in 2009 and by February 2011, one of the major clearing houses, the ICE Trust in North America and ICE Clear in Europe, had together cleared more than $15 trillion of credit derivatives, of which over 80% were CDS indices.

One area of valid criticism of the market was its opaqueness pre-2008, which was unsurprising given the OTC nature of credit derivative transactions. The publication of high-level position data by the New York-based DTCC who are responsible for CDS settlements has added a new level of transparency with respect to market size, the reference entities being traded and the different types of counterparties.

A recurring pattern of the credit derivative market has been that each time there is a credit crisis that exposes any flaws in the mechanics of the market, the market moves quickly to attempt to eliminate such flaws so that the same problems will not recur. This reflects the importance that the market attributes to a well-functioning credit derivatives market. As a result, the market is now better settled, more transparent, less exposed to systemic risk, and better regulated than it has ever been.

KEY POINTS

- The credit derivatives market is dominated by the single-name credit default swap (CDS) and the CDS indices.
- The growth of the CDS and CDS index market has been driven by its many uses. These include transferring credit risk, hedging credit risk, isolation of credit risk, leveraging and yield enhancement, structured credit investments, and managing regulatory risk.
- The simplest way to think of the CDS is as an insurance contract in which one party, the "protection buyer," pays a premium to be protected against a credit loss on a specific face amount of bonds or loans issued by a specified corporate or sovereign reference entity.
- The other party to the CDS, known as the "seller of protection," receives the premium and takes on the credit risk. The protection seller makes a contractual payment to the protection buyer if a credit event occurs during the tenure of the contract.
- The "credit event" is the term used by the credit derivative market to define each of the events that can trigger the payment of the CDS protection. Credit events may include bankruptcy, failure to pay, obligations acceleration, repudiation/moratorium of debt, and restructuring of debt.

- The event of restructuring is a "soft" credit event since debt can continue to trade with a term structure after a restructuring. Since this can create a potentially valuable "delivery option" for protection buyers, it is excluded from the standard CDS contract on North America-domiciled companies. However, regulatory and other differences mean that it is included in standard contracts on Europe- and Asia-domiciled companies.
- To avoid a "short squeeze" following a credit event and to ensure that the same recovery rate is used across the market, the CDS market has introduced an auction process in which holders of the relevant CDS engage and only the net amount of deliverable obligations need to be physically traded.
- Credit default swap indices are equally weighted portfolios of up to 125 CDS that can be traded in one single highly liquid transaction. The CDS index market provides asset managers with a highly liquid way to assume or hedge an exposure to market-wide or sector-wide credit risk.
- Following the financial crisis of 2008–2009, the credit derivative market made a number of substantial reforms in order to ensure a well ordered market-wide settlement mechanism following credit events, to improve transparency and reduce systemic risk via the use of centralized counterparties.
- A CDS or CDS index contract can be sold at any time before maturity, allowing the owner to realize any gain or loss resulting from changes in the market perceived credit quality of the reference entity.

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CHAPTER
SIXTY-SEVEN

CREDIT DERIVATIVE VALUATION AND RISK

DOMINIC O'KANE, D.PHIL. (OXON)
Affiliated Professor of Finance
EDHEC Business School

The purpose of this chapter is to set out the valuation methodology for credit swaps (CDS) and CDS indices. As described in Chapter 66, a credit default swap (CDS) is the most commonly traded credit derivative contract. It is also the building block for the CDS indices. An understanding of the valuation and risk management of CDS is therefore essential if we are to understand the valuation and risk management of CDS indices and other credit derivatives.

CDS VALUATION

For valuation purposes the essential features of a CDS contract are as follows:

- A regular fixed coupon is paid on the premium leg from the protection buyer to the protection seller according to a frequency and basis convention as set out in Exhibit 67–1. The coupon is paid until contract maturity date or a credit event, whichever occurs first. If the credit event occurs between two coupon payment dates, the market standard convention is that the portion of the coupon that had accrued from the previous payment date until the Event Determination Date[1] must be paid by the protection buyer.
- A payment of par minus the recovery rate is paid following a credit event. The recovery rate is set at the auction (which was described in Chapter 66) and paid shortly after on the auction settlement date.

We therefore have future cash flows which are contingent on a credit event. The CDS value is given by the expected present value of these flows calculated in the "risk-neutral" measure (i.e., using probabilities of a credit event that exactly reprice the term structure of market prices of quoted CDS).

The author acknowledges the helpful comments from Samuel Morgan and Mark Ames.

1. This is the date the question to determine a credit event was submitted to the determinations committee (DC).

EXHIBIT 67–1

Standard CDS Contract Specifications for North American and European Markets

Specification	North America	Europe
Maturity Date	CDS dates unadjusted	CDS dates unadjusted
Accrual Dates	CDS dates adjusted except for maturity date	CDS dates adjusted except for maturity date
Payment Dates	CDS dates that are holiday adjusted	CDS dates that are holiday adjusted
Coupons	100 bp and 500 bp	25 bp, 100 bp, 500 bp, and 1,000 bp
Frequency	Quarterly	Quarterly
Day Count Basis	Actual/360	Actual/360
Pay Accrued on Default	Yes	Yes

The precise rules which generate the schedule of premium leg payments are listed in Exhibit 67–1. The CDS dates referred to in this Exhibit are March 20, June 20, September 20, and December 20.

Need for a Model

The pricing and risk management of a CDS contract requires the use of a pricing model. There are a number of reasons for this:

1. The CDS market is OTC. As such, there is no central location where trades are executed from which prices can be instantly reported. Prices are instead agreed bilaterally and privately. Market pricing providers such as Markit[2] only provide end-of-day pricing based on aggregating pricing submissions from various dealers.
2. Even if CDS contracts were exchange-traded, the quotation of prices would be complicated by the fact that there are so many different variations in the contracts outstanding. Consider just those contracts written against a single reference entity and assume that the longest maturity contract is 10 years and that all contracts trade with the same coupon and credit events. Since maturity dates are on a quarterly schedule, we can have as many as 40 different contracts being traded, albeit with varying degrees of liquidity. Quoting so many numbers per issuer can be cumbersome. A model that allows pricing based on a smaller number of market inputs is certainly preferable.

2. www.markit.com.

3. Although there is the concept of a standard CDS contract, market participants can request customized features which may deviate from this standard. For example, a company may wish to buy a forward CDS contract in which protection starts at some future date. To price this correctly relative to other CDS, a model is required that must also reprice the current market prices.
4. A valuation model is also important for risk management. With bonds, we need, at the very least, to introduce the concept of a yield-to-maturity and yield-curve before we can start to hedge the interest rate risk of a bond portfolio with other bonds. The same is true with a portfolio of credit default swaps. A model is needed in order to be able to quantify spread risk and to hedge the credit risk sensitivity of one CDS against another.

The value of a CDS contract is simply the upfront value at which the CDS contract should trade. For a protection seller, this is equal to the expected present value of the incoming coupons on the premium leg minus the expected present value of the protection leg. For a protection buyer, it is the negative of this since the protection buyer is receiving the protection but paying the coupons.

Even without a model, we can begin to think about the factors that affect the CDS value. We consider the two legs separately:

1. The value of the premium leg is the expected present value of the coupons paid until maturity or a credit event, whichever happens first. If the credit quality of the reference credit falls then this will make an early credit event more likely and so it is more likely that not all of the coupons will be received. The expected present value of the premium leg will then fall. Also, as it is an annuity of fixed coupons, its present value will also fall if interest rates rise. The value of the premium leg also increases with CDS maturity since more coupons are to be paid.
2. The value of the protection leg increases if the credit deteriorates since it becomes more likely that the payment of par minus the recovery rate will be received. It will also increase with increasing contract maturity as protection for a longer period is always more valuable than for a shorter period. However, it falls as interest rates increase since it is the present value of a future contingent payment.

Before we move on to describe a model that can value each of the legs, we first wish to show that it is possible to actually determine the no-arbitrage value of the upfront cost of protection by reference to the cash bond market.

THE CDS–BOND RELATIONSHIP

Subject to a number of important assumptions, there is a fundamental no-arbitrage relationship between the upfront value of a CDS and the price of a specific floating rate bond issued by the same reference entity. Specifically, our aim is to

show that there is an exact relationship between the upfront cost of a time T maturity CDS, U, and the price P of a floating rate note with a time T maturity where the floating rate note pays a floating rate coupon equal to LIBOR plus a spread C. This spread must be equal to the fixed spread of the CDS. We need to consider the following trading strategy:

1. At time zero, an investor borrows an amount $P + U$ at a funding rate of LIBOR. This assumes that the investor has a credit quality similar to that of highly rated commercial banks. This funding is locked in until future time T. Interest payments are made quarterly.
2. At time zero, the investor uses P of the borrowed money to buy one unit of face value of a time T maturity floating rate note issued by the reference entity at a specific seniority. The full price of this bond is P. For simplicity we assume that the purchase begins on a coupon payment date so that there is no accrued interest to consider.
3. At the same time, the investor uses U of the borrowed money to buy CDS protection on one unit of face value of the reference entity that matures at future time T. Note that U can be positive or negative. Following this, the now hedged investor will have to make quarterly coupon payments.

To analyze this strategy, we need to determine the payments at four different types of event: (1) initiation, (2) coupon payment dates, (3) following a credit event, and (4) maturity time T (assuming that no credit event has occurred). These are shown in Exhibit 67–2.

For simplicity we assumed that the credit event occurs on a coupon payment date so that the repayment of the funding simply costs par, i.e., the face value of the borrowing, which in this case is $(P + U)$, and so that there is no coupon accrued to be paid on the CDS.

As the initial net cash-flow is zero—the strategy costs nothing to enter—the expected value of the future payments should equal zero. For this to be true, we require that $P + U = 100\%$, i.e., there is a fundamental no-arbitrage relationship

EXHIBIT 67–2

No-Arbitrage Strategy of Bond plus CDS Protection

Time	Funding	Bond	CDS	Net
Initiation	$P + U$	$-P$	$-U$	0
Coupon Dates	$-(P + U)\Delta L$	$(L + C)\,\Delta$	$-C\Delta$	$-(P + U)L\Delta + L\Delta$
Credit Event	$-(P + U)$	R	$(100\% - R)$	$100\% - (P + U)$
Maturity	$-(P + U)$	100%	0	$100\% - (P + U)$

between the upfront cost of the CDS and the price of a floating rate note issued by the same reference entity. For example, if the LIBOR floater is priced at par, then the upfront value is zero. However if the LIBOR floater is worth more than par, then the upfront cost of protection is negative. If the LIBOR floater is worth less than par, then the upfront cost of protection is positive.

In order to establish this relationship, we have had to make a number of simplifying assumptions. The main ones are:

1. We assumed that the bond buyer funded at LIBOR flat and that funding at this level can be locked in until the maturity of the CDS. In practice, the funding of the bond will be done in the repo market where it will generally not be possible to lock-in the funding level for any extended period. The hedged investor therefore has funding risk, which can work for or against them. There may also be a haircut on the amount funded and this depends on the market risk of the bond, which is used as collateral in the repo.
2. We assumed the existence of a T-maturity *pari passu* floater, which pays LIBOR plus C where C is equal to the fixed spread of the CDS contract.
3. We ignored the effect of the delivery option, which could allow the protection buyer to deliver a cheaper bond (if one exists). This is most likely to be of value if the CDS includes restructuring as a credit event. The value of this option should make the cost of protection higher.
4. We assumed that the credit event falls on a coupon payment date. In practice a default between coupon payment dates will mean an additional payment by the protection buyer of the accrued coupon on the CDS. For the bond, it may mean that the unpaid coupons are added to the bondholders' claim in bankruptcy.
5. We ignored the effect of counterparty risk on the CDS. Counterparty risk is typically mitigated by the posting of upfront collateral.
6. We ignored tax effects that may treat the coupon and principal differently.
7. We ignored transaction costs and market technical effects. In the latter case, we note that since the CDS market makes it easier to short credit risk, any negative news on a credit will typically impact the CDS market first, causing the CDS upfront price to increase before bond prices fall.

What we have done here is to establish a link between the upfront costs of CDS and the pricing of a specific bond issued by the same reference entity. However, in practice, this is not a viable way to price CDS contracts since it is almost certain that the required T-maturity *pari passu* floater, which pays a spread equal to the coupon on the CDS, does not exist. Also, the list of assumptions means that although there is a strong relationship between bond prices and CDS upfront costs, the relationship is not exact.

The CDS Basis

The difference between the cash and CDS market is known as the CDS basis. It is defined as

$$\text{CDS Basis} = \text{CDS Par Spread} - \text{Bond LIBOR Spread}$$

This is not an exact definition since there are various ways to quote the bond LIBOR spread.[3] One LIBOR spread widely used by the market is the asset swap spread of a bond of the issuer with a similar maturity to the CDS, which is trading at a price close to par.

Trading the CDS basis has become a relative value strategy of a number of credit investors, in particular credit hedge funds. The aim of basis trading is to determine which of the assumptions listed above is driving the difference between CDS spreads and bond spreads and to take a view on whether these are correctly or incorrectly priced and liable to change.

The standard basis trade is the "negative basis trade" in which the investor buys the bond and buys protection. It is called a negative basis trade because the investor receives the bond spread and pays the CDS spread—the investor receives negative of the basis as defined above.

Valuation of an Existing Contract

Consider an investor who sells protection using a five-year CDS contract at time zero. The upfront cost, which is the amount paid in cash to enter the contract is $U(0)$. In return, the investor receives a regular coupon C and we call the expected present value of this the value of the premium leg. He also has to pay the counterparty $(1 - R)$ on the face value of the protection if there is a credit event between the effective date and the contract maturity time. The expected present value of payment is the value of the protection leg. We can therefore state that $U(0)$ is the cost of this where

$$U(0) = V_{\text{Premium}}(0,5) - V_{\text{Protection}}(0,5)$$

This is at initiation. Subsequently, at time t, the value of the premium leg and protection legs will change as coupons are received, maturity approaches and the market's view of the default risk of the reference credit changes. At this time the value of the contract is given by

$$U(t) = V_{\text{Premium}}(t,5) - V_{\text{Protection}}(t,5)$$

One year later, the investor wishes to unwind his position. Given that he sold protection, he must now buy protection. The cost of entering into the long protection position is given by $-U(1)$ where

$$U(1) = V_{\text{Premium}}(1,5) - V_{\text{Protection}}(1,5)$$

3. These include the asset swap spread, the par floater spread, the discount margin and the zero volatility spread.

Since the coupon dates and any contingent protection payments on this new contract match exactly the coupon payment dates and any contingent protection payment on the existing contract, the combined position has future cash flows equal to zero. The mark-to-market value of this short protection CDS position at any time is therefore simply the upfront cost of buying protection to the same maturity as the initial contract. This is different from the P&L which is the money earned or lost by first selling protection and then closing out the trade one year later by buying protection. This is equal to the upfront cost $U(1)$ which was received plus all of the rolled-up coupon payments minus the cost of repaying any initial loan $U(0)$.

Market Pricing

The pricing of CDS is done with reference to the spreads at which the current market standard contracts trade. These are for contracts which terminate at the main maturity points, which include six-months and one, two, three, four, five, seven, and 10 years. The market has two conventions for quoting spreads. They are:

1. Par Spreads: The T-year par spread is defined as the coupon that would be paid for protection on a T-year contract *which has no initial cost.*
2. Flat Quoted Spread: The T-year flat quoted spread is defined as the level at which a flat CDS par spread curve needs to be marked in order that the model-implied upfront value matches the upfront value quoted in the market. It therefore ignores the shape of the term structure of the CDS market—it is the CDS equivalent of the bond yield-to-maturity.

The par spread was the quotation convention for the CDS market until 2010. The "problem" with the par spread is that calculation of the upfront value requires knowledge of the full term structure of par spreads of quoted CDS contracts with the same or shorter maturities. Therefore, several par spreads may be needed to calculate one CDS upfront value and one CDS upfront value cannot be used to imply a term structure of par spreads. As a result, the quoted flat spread has become the market standard. Its existence is based on a need to have a spread-based quotation for the price of a CDS contract. Use of the quoted flat spread also entails using the market standard recovery rate assumption, which is currently set at 40% for senior unsecured debt.

Because the quoted spread convention assumes that the spread curve is flat, there is a one-to-one mapping (based on the pricing model that we will describe below) between the T-year maturity quoted flat CDS spread and the upfront cost of a T-year CDS contract. Note also that if the par spread curve is actually flat, then the quoted flat spreads will all be the same for all maturity points and par and quoted flat spreads will be equal.[4] In order to assist clarity, we will be using the notation in Exhibit 67–3 to denote these different coupons and spread measures in what follows.

4. This presumes that the same recovery rate assumption is used.

EXHIBIT 67–3

Notation for Spreads and Coupons

Symbol	Description
$C(T)$	The coupon of a T-year maturity CDS contract.
$U(t)$	The upfront value of a T-year maturity CDS contract at time t.
$S(t, T)$	The time t par spread paid on a T-year maturity CDS contract that has no initial cost.
$\bar{S}(t, T)$	The "quoted" spread is the level of a flat par CDS spread curve that sets the model-implied upfront cost of a T-year CDS equal to its market value at time t.

MODEL

To value a CDS, we need a model. This model must satisfy the following requirements:

1. It must capture a credit event as a single event that can occur at any future time.
2. It must capture the timing of the default and the fact that the market may expect the future default rate to be a varying function of time, i.e., it can have a term structure.
3. It must capture the payment of par minus the recovery rate following a credit event.
4. It must be able to reprice the term structure of market prices exactly.
5. It must be fast to calibrate to the market and fast to price.

The standard model in the market is based on the use of the survival probability $Q(T)$. This is the probability that the reference credit survives without experiencing a credit event from today (time zero) to time T in the future. The value of $Q(T)$ must be between 0 and 1, and must be a constant or decreasing function of T.

Valuation of the Premium Leg

The premium leg of a CDS is the payment of the fixed coupon that continues at quarterly intervals until a credit event or maturity, whichever occurs first. Each coupon is therefore a conditional payment—conditional on the reference entity surviving until the coupon payment date. We also need to discount these future

conditional coupons at the LIBOR rate. If we assume that the premium leg has N remaining coupons, we can write

$$V_{\text{Premium}} = C(T)\sum_{i=1}^{N} \Delta(t_{i-1}, t_i) Z(t_i) Q(t_i)$$

That is, for each payment date we multiply the fixed coupon $C(T)$ by the year fraction $\Delta(t_{i-1}, t_i)$ since the previous coupon payment date in the corresponding basis.[5] We then weight it by the probability of the reference entity surviving to the coupon payment date by multiplying by $Q(t_i)$. We finally discount it back to today at the LIBOR rate using the discount factor $Z(t_i)$.

By itself, this equation fails to take into account the coupon accrued that has to be paid if there is a credit event between coupon payment dates as it assumes that the CDS only pays a coupon if the reference credit survives up to the coupon payment date. An exact calculation of the value of the contribution of the coupon accrued is beyond the scope of this chapter. However, we can approximate the value of the contribution by simply assuming that if the reference credit experiences a credit event in the period before the coupon is paid, it will on average occur in the middle of the period. In this case, the amount of accrued coupon will be

$$\frac{C(T)\Delta(t_{i-1}, t_i)}{2}$$

i.e., one half of the full coupon. The probability of defaulting in the period before the coupon is due to be paid is given by $Q(t_{i-1}) - Q(t_i)$. For simplicity and without any significant loss of accuracy we can assume that this is then paid at the end of the period. We therefore have a coupon accrued contribution given by

$$\frac{C(T)}{2}\sum_{i=1}^{N} \Delta(t_{i-1}, t_i) Z(t_i)(Q(t_{i-1}) - Q(t_i))$$

Adding this to the value of the premium leg above gives

$$V_{\text{Premium}} = \frac{C(T)}{2}\sum_{i=1}^{N} \Delta(t_{i-1}, t_i) Z(t_i)(Q(t_i) + Q(t_{i-1}))$$

We can rewrite this as

$$V_{\text{Premium}} = C(T)A(T)$$

5. The market standard is Actual/360. Care needs to be taken since in practice there may be a difference between the accrual dates and the actual payment dates. In particular the actual final payment date at maturity is usually holiday/weekend adjusted while the final accrual date is not.

where

$$A(T) = \frac{1}{2}\sum_{i=1}^{N} \Delta(t_{i-1}, t_i) Z(t_i)(Q(t_i) + Q(t_{i-1}))$$

The quantity is known as the risky annuity. It is the expected present value of the premium leg assuming it pays an annualized coupon of \$1 and any accrued fraction of this coupon if there is a credit event. It is a function of the entire shape of the survival curve since each premium payment is weighted by the survival probability to the premium payment date.

Value of the Protection Leg

The protection leg pays $(1 - R)$ at the time of a credit event.[6] To find the present value of this we have to take into account when the payment occurs. We need to split the time between today and the end of the contract into lots of small intervals and determine the probability of defaulting in each small time period and then discount the payment back to today.

Suppose we split the time between now, time 0, and the maturity date in T years into M such intervals of length T/M. The value of the protection is then given by

$$V_{\text{Protection}} = (1 - R)\sum_{n=1}^{M} Z(t_n)(Q(t_{n-1}) - Q(t_n))$$

where $(1-R)$ is the amount paid following a credit event, which we assume does not depend on the timing of the credit event, and $Q(t_{n-1}) - Q(t_n)$ is the probability of defaulting between time t_{n-1} and t_n.

In practice, the value of M must be a large number in order to best capture the full shape of the survival probability curve and the discount curve. However, it cannot be too large otherwise it would become numerically slow to price a CDS contract.[7]

The Upfront Cost

Here we define the upfront cost as the cost which must be paid by a protection buyer to enter into a CDS contract. It is therefore the expected present value of the protection leg minus the expected present value of the premium leg; that is, it is given by

$$U(0) = V_{\text{Protection}} - V_{\text{Premium}}$$

6. Strictly speaking, payment occurs on the settlement date of the post-credit event auction. The two steps in the auction are described in Chapter 66.
7. A discussion of appropriate values for M is provided in Dominic O'Kane, *Modelling Single-Name and Multi-name Credit Derivatives* (John Wiley & Sons, 2008).

where

$$V_{\text{Premium}} = \frac{C(T)}{2}\sum_{i=1}^{N}\Delta(t_{i-1},t_i)Z(t_i)(Q(t_i)+Q(t_{i-1})) = C(T)A(T)$$

and

$$V_{\text{Protection}} = (1-R)\sum_{n=1}^{M} Z(t_n)(Q(t_{n-1})-Q(t_n))$$

These are all at time 0.

The Upfront and the Par CDS Spread

The T-year par spread $S(T)$ is the value of the coupon on the T-year CDS, which makes the current value of the contract equal to zero. Therefore

$$S(T)A(T) - V_{\text{Protection}} = 0 \Rightarrow V_{\text{Protection}} = S(T)A(T)$$

But the value of the contract at time zero using its actual coupon is

$$U(0) = V_{\text{Protection}} - C(T)A(T)$$

and we can substitute in the protection leg value to write this as

$$U(0) = \big(S(T) - C(T)\big)A(T)$$

The situation changes when we calculate the value of the contract using the flat spread. This is simply defined via the equation

$$U(0) = (\bar{S}(T) - C(T))\bar{A}(T)$$

This equation looks almost identical to the par spread valuation above. However there is one major difference. The value of the risky annuity here is only a function of the quoted flat spread $\bar{S}(T)$, whereas the value of the risky annuity using the par spread is a function of the *term structure of par spreads*. Clearly, the quoted flat spread does not take into account the term structure of spreads.

Interpolation of the Survival Curve

Before we can use this model, we must calibrate it to the term structure of market prices. This can mean a number of things. It could mean calibrating it to a term structure of upfront costs, a term structure of par spreads, or a term structure of flat spreads. Whichever it is, we will usually have market price data at maturity points starting at six months and then up to 10 years in annual steps. To use these 11 market prices to calibrate a term structure of survival probabilities we need to simplify the term structure of survival probabilities so that it is described by

exactly 11 variables. Then we will have one unknown variable for each piece of data and we should then be able to fit exactly the market prices using this simplified term structure.

There are many ways to do this simplification. The market standard is to introduce the continuously compounded forward default rate $h(t)$. This is defined in terms of the survival probability as

$$Q(T) = \exp\left(-\int_0^T h(t)dt\right)$$

A common simplification is to assume that this continuously compounded forward default rate is piecewise flat as shown in Exhibit 67–4.

Given 11 market prices, the term structure of this continuously compounded forward default rate takes 11 different values: $h(0.5)$, $h(1.0)$, $h(2.0), \ldots, h(10)$, where each $h(t)$ is the value of the continuously compounded forward default rate from the previous time to time t. We then have

$$Q(0.5) = \exp(-0.5 \times h(0.5))$$
$$Q(1) = Q(0.5) \times \exp(-0.50 \times h(1.0))$$
$$\ldots$$
$$Q(10) = Q(9.0) \times \exp(-h(10.0))$$

EXHIBIT 67–4

Piecewise Flat Term Structure of the Forward Default Rate in Which We Calibrate to the 6M, 1Y, 2Y, ..., 10Y CDS Upfront Prices

However, the power of this approach is that it allows us to interpolate the value of the survival curve to other times. So for example we have

$$Q(0.3) = \exp(-0.3 \times h(0.5))$$
$$Q(0.7) = Q(0.5) \times \exp(-0.20 \times h(1.0))$$
$$Q(1.9) = Q(1.0) \times \exp(-0.90 \times h(2.0))$$

The whole term structure of survival probabilities is determined by these 11 values of the continuously compounded forward default rate. As long as the value of $h(t)$ is greater than or equal to zero, the term structure of CDS spreads will be arbitrage-free.[8]

Calibration by Bootstrap

Given the model and this interpolation scheme, we need one more input before we can calibrate the values of the continuously compounded forward rates to the market prices of CDS. This is the value of the expected recovery rate R. Note that this does not have to be the same value as the one used by the market to convert the flat quoted spread to an upfront and back which is currently set equal to 40%. It can be a value chosen by the model user.[9] With all of this information, the calibration can then be performed. This is done using a bootstrap.[10] The process is as follows:

1. Search for the value of $h(0.5)$ for which the model-implied upfront value equals the market quoted upfront of the six-month contract given the fixed coupon. As there is one unknown and one price, we should be able to determine $h(0.5)$ so that the market price is fitted exactly.
2. Using $h(0.5)$, now search for the value of $h(1.0)$ for which the model implied upfront equals the market quoted upfront of the one-year contract given its fixed coupon.
3. Repeat step two for each next longer maturity CDS, each time using knowledge of all the previously calibrated values of $h(t)$ to calculate the next one.

8. A term structure of CDS spreads can exhibit an arbitrage if the value of the protection leg to time T_1 is greater than the value of the protection leg to time T_2 where $T_2 > T_1$. In some cases this can allow for a strategy which can guarantee a positive income at no initial cost.
9. The effect of choosing a different recovery rate is that although the model will be calibrated to the market prices of quoted CDS contracts, the value of the protection and premium legs taken separately may differ from the value of the protection and premium legs according to the market standard recovery rate assumption.
10. A bootstrap is the name given to an algorithm that recursively solves a system of coupled equations one at a time, with each solution being found only after a set of the previous parameters have been found.

At the end of this process, we should have a value of h for each market price. From this we are able to compute the market-implied value of $Q(T)$ to any future time T. The value of $Q(T)$ that emerges from our market calibration is the "risk-neutral" survival probability. By risk-neutral, we mean the probability that, according to our model, reprices the market prices of CDS spreads—any other set of probabilities would not reprice the market and hence could create arbitrage possibilities. These spreads are credit-specific, forward-looking measures of the compensation required by a protection seller to sell protection until time T.

It is generally found[11] that credit spreads overcompensate the investor for the expected loss based on the incidence of default of other credits that had the same credit rating. There are a number of reasons why this may be the case. Mainly it is because the market is forward looking and may not consider historical default probabilities, especially when averaged over an economic cycle, to be appropriate given the current state of the economy. Also, because there is typically a large systemic and hence nondiversifiable component to credit spreads, investors demand an additional premium.

NEW AND EXISTING CONTRACTS

The price calculated by a CDS valuation model is the full price, i.e., the cash amount actually paid for the protection. One of the contractual details which determines this value is the date when the contract starts accruing the premium. In order to improve market fungibility of CDS contracts, the standard is for all new contracts to have a full first coupon; i.e., they begin accruing from the previous coupon payment date even if the contract was traded and settled more recently. This makes all contracts with the same maturity date identical in term of their cash flows. It also means that a hedger who buys protection mid-payment period will have to pay for protection that was not received and should expect to be reimbursed for this through the value of the upfront payment. After all, the upfront cash amount to be paid to enter into this contract for protection is the expected present value of the protection leg minus the expected value of the premium leg. This premium leg will include a full first coupon.

The simplest example we can use to examine the effect of this is to assume that the CDS has a fixed coupon of 100 bp and the par spread to the same maturity is also at 100 bp. However, the par spread is based on a CDS contract which starts accruing at $T + 1$, i.e., one day after the trade date, which must by definition have zero upfront value. Calibration of our CDS model determines the survival probability curve that ensures that this is the case. In more general terms, the value of the same maturity CDS used to calibrate the CDS valuation model is given by:

$$U_{Calibration}(t) = V_{Protection} - C(T)A(t,T) = 0$$

11. For a literature review. see John Hull, Mirela Predescu, and Alan White, "Bond Prices, Default Probabilities and Risk Premiums," *Journal of Credit Risk* 1(2) (2005), pp. 53–60.

If we then use this curve to price our existing contract, we will find that the value of the contract will be

$$U_{Contract}(t) = V_{Protection} - C(T)A(t_0, 0)$$

where t_0 is the time of the previous coupon. But we can then write

$$A(t_0, T) \approx A(t, T) + \Delta(t_0, 0)$$

which should be a very good approximation.[12] This gives

$$U_{Contract}(t) = V_{Protection} - C(T)A(t, T) - C(T)\Delta(t_0, 0)$$

The first two terms on the right-hand side equal the value of the CDS contract we are calibrating to which is zero, and so we have

$$U_{Contract}(t) = -C(T)\Delta(t_0, 0)$$

This is the negative of the coupon which has accrued since the previous coupon date. The protection buyer therefore finds that the contract pays him for the portion of coupon which accrued since the last coupon date which he has to pay on the next payment date, but whose benefit he did not enjoy since he wishes to enter the contract today. Clearly the payment of the coupon can be up to three months in the future (this is offset by the fact that the further in the future the coupon payment occurs the less that has accrued) while the upfront cost is paid on the settlement date which is trade date plus three days, holiday adjusted. For this reason, setting the value of the contract equal to the negative of the accrued coupon is a good approximation but one that would only be exact in a world of zero interest rates.

There is one more issue to consider—the CDS contract provides protection against a credit event which occurred between T-60 and today. If such an event has been determined by the Determinations Committee (see Chapter 66) then the CDS contract would be in its post-credit event settlement process and the upfront cost would be close to par minus the expected recovery rate. If the event has not been determined, the implicit assumption is that market expectations that a credit event occurred in the past 60 days are already priced into the CDS spread curve.

RISK MANAGEMENT

We now wish to understand the factors that drive the valuation of a CDS contract. Specifically, we want to be able to calculate the hedge ratios needed to ensure that the value of a portfolio of CDS contracts on the same reference credit is immunized

12. It is based on the observation that any already accrued coupon will either be paid on the next coupon date if there is no default or it will be paid immediately if there is a default. In this sense it is a risk-free payment made at some point in the short period between today and the next coupon date. Since the period is short we can almost always ignore the time-value issue and not discount it.

against parallel moves in the CDS spread curve and the LIBOR interest rate curve. We begin by writing the time t upfront value of a (short protection) CDS contract as

$$U(t,S(t,T)) = \big(C - S(t,T)\big)\,A(T,S(t,T))$$

where $S(t, T)$ is the time T maturity par CDS spread as seen at time t. Note that we have inserted an explicit par spread dependency into the upfront value and the risky annuity term $A(T, S(t, T))$ to remind ourselves that a change in the par spread followed by a recalibration will cause the term structure of survival probabilities to change and so will change the present value of the risky annuity and the value of the upfront.

Spread DV01 of a CDS

The credit duration of a CDS contract is usually known as the Spread DV01. It is defined as the change in the upfront value of the contract for a 1 bp parallel bump upwards in the CDS spread curve. For a short protection position, we can write this as

$$\text{Spread DV01} = U(t,S+1bp) - U(t,S)$$

This gives

$$\text{Spread DV01} = -A(T,S+1bp)\cdot 1bp + (S-C)\cdot\big(A(T,S) - A(T,S+1bp)\big)$$

There are two contributions to the Spread DV01:

1. The first term describes a fall in the upfront value of the short protection position by $A(T, S + 1\ bp)$ times the change in the spread. The value falls because we have sold protection and the credit quality of the reference credit, as implied by the spread which was bumped, has worsened so the position has lost value.
2. There is a second term due the fact that the change in spread also causes the value of $A(T, S)$ to change. Because this term is multiplied by the spread difference $(S - C)$, it is usually much smaller then the first term. Also, the sign of the change is driven by the sign of $(S - C)$. If this is positive, it means that this term will offset the effect of the first term and reduce the Spread DV01. If negative it can increase the Spread DV01.

The Spread DV01 of a short protection position is therefore typically close in value to the negative of the risky annuity given by $A(T, S)$ multiplied by 1 basis point and approaches[13] it if $S = C$. The spread sensitivity from the perspective of a long protection position is simply the negative of that of a short protection position.

Hedging different CDS positions using the Spread DV01 is only really effective if the quoted spread or par spread of the different contracts move by

13. It does not equal it exactly, since when $S = C$ the Spread DV01 equals –A(S + 1) and not –A(S).

the same amount. For contracts of differing maturity, this requires the CDS curve to move in parallel shifts, which is not always the case. For this reason, use of the Spread DV01 should generally only apply to contracts of a similar maturity. To go beyond Spread DV01, we would need to calculate the sensitivity of a CDS contract to movements of different curve points (e.g., one year, three year, five year, seven year, and 10 year), and determine the set of positions in each of these contracts needed to immunize the hedged portfolio against spread movements.[14]

Interest Rate Duration of a CDS

The interest rate sensitivity of a CDS contract is known as its IR DV01. It is defined as the change in the upfront value of the contract for a 1 bp parallel bump upwards in the LIBOR curve while keeping the par spread curve fixed. As the only interest rate dependency is in the annuity term, we have

$$\text{IR } 01 = (C - S) \cdot (A^*(T) - A(T))$$

where $A^*(T)$ is the value of the risky annuity calculated using the bumped interest rate curve. Since this is the present value of future cash flows, we can conclude that $A^*(T) - A(T) < 0$. We can therefore conclude that: (1) if $C = S$ the interest rate sensitivity of a CDS is zero, (2) if $S < C$ then the IR DV01 is negative, and (3) if $S > C$ then the IR DV01 is positive.

In general the interest rate sensitivity of a CDS is low, especially when compared with a fixed-rate corporate bond with the same maturity date. This is due to the fact that the bond has coupons plus a payment of par at maturity, while the CDS is effectively a credit risky annuity with annualized coupon payments of $(C - S)$ and unlike a bond there is no payment of par at maturity. In fact the interest rate sensitivity of a CDS actually close resembles the interest rate sensitivity of a same-maturity par floating rate note issued by the reference entity.

Example

Exhibit 67–5 shows an example[15] of the pricing of a real CDS trade to buy protection until March 20, 2016. The CDS coupon (deal spread) has been fixed at 100 bp. The pricing of the CDS is captured by the current flat spread, called the "quoted spread," to the contract maturity date, which is 34.32 bp. This is the only spread quote needed to determine the upfront value. Both the deal and the quoted spread assume the market standard recovery rate of 40%.[16]

14. This procedure is discussed in detail in O'Kane, *Modelling Single-Name and Multi-name Credit Derivatives.*
15. The valuation here reproduces that produced by the standard CDS valuation calculator found on Bloomberg, which is accessed via the code CDSW.
16. These would only differ if the user was attempting to price a fixed recovery default swap.

EXHIBIT 67–5

The Value of the CDS Contract

Trade Description			
Notional:	$10m	Trade Date:	3rd February 2011
Maturity:	20 March 2016	Settlement:	8th February 2011
Buy/Sell:	Buy Protection	Quoted Spread:	34.32 bp
Deal Spread	100 bp	Currency:	USD
Valuation Results			
Price	103.22035	Accrued	–$12,778 (46 days)
Principal	–$322,035	Spread DV01:	5,036.41
Cash Amount	–$334,813	IR DV01:	84.26

We explain the valuation outputs in Exhibit 67–5:

- **Price:** This is the "clean" price for a protection seller who was to buy the CDS together with a par LIBOR floating rate note. It excludes the payment of accrued interest that would need to be added to the actual price paid.
- **Principal:** This is the clean (excluding accrued interest) value of the contract. It is computed by subtracting the accrued interest from the cash amount defined below.
- **Accrued Interest:** This is the amount of coupon that has accrued since the last coupon payment date or the first accrual date. For a new contract and an existing contract this is always the CDS Date that falls before the trade date. For a protection buyer the accrued interest is always negative while for a protection seller it is always positive. The valuation shows 46 days of a 100 bp coupon that has accrued from the previous payment date on 20 December 20, 2010 to T+1 calendar, which falls on February 4, 2011.
- **Cash Amount:** This is the actual upfront amount that has to be paid to enter into this contract. The valuation is –$334,813 meaning that the protection buyer receives $334,813 to enter into this contract. This is because the protection buyer who enters into this contract has to pay an annualized coupon of 100 bp for up to five years for a reference entity with a quoted flat spread of 34.32 bp. Because the coupon being paid is higher than the cost of protection implied by the quoted spread, the protection buyer has to be compensated upfront.
- **Spread DV01:** The spread sensitivity of the long protection position is calculated to be $5,036, meaning that a 1 bp increase in the quoted spread curve would cause the value of the CDS position to increase by this amount.

- **IR DV01:** The interest rate sensitivity of the contract is also positive, but much smaller at $84.24. This makes it very clear that a CDS is almost purely a credit-spread product.

Exhibit 67–6 shows the cash flows on the premium leg of the CDS. We see the payment dates and the corresponding amounts calculated using the Actual 360 day count convention. We also see the discount factors implied by the LIBOR deposit rates and swap rates used. Finally we see the survival probabilities

EXHIBIT 67–6

Payment Dates, Amounts and the Corresponding Discount Factors and Survival Probabilities for the Example CDS Trade. Note that the Payment Dates Have Been Holiday Adjusted.

Payment Date	Amount ($)	Discount Factor	Survival Probability	Default Probability
Tue 8 Feb 2011		0.999965	0.999920	0.000080
Mon 21 Mar 2011	25,277.78	0.999681	0.999268	0.000732
Mon 20 Jun 2011	25,277.78	0.999050	0.997822	0.002178
Tue 20 Sep 2011	25,555.56	0.998083	0.996362	0.003638
Tue 20 Dec 2011	25,277.78	0.996830	0.994920	0.005080
Tue 20 Mar 2012	25,277.78	0.994574	0.993480	0.006520
Wed 20 Jun 2012	25,555.56	0.991120	0.992031	0.007969
Thu 20 Sep 2012	25,555.56	0.987678	0.990585	0.009415
Thu 20 Dec 2012	25,277.78	0.984285	0.989157	0.010843
Wed 20 Mar 2013	25,000.00	0.979280	0.987747	0.012253
Thu 20 Jun 2013	25,555.56	0.972176	0.986309	0.013691
Fri 20 Sep 2013	25,555.56	0.965123	0.984874	0.015126
Fri 20 Dec 2013	25,277.78	0.958198	0.983456	0.016544
Thu 20 Mar 2014	25,000.00	0.951042	0.982056	0.017944
Fri 20 Jun 2014	25,555.56	0.943351	0.980627	0.019373
Mon 22 Sep 2014	26,111.11	0.935557	0.979170	0.020830
Mon 22 Dec 2014	25,277.78	0.928074	0.977761	0.022239
Fri 20 Mar 2015	24,444.44	0.920894	0.976400	0.023600
Mon 22 Jun 2015	26,111.11	0.913285	0.974950	0.025050
Mon 21 Sep 2015	25,277.78	0.905980	0.973548	0.026452
Mon 21 Dec 2015	25,277.78	0.898733	0.972147	0.027853
Mon 21 Mar 2016	25,277.78	0.888739	0.970749	0.029251

implied by our CDS valuation model. The default probability is simply one minus the survival probability.

Approximation

For those wishing to evaluate trading strategies, the Bloomberg pricer found under CDSW can be limiting and a simple Excel-based pricer would be quite useful, even if it is not exact. It is therefore worth describing a simple approximation that is based on the observation that the value of the risky annuity of a new CDS contract can be linked directly to the quoted flat spread $\bar{S}$ and the recovery rate assumption R using the following approximation

$$A(\bar{S},T) \approx \frac{1-\exp\left(-\left(\mathrm{W}+\frac{\bar{S}}{(1-R)}\right)T\right)}{\mathrm{W}+\frac{\bar{S}}{(1-R)}} \times \frac{365}{360}$$

where W is the swap rate to the contract maturity in T years and the ratio of 365/360 is used to adjust for the Actual 360 convention used to determine the size of premium payments.[17] The value of a long protection CDS position is simply given using the standard valuation equation:

$$U(t) = \left(\bar{S} - C\right) A(\bar{S},T)$$

Taking the example above where the quoted spread is 34.23 bp, the time from today to contract maturity is 5.122 years and the 5-year swap rate is 2.4%, we find that

$$A(\bar{S},T) = \frac{1-\exp\left(-\left(0.024+\frac{0.003432}{(1-0.4)}\right)\cdot 5.122\right)}{0.024+\frac{0.003432}{(1-0.4)}} \times \frac{365}{360} = 4.81764$$

We therefore calculate

$$U_{Existing}(t) = \$10,000,000 \cdot \frac{(34.32-100)}{10000} \cdot 4.81764 - \$12,778 = -\$329,992$$

This should be compared to the cash amount calculated by the Bloomberg valuation (not shown) which was –$334,813, a difference of about $5,000 on a $10 million face value. Note that we had to subtract the 46 days of accrued coupon which have

17. Using an Actual 360 basis the sum of the actual coupon payments over a year exceeds the amount implied by the annualized coupon by this ratio in non-leap years. Any good approximation of the risky annuity needs to account for this.

to be paid by the protection buyer at the end of this coupon period. These are worth \$12,778. The reason for doing this is that this contract requires the protection buyer to pay a full coupon on the next payment date. However the quoted spread of 34.32 bp is for a contract that starts accruing from T + 1. To account for this we need to compensate the protection buyer for having to make this extra future payment and to a very good first approximation, this can be done by subtracting the accrued coupon. The valuation is within 1.5% of the Bloomberg result—corrections to the interest rate used to discount the CDS cash flows to account for the slope in the swap curve can further improve the accuracy of this approximation.[18]

CDS INDEX VALUATION

The mechanics of the CDS index have been set out in Chapter 66. We showed that a CDS index is equivalent to a portfolio of CDS in which the individual CDS all pay the same index coupon given by $C_I(T)$. In this section, we wish to show that for valuation purposes a CDS index can actually be treated as though it were a CDS contract. We recall from Chapter 66 that the buyer of a time T-maturity CDS index is selling protection on a portfolio of P different time T-maturity CDS contracts, and receiving a coupon $C_I(T)$ in return for assuming this risk. Credit events in the portfolio result in the relevant CDS being removed from the index and settled via the standard auction procedure described in Chapter 66.

On each coupon payment date the size of the coupon payment is proportional to the size of the remaining portfolio of CDS. It therefore falls in absolute terms as credit events occur.

Therefore, unlike a single-name CDS, a CDS index does not have a single credit event which causes it to pay out a single loss and then cancel. Instead, the contract remains active[19] until maturity, with loss payments being made as and when credit events occur.

Index Valuation

From the perspective of an index buyer (protection seller), the CDS index value is equal to the premium legs of the P underlying CDS contracts that each pay the index coupon, minus the expected present value of the P protection legs. Using the notation set out in Exhibit 67–5, we can therefore write the value of the index premium leg as

18. The main reason for the difference is the upward sloping swap curve in February 2011, which rises from 0.46% at six months to 2.4% at five years. This is not consistent with our assumption of a flat swap curve. Using a maturity-weighted average swap rate of 1.67%, we obtained a valuation with an error of less than 0.1%.

19. Strictly speaking, the CDS index contract would cancel if all of the credits in the reference portfolio experienced a credit event. However given that the reference portfolio usually consists of 50–125 individual credits, the probability of this happening within the lifetime of a typical CDS index contract is considered to be close to zero.

EXHIBIT 67–7

Notation Used in the Valuation of CDS Indices

Symbol	Description
$C_I(T)$	The coupon of a T-year maturity CDS index.
$U_I(T)$	The upfront value of a T-year maturity CDS index.
$S_I(T)$	The par spread paid on a T-year maturity CDS index which has no initial cost.
$S_P(T)$	The par spread paid on a T-year maturity CDS on reference credit p.
$\bar{S}_I(T)$	The "quoted" spread is the level of a flat par CDS index spread curve which sets the model-implied upfront cost of a T-year CDS index equal to its market value.

$$\frac{C_I(T)}{P}\sum_{p=1}^{P} A_p(T)$$

We can also write the value of the index protection leg in terms of the individual CDS spreads as

$$\frac{1}{P}\sum_{p=1}^{P} S_p(T)A_p(T)$$

We are assuming here that the reference credits are all equally weighted.[20] The value of the index (short protection) position is then

$$V^{Index} = \frac{1}{P}\sum_{p=1}^{P}(C_I(T) - S_p(T))A_p(T)$$

The most common application for CDS index pricing is Bloomberg's CDSW function. This treats a CDS index as a standard CDS contract. As with CDS, price quotations for the CDS indices are almost exclusively done using the "quoted" flat index spread defined as the level at which we would mark a flat CDS index par spread so that, when using the standard CDS pricing model, it would cause the index model price to refit the market upfront index price. We therefore have

$$V^{Index} = \frac{1}{P}\sum_{p=1}^{P}(C_I(T) - S_p(T))A_p(T) = (C_I(T) - \bar{S}_I(T))\bar{A}_I(T)$$

20. This is always the case on the issue date of an index. However, if one or more company splits or merges then this could cause some reference credits to have a smaller or larger notional than the others. Even if this does occur, it does not affect any of the index pricing analysis presented in this chapter.

The point here is that this mapping of a CDS index onto a single CDS contract allows us to use our single-name CDS analytics to value and risk manage the CDS index. By doing so, we price the CDS index as though it has its own index survival probability $Q_I(t)$. Note that if we assume that the expected recovery rates of all of the credits in the index are the same, we can write

$$Q_I(t) = \frac{1}{P}\sum_{p=1}^{P} Q_p(t) = N_I(t)$$

where $N_I(t)$ is the expected surviving notional of the index at time t. We do not use this relationship in pricing because it assumes that all recovery rates are the same, which is not always the case. However, in general, it is approximately true and does provide some intuition about the interpretation of the index survival probability.

The CDS Index Basis

If this relationship is not obeyed, there is then a theoretical mispricing. However, this theoretical mispricing may not be arbitrageable for a number of reasons:

1. Model prices are usually mid-market. Therefore, if we take into account the cost of crossing the bid-offer spread that would need to be done to monetize any mispricing, this mispricing may not be a real arbitrage opportunity after all.
2. Obtaining accurate and contemporaneous flat spreads for all of the constituents of a CDS index may not be possible.
3. Where CDS and CDS indices trade with different restructuring clauses, the replication is not exact and this relationship should not be exactly obeyed.

Despite these caveats, CDS indices have traded away from their CDS-implied spread. This will generally be due to market technical factors such as a market demand to buy or sell systemic versus single-name credit protection. If the deviation becomes large enough to be arbitraged, then hedge funds and other market players will step in to monetize the profit until their activities eliminate the arbitrage.

Risk Management

Since the CDS index contract is valued as though it was a single-name CDS contract, its price sensitivities are identical to those of a single-name CDS contract with the same term structure of par spreads or quoted spread, the same recovery rate, the same maturity and the same interest rate environment. As a result, we refer the reader to the section on CDS risk management.

KEY POINTS

- Since the introduction of fixed coupons for CDS contracts in 2009, entry to a CDS contract almost always involves some initial upfront cash payment, which can be positive or negative.
- From the perspective of a protection seller, the size and sign of the initial cash value of the contract depends on whether the fixed coupon is sufficient to compensate the protection seller for the market perceived risk of a credit event. If the coupon is low, the protection seller may receive cash at trade initiation. If the coupon is high, the protection seller may have to pay cash at trade initiation. The situation is reversed for a protection buyer.
- The purpose of the valuation of CDS and CDS indices is to calculate this upfront cash payment. This requires a model in order to determine the expected present value of the premium and protection leg of the contract.
- This model needs to take into account the probability of and the timing of a credit event. For the premium leg, it needs to take into account the risk that not all coupons will be paid. For the protection leg it needs to value the unknown payment of par minus recovery made at the time of the credit event, if one occurs. It also needs to be flexible enough to exactly reprice the term structure of quoted market spreads.
- One type of market quote is the CDS par spread. This is the value of the coupon that would need to be paid on the premium leg of a CDS in order for the contract to have zero upfront value on trade date. The value of a CDS is a function of the term structure of CDS par spreads.
- Since 2011, the CDS market has also begun to use an alternative measure known as the flat "quoted" spread. This is the level at which a flat term structure of par spreads would need to be set in order that they reprice the market quoted upfront value. As a result, only one quoted spread is needed to value a CDS contract.
- The probability of a CDS experiencing a credit event as implied by CDS market spreads usually exceeds the historical default probability implied by the default rate of credits that were initially assigned the same credit rating. This is because spreads are forward-looking and embed a risk premium.
- The model allows the holder of a CDS position to calculate the sensitivity of the value of the contract to changes in the quoted spread and so enables him to hedge it with other CDS contracts.
- For valuation purposes, a CDS index can be treated as a single-name CDS and valued and risk-managed using the same model as the CDS.

CHAPTER
SIXTY-EIGHT

HEDGING TAIL RISK

STEPHEN J. ANTCZAK, CFA

The recent financial crisis has created an increased focus on "tail risk" and ways to minimize exposure to the unexpected. Once the domain of risk managers and fringe thinkers on trading desks, it has become a common phrase among the lexicon on trading floors. For that matter, it is a common phrase even away from trading floors (e.g., Google "tail risk" and one may be surprised at the number of hits received). In fact, a number of hedge funds have recently been created solely to take advantage of tail risk.

In this chapter, we first discuss why tail events seem to occur with such regularity. We find that one or all of three characteristics (leverage, transient funding, and the influence of "noneconomic" objectives and constraints on investment decisions) are associated with many, if not most, tail events. We then provide some background on three specific tail risks that we "hedge" later in the chapter. These are a sharp decline in the equity market, public sector fiscal imbalances, and an economic downturn. It is important to recognize that we define an equity market downturn as a risk for fixed income investors in part because of the high correlation between stocks and segments of the fixed income market. The co-movement between the equity market and the high-yield sector of the credit market from May 2001 to May 2010 is shown in Exhibit 68–1. In addition, many bond investors, and for that matter investors in general, tend to view both opportunities and risks in a cross market context far more now than in years past.

With regard to constructing hedges, we next highlight four key challenges that most hedges face: (1) correlation between the portfolio being protected and the hedge vehicle itself, (2) cost, (3) the potential for slippage, and (4) the reliance on historical relationships, as these relationships can be transitory over time. We then consider two very broadly defined hedging strategies—unfunded and funded approaches—and note that both types typically face the challenges highlighted above (Exhibit 68–2). We define unfunded hedges as those for which an investor

This chapter was written when the author was the Head of U.S. Credit Strategy at Société Générale. The author would like to thank Jung Lee and Sandeep Mody for their assistance in developing this chapter.

EXHIBIT 68–1

Co-movement of the Equity and High-Yield Credit Markets: May 2001–May 2010

Source: SG Cross Asset Research.

Note: As of March 14, 2011.

is willing to dedicate a certain amount of capital to protect the portfolio. In some respects, unfunded strategies are comparable to insurance policies. Funded strategies tend to be utilized by market participants who are unable or unwilling to pay the cost of insurance outright. They nonetheless require a hedge, and therefore want (or need) to go long an asset to pay for insurance. Funded hedges tend to

EXHIBIT 68–2

Select Characteristics of Unfunded and Funded Hedges

	Unfunded Hedges	Funded Hedges
Definition	Investors dedicate capital to protect portfolios	Long exposure is used to pay for the cost of insurance
Primary concern	Loss prevention	Cost, asymmetric payoff profile, loss prevention
Goal	Protect portfolios against a wide variety of events	Protect an asset against a fairly specific problem with a "high" chance of occurring
Hedge modeling	History (to a large extent)	Scenario analysis (to a large extent)
Key concerns (albeit not all)	Cost, correlation, slippage, reliance on historical relationship	Cost, correlation, slippage, reliance on historical relationship, introduction of additional risks due to more "moving parts"

Source: SG Cross Asset Research.

become more popular when the catalyst for a market setback is difficult to predict, as performance can lag if a premium is continuously being paid to protect against an event that does not occur. We assess the performance of various hedging vehicles in the context of a declining stock market tail event.

We then assess the effectiveness of various funded packages in the contexts of the second (sovereign credit event) and third risks (economic downturn). Finally, we discuss trade-specific hedge risks, such as counterparty risk. We find that funded hedges can be more risky than unfunded approaches, in large part because they have more "moving parts," but they are not necessarily less effective.

STEP-BY-STEP GUIDE TO HEDGING

There is no perfect hedging vehicle or approach, but we do believe that a checklist consisting of the following six steps can be fairly useful when constructing one.

- *Step One. Decide whether to hedge.* A credit portfolio manager sees a high likelihood of a tail event occurring. Does this mean that he should necessarily hedge? Perhaps, but not necessarily, as there are a number of factors that could warrant not hedging. Suppose that this portfolio manager handles 25% of an endowment's capital. What happens if the endowment also expects a tail event and shifts the 75% of funds that are not handled by this credit manager into cash? If the credit manager also hedges, the endowment may very well be overhedged. Or what if the portfolio manager anticipates a sharp pickup in defaults, but comes to this conclusion *after* the consensus does? It may already be priced in and therefore not cost effective (Exhibit 68–3).

EXHIBIT 68–3

U.S. Speculative-Grade Default Rate versus High-Yield Bond Index

Source of data: SG Cross Asset Research, Bloomberg, Moody's.

Note: As of January 31, 2011.

Default rates are LTM matched with one year back.

- *Step Two. Decide what to hedge.* Even if an investor decides that it is worthwhile to hedge, it is almost as important to understand exactly what is to be hedged. One type of tail event (e.g., sovereign default) could require a very different type of hedge than another (e.g., BP oil spill).
- *Step Three. Identify challenges to watch out for.* There are a number of challenges that could have some influence on the efficiency of virtually all hedge vehicles. These include the correlation between the hedging vehicle and the asset being hedged, the cost of the hedge, the potential for slippage between the hedged asset and the hedge itself, and the reliance on historical data to anticipate potential future performance.
- *Step Four. Decide whether to fund or not.* Given that hedges are in some ways comparable to insurance policies, an important choice must be made with regard to how to pay the premium. One could simply dedicate a certain amount of capital to pay for insurance and "write off" the premium. The downside, though, is that it is quite possible to underperform benchmarks or competitors if a tail event does not occur. Conversely, one could fund the hedge by going long an asset that is less sensitive to a tail event than the hedge, but there is a tradeoff as new risk factors can be introduced.
- *Step Five. Craft an efficient hedge.* Finding an efficient hedge to a large extent involves balancing the payoff potential in the event of a tail scenario with challenges such as cost. In addition, one can often use scenario analysis to identify downside risk with which one is comfortable.
- *Step Six. Identify trade-specific risks.* While we identified four generic challenges that can influence the typical hedge, there can be a number of trade-specific risks that are important to consider as well. For example, some hedges may have significant counterparty risk, liquidity can be far more of a factor for some hedges than others, etc.

THE NEED TO HEDGE

In theory, tail risk should happen infrequently—the once-in-a-lifetime storm, so to speak—but reality may be a bit different than theory. In Exhibit 68–4 we present a sample of some catalysts for major downturns from 1990 to 2010. The exhibit shows that we have seen catalysts for major downward moves fairly frequently—essentially every three years or so.

While there is no single reason that can account for what seems to be relatively frequent tail events, three ingredients do seem to be well represented among most observations—excess leverage (be it financial, operational, or the like) combined with unstable access to funding and potentially noneconomic investment objectives/constraints. Events ranging from the Russian default to the U.S. real estate bubble shared some of these characteristics.

EXHIBIT 68–4

Sample of Some Catalysts for Major Downturns, 1990–2010

Source: SG Cross Asset Research.

With regard to noneconomic objectives and constraints, for a variety of reasons the actions of some market participants are at times influenced by somewhat arbitrary factors that are not necessarily related to investment efficiency. For example, the performance of many market participants is measured on a quarterly or annual basis, and as a result they may have limited capacity to "sit on cash." Cash inflows into the bond markets were robust in 2010, and even while many portfolio managers did not see particularly attractive value, they did not have the option of holding high cash balances. In essence, some investors had to buy. But in our experience, valuations supported by "reluctant participants" can be susceptible should volatility or uncertainty edge higher. These investors can look to re-deploy capital to their respective comfort zones quickly.

The factor detailed above goes hand in hand with the market's tendency to be lulled by incremental movements, in our view. That is, if one has to put money to work, is investing in a leverage buyout with 4.5 turns of leverage really all that different from one with 4 turns? Are 5 turns really all that different from 4.5 turns? The problem is that over time the investment community can find itself a long, long way from shore, so to speak. Is 8.5 turns really all that different from 8 turns? No, but it is *very* different from 4 turns. Lastly, the financing of assets is not necessarily done on a matched-maturity basis. If funding becomes more difficult, forced selling can very well ensue and snowball out of control. Mismatched funding can take many paths to influence valuations (hedge fund withdrawals and heightened collateral requirements are two examples).

These characteristics were well exhibited in the housing market crisis that began in 2007. With regard to leverage, Exhibit 68–5 shows that the amount of lower-quality mortgage supply that was originated from 2001 to 2007 grew gradually, but that over time growth became extreme relative to the original starting point. In 2001 and 2002, the supply of Alternative-A loans (Alt-A)—viewed in terms of quality as one notch above subprime—was averaging about $2.0 billion per month.

EXHIBIT 68–5

Monthly Alt-A Mortgage Supply, 2001–1007

Source of data: SG Cross Asset Research, Bloomberg.

This number continually edged higher in the following years—on average $4.4 billion in 2003 and $6.1 billion in 2004. This was still manageable, but before long the average monthly supply was $15+ billion.

Leverage can come in many forms. The robust amount of low-quality mortgage bonds issued was not the only source of housing market leverage in the 2000s. If we define leverage as more exposure to a change in "underlying" valuations (home prices, in this example), then the structured product market boosted leverage in the system severely as well.

Consider common structures back then as shown in Exhibit 68–6. Essentially, a pool of lower-quality mortgage loans was used to create an asset-backed security (ABS), and the mezzanine bond was used to create another, more levered bond, an ABS collateralized debt obligation (ABS CDO). And then a slice of mezzanine debt from the ABS CDO was used to create another security, a CDO with CDO collateral, popularly referred to as a CDO-squared or CDO^2, of which the net effect was an even smaller equity base supporting an even larger debt amount.

So where did we end up? To put the resulting leverage into perspective, in some cases in order to wipe out the entire CDO-squared—all the way through the triple-A tranche—the default rate would only have to hit a 13.4% pace (assuming a 50% recovery and significant overcollateralization). Note that the percentage of seriously delinquent[1] subprime loans as of the third quarter of 2010 according to Bloomberg was 27.7%, more than double the amount needed to impact the triple-A tranches. And at the same time, the number of "reluctant market participants" may have been rising as well—by many metrics valuations were quite full—which may have left prices in the mortgage market particularly susceptible to any rise in volatility or uncertainty. Exhibit 68–7 shows total

1. "Seriously delinquent" percentage is defined as the non-seasonally adjusted rate of loans that are 90 or more days delinquent or in the process of foreclosure.

EXHIBIT 68–6

Evolution of Leveraged Mortgage-Related Structures

Source: SG Cross Asset Research.

assets in money market funds relative to the total return performance of a broad portfolio of mortgage bonds. When volatility edged higher, investors increasingly looked to "park" in cash, and valuations of mortgage bonds had little support and declined soon after.

EXHIBIT 68–7

Total Assets in Money Market Funds versus the CBOE Volatility Index (VIX) and a Portfolio of Mortgage Bonds

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of 4Q 10, returns are last four-quarter rolling average.

The key takeaway here is that there has been an increased focus on tail events, in part because they appear to arise more frequently than expected. We believe that to a large extent this is a function of the following three factors:

1. Market participants' actions may be influenced by factors not necessarily related to investment efficiency, and can "force" investors to take actions unwillingly. Valuations supported by such "reluctant participants" can be susceptible to any increase in volatility or uncertainty.
2. Investors have a tendency to move incrementally, and over time the risk profile of a particular asset class or market segment can increase dramatically and without being noticed.
3. Financing can often be mismatched relative to the assets being supported.

As such, we believe that it is important for investors to always be mindful of the potential for an unexpected drop in valuations as well as ways to protect against possible declines.

OVERVIEW OF SELECT TAIL RISKS

History suggests there may be an innumerable number of tail risk possibilities. Tulip mania? South Sea? Silver? Internet? Housing? It is very difficult to identify bubbles, much less predict when one may burst. However, this does not mean that potential bubbles cannot be effectively hedged, in our opinion.

The goal of this chapter is to provide a framework for hedging tail risk, and in this regard we model three specific risks to be hedged:

1. A severe stock market downturn
2. A sovereign credit event
3. An economic downturn

Below we provide an overview of these tail events.

Stock Market Downturn

Many investors, whether they are equity market investors or not, are cognizant of the performance of the stock market. Because of the depth and breadth of the investor base in this space and the relative liquidity of the stock market, many believe that the equities are an important barometer of risk appetites across all markets. If valuations in the broader stock market encounter pressure, then valuations may well be pressured in other markets as well.

Meaningful declines in the stock market (as gauged by the S&P 500) are not all that infrequent. Over the 25 years from 1985 to 2010 and based on monthly data, for example, the S&P 500 has experienced two-standard deviation declines 12 times and three-standard deviation declines three times (Exhibit 68–8).

EXHIBIT 68–8

Standard Deviation Movements in the S&P 500, 1985–2010

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of December 31, 2010. Monthly change since 1985.

Note that we define an equity market downturn as a risk for fixed income investors in part due to the high correlation between stocks and select segments of the fixed income market, as shown, for example, in Exhibit 68–9. In addition, bond investors, and for that matter investors in general, tend to view both opportunities and risks in a cross market context far more today than in years past.

The key point here is that hedging potential equity market tail events can be important for investors in virtually all asset classes.

EXHIBIT 68–9

Standard Deviation Movements in the High-Yield Debt Market, 1997–2010

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of December 31, 2010. Monthly change.

EXHIBIT 68–10

Spread Levels in the High-Yield Market and the Spillover Impact the S&P 500

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of January 31, 2011 for SPX, 3Q 10 for corporate profits. Corporate profits include inventory valuation adjustments and capital consumption adjustments, SAAR.

In addition, the equity market tends to be correlated with (or even lead) various economic metrics. For example, in Exhibit 68–10 we overlay historical S&P 500 index levels with corporate profits and we see two very similar trends. As such, one could expect a decline in the equity valuations at times of or in periods leading up to economic downturns, and a softer economic backdrop could very well have implications for other markets.

Sovereign Credit Risk

Public sector fiscal imbalances within many developed countries have increased since the financial crisis in 2008. Some worry that the problem could once again become a market focal point and weigh on valuations.

To illustrate the magnitude of the problem, Exhibit 68–11 shows how drastically the gross debt outstanding for the U.S. and Portugal have risen since 2007. It is worth noting that many public sector entities fit a similar profile. Moreover, history suggests that any public sector credit event could have a meaningful spillover effect on valuations elsewhere. For example, when sovereign fears spiked in the spring of 2010, spread levels for many European financials jumped as investors became worried that their sovereign exposure would require meaningful asset writedowns. Even more distant markets, such as the U.S. high-yield market and the S&P 500, were pressured considerably, as can be seen in Exhibit 68–12.

Economic Downturn

Most asset classes are, at least to some extent, influenced by the broad economic backdrop. For example, one key metric of the economic environment is consumer

EXHIBIT 68–11

Portugal and the U.S. Gross Debt Levels

Source of data: SG Cross Asset Research, Bloomberg, IGCP.

Note: Gross debt level.

confidence, and Exhibit 68–13 shows that there is a fairly high correlation between this economic metric and equity market performance.

But there are many different components of the overall economic background and as a result, hedging an unexpected "downturn" can be challenging. For example, Exhibit 68–14 shows retail sales (ex auto) and corporate profits—two very important components of the broader economy with the potential to significantly influence corporate valuations—have done very different things in

EXHIBIT 68–12

Percent Change in Levels of iTraxx SovX WE, iTraxx Subordinated Financials, and S&P 500, April–July 2010

Source of data: SG Cross Asset Research, Bloomberg, Markit.

Note: Indexed to April 1, 2010.

EXHIBIT 68–13

S&P 500 versus Consumer Confidence, January 1993 to January 2011

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of January 31, 2011.

2009 and 2010. Specifically, during the March 2009 to September 2010 period retail sales growth remained essentially flat, while corporate profits growth was up 44%. Is the economic backdrop good or bad?

The key takeaway is that hedging economic tail risk can be important, but can also be very challenging for a variety of reasons. These include the number of different economic metrics as well as the sensitivity of various asset valuations to these economic subcomponents.

EXHIBIT 68–14

Changes in Corporate Profits and Retail Sales (ex Auto), Q1 2009 to Q3 2010

Source of data: SG Cross Asset Research, Bloomberg.

GENERIC CHALLENGES FACING HEDGERS

As noted earlier, there is no perfect hedge. Before attempting to craft an "efficient" hedge for the three tail risks identified in the previous section, we must first discuss the following four challenges that one often faces.

1. The correlation between the portfolio being protected and the hedge vehicle
2. The cost of hedging
3. The potential for slippage
4. The reliance on historical relationships because these relationships can be transitory over time

Correlation

The first challenge that we focus on is correlation, or the chance that the portfolio being hedged and the hedging vehicle itself do not move in the same direction and/or by the same magnitude as expected. Said differently, imagine purchasing an insurance policy to protect against some event, but the payment received when (and if) the event actually occurred was meaningfully different than the actual loss incurred.

To better put this risk into perspective, we consider how specific hedging vehicles have performed historically relative to equity market selloffs (we acknowledge the narrow definition of risk). Exhibit 68–16 examines price changes for the S&P 500 and the Russell 2000 stock indexes from 1980 to 2010 relative to a variety of hedging tools, such as the 10-year Treasury and spot gold. Again, the expectation is that a stock market downturn could have a meaningful spillover impact on certain segments of the fixed income markets.

The observations in Exhibit 68–15 represent periods in which either the S&P 500 or Russell 2000 valuations (or both) declined by 20% or more. Movements of the various hedging tools presented in this exhibit are considered to be at least partially successful if their values changed by 10% or more (and move in the right direction).

This study provides three noteworthy points, in our view:

- Of the 13 times that the stock market declined 20% or more from 1980 to 2010, we see that there are many instances in which various hedging tools did not even move in the "right" direction. For example, while gold can be a beneficiary of a "flight-to-quality" bid during times of turmoil, it nonetheless would not have been an efficient hedge against a decline in equity prices. Spot gold experienced only three observations of "material" movement in the correct direction. And the changes in the value of the dollar was essentially a coin flip during times of significant negative changes in equity valuations—up 46% of the time, down 54%.

EXHIBIT 68–15

Performance of Various Hedging Vehicles, 1980–2010

Period		Risk Assets (%)		Typical Tail Hedge Instruments (%)				
		S&P 500	Rus 2000	Gold	Dollar (DXY)	10Y Trsy	VIX	CDX.IG
Feb-80	Mar-80	–17	–27	–32	12	–14	47	
Jun-81	Sep-81	–16	–23	–13	3	–4	47	
Oct-87	Nov-87	–31	–39	4	–8	10	332	
Jul-90	Oct-90	–20	–30	10	–9	–3	111	
Apr-98	Oct-98	–15	–37	–5	–9	8	130	246
Mar-00	Apr-00	–4	–25	–8	6	3	74	38
Jan-01	Apr-01	–20	–17	9	6	2	58	14
Jul-01	Sep-01	–22	–26	8	–6	6	127	23
Mar-02	Jul-02	–32	–28	4	–7	8	148	48
Aug-02	Oct-02	–19	–20	–12	–2	4	52	22
Oct-07	Mar-08	–17	–21	31	–9	11	85	240
Aug-08	Mar-09	–48	–54	22	17	9	164	75
Apr-10	Jul-10	–16	–20	7	6	6	93	54
			Average	**2**	**0**	**4**	**113**	**84**
			% of Times Up	**62**	**46**	**77**	**100**	**100**

Source: SG Cross Asset Research.

- Even if the direction of movements between a portfolio being hedged and the hedge itself is highly connected, differences in the magnitude of movements can limit effectiveness as well. For example, Treasuries tend to benefit from a flight-to-quality during periods of severe stress; Exhibit 68–15 shows that the 10-year Treasury moved in the "right" direction 77% of the time. That said, the rise in price of the 10-year seemed fairly modest in comparison to the fall in stock market valuations (e.g., on average the 10-year Treasury price rose 4% versus a decline in the S&P 500 of 21%). One may have to buy an awful lot of Treasuries to hedge, which can present new problems.
- Solely in the context of correlation, we find the VIX and the CDX.IG indexes to be efficient. In terms of consistency, both vehicles moved in the "right" direction each time the S&P 500 and/or the Russell indexes experienced declines of 20% or more, and in terms of magnitude, on average the VIX and the CDX.IG hedges were "in-the-money" by 113% and 84%, respectively.

What Makes the VIX and CDX.IG Indexes Special?

The VIX and the CDX.IG indexes may have many special features, but two that really stand out are the tendency of these vehicles to gap, and for such gaps to be in the "right" direction (i.e., asymmetric payoff profile). With regard to the tendency to gap, we examined how many times the value of the S&P 500 (for reference), VIX, and CDX.IG indexes rose or fell by more than 25% of their respective one-year rolling averages, as shown in Exhibits 68–16 through 68–18. By this

EXHIBIT 68–16

S&P 500 Observations That Are More Than 25% from One-Year Rolling Average from January 1997 to February 2010

Source: SG Cross Asset Research.

Note: As of February 10, 2011.

EXHIBIT 68–17

VIX Observations That Are More Than 25% from One-Year Rolling Average from January 1997 to February 2010

Source: SG Cross Asset Research.

Note: As of February 10, 2011.

metric, we see that extreme observations for the S&P 500 are fairly infrequent (4%), particularly when compared to the VIX (28%) or CDX.IG (43%). Note that we have a longer time series for the S&P 500 and the VIX than for CDX.IG.

With regard to asymmetry, we looked at the percent changes for the VIX index and CDX.IG spread over two-week holding periods. We focused on only those observations that moved by 15% or more (see Exhibit 68–19). For the VIX index we find that the number of times since 1997 that the level increased by 15% or more in a two-week period significantly outnumbers the number of times the level declined by 15% or more (459 versus 337, respectively). We find a similar

EXHIBIT 68–18

CDX.IG Observations That Are More Than 25% from One-Year Rolling Average from January 1997 to February 2010

Source: SG Cross Asset Research.

Note: As of February 10, 2011.

EXHIBIT 68–19

Number of "Large" Positive and Negative Changes in VIX and CDX.IG

Two-Week Change	VIX	CDX.IG
–15% or more	337	71
+15% or more	459	146
Ratio	**1.4**	**2.1**

Source: SG Cross Asset Research.

Note: CDX.IG data since November 2004. VIX data since January 1997. Two-week changes.

trend for CDX.IG (71 times for spread tightening by 15% or more versus 156 times spread widening by 15% or more) using data going back to late 2004.

The key point is that a tendency to exhibit large and asymmetric movements is an important characteristic of any hedging vehicle.

Cost of Hedging

The second key challenge that hedgers may face is cost; that is, it may not matter how closely a hedge vehicle tracks the portfolio that one is protecting or by how much the hedge could move should a tail event occur if the cost is too expensive. Purely in the context of correlation short-tenor, at-the-money S&P 500 puts may be a compelling way to protect against declines in the S&P 500, but when cost is taken into consideration this hedging vehicle can be far less efficient.

To get a better sense of the *relative* cost of various hedging tools, we consider seven typical vehicles, such as S&P 500 puts and call options on the VIX index, in the context of equity market tail risk. In Exhibit 68–20 we present the cost[2] of each of these tools and we see that the range is very, very dramatic. For example, the cost of options can be fairly high (e.g., S&P 500 put), while the cost of others tends to be more modest (e.g., CDX.IG). Some hedges actually pay investors to hedge (e.g., Treasuries). Note that in terms of hedge ratio, we risk-weight each of the tools in Exhibit 68–20.

Slippage

The relationship between the S&P 500 and various hedging vehicles may very well exhibit a high correlation most of the time, and the cost may be fairly low as well. But does this mean that it is an efficient hedge? Not necessarily.

2. We assume a 30-day holding period, and the notional amount of each hedge is weighted so that each exhibits the same risk. We use theoretical (calculated) prices for options.

EXHIBIT 68–20

Cost of Various Hedging Tools

Source of data: SG Cross Asset Research, Bloomberg.
Note: As of January 21, 2011.

Another key factor to consider is the potential for infrequent but meaningful "slippage." To illustrate, suppose that an investor used the high-yield index to protect against a sharp decline in equities. One reason for this decision was the relative cheapness of the hedge. Suppose an investor implemented this hedge on January 2, 2009. Over the following year the S&P 500 rallied about 20%, so ideally the high-yield market would have rallied by the same amount or less. However, it did not. A "unique" event occurred and the high-yield market benefited from a return of liquidity to the marketplace and many issuers were able to refinance their upcoming maturities. As a result, the probability of default for the typical high-yield company tumbled drastically (see Exhibit 68–21) and the total return of the high-yield space was 56% in 2009. As such, our investor's portfolio gains would have been wiped out and she would have actually incurred a loss of 36% (S&P +20% – HY +56% = –36%, assuming a notional hedge ratio; see Exhibit 68–22).

Cost, Correlation, and Slippage in the Real World

In 2007 volatility across the marketplace was edging higher, signs of an economic slowdown were emerging, and investors were more and more worried about a potential housing market bubble, among other concerns. By early 2008 many were increasingly worried about the exposure of select banks and brokers to these and other problems. To protect against these risks some investors looked to buy protection in the CDS market on banks and brokers that they viewed as particularly vulnerable (e.g., Bear Stearns). Suppose that an equity investor purchased five-year protection on Bear Stearns in early 2008.

Turns out, there were (at least) two problems with this hedge. First, Bear Stearns protection was fairly expensive—five-year CDS was trading at about 315 bp in the first trading session of March 2008, relative to approximately 165 bp

EXHIBIT 68–21

U.S. Speculative Grade Default Rates, 1971–2010

Source of data: SG Cross Asset Research, Moody's.
Note: As of January 31, 2011.

for the typical name in the high-grade market. As such, if challenges in the banking system did not magnify purchasing this "insurance" could have weighed on performance somewhat.

The second and more significant problem was slippage relative to the S&P 500. Irrespective of the historical correlation between Bear CDS and the S&P 500, a unique event rendered correlation somewhat meaningless. Again, suppose that an investor purchased Bear Stearns CDS at 315 bp in early March. On March 24, the Federal Reserve deemed Bear Stearns "too big to fail" and took the unusual approach of encouraging JPMorgan to absorb Bear Stearns. A slight exaggeration, but in effect Exhibit 68–23 shows that Bear's default risk instantly became JPMorgan default risk (far lower!), and Bear CDS rallied to 186 bp by end of the day. In effect, the hedge would have ended up costing our investor far more than the amount her S&P 500 position had rallied.

EXHIBIT 68–22

S&P 500 Price Return versus Short Position in High-Yield Index in 2009

Source of data: SG Cross Asset Research, Bloomberg.

EXHIBIT 68–23

Bear Stearns versus JP Morgan Five-Year CDS Spreads

Source of data: SG Cross Asset Research, Bloomberg, Markit.
Note: Data in Q1 2008.

Reliance on History

Past performance is not an indicator of future returns, the old saying goes. But history is often used to determine how a potential hedge vehicle is likely to perform relative to a particular portfolio. Unfortunately historical relationships can be transient. To illustrate, in Exhibits 68–24 and 68–25 we present the relationship between the 10-year Treasury and the S&P 500 during two different periods, 1970 to 1979 and 2001 to 2010. Exhibit 68–24 plots these two assets during the 1970s, and we see that the correlation was –19%; based on this data one would certainly not expect the 10-year Treasury to be an effective stock market hedging vehicle.

EXHIBIT 68–24

Correlation of the S&P 500 and 10-Year Treasury, 1970–1979

Source of data: SG Cross Asset Research, Bloomberg.

EXHIBIT 68–25

Correlation of the S&P 500 and 10-Year Treasury, 2001–2010

Source of data: SG Cross Asset Research, Bloomberg.

However, the relationship has not been stable over time, and Exhibit 68–25 shows the correlation between these two markets has increased sharply in the 2001–2010 period. Trend reversals occur and can be very dangerous.

UNFUNDED HEDGES (INSURANCE)

A bond investor utilizing an unfunded hedging strategy is essentially looking to purchase an insurance policy. In this section we consider the effectiveness of various unfunded hedging vehicles in the context of the four challenges introduced in the previous section. We define tail risk as a sharp decline in the S&P 500; as noted earlier, over the 25 years from 1985 to 2010 the S&P 500 has experienced two-standard deviation declines 12 times and three-standard deviation declines three times.

In essence, given that stock and credit market performance can be fairly highly correlated, this bond investor is worried about protecting his portfolio from the spillover impact of an equity market selloff. To illustrate, Exhibit 68-26 shows that that from 1997 to 2010 the high-yield market, for example, has experienced eight declines of two standard deviations or more (compared to eight declines in the S&P 500 during the same period as shown in Exhibit 68–27). During the periods that the S&P 500 had declined by two or more standard deviations, the spread in the high-yield market widened by about 19% on average and there were three overlapping periods between the sharp downturns in the equity space and the high-yield market.

Assessing the Effectiveness of Various Hedging Vehicles

The seven common hedging vehicles that we evaluate are Treasury, Treasury future, HY index, CDX.IG, CDX.HY, SPX put, and VIX call hedges. We find that

EXHIBIT 68–26

Standard Deviation Movements in the High-Yield Debt Market, 1997–2010

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of December 31, 2010. Monthly change.

there is no "perfect" hedge, and a tradeoff is required based on a particular investor's preferences, objectives, and constraints. Note that we consider a fairly wide variety of hedging tools in the section, ranging from cash market instruments to derivatives in both the debt and equity markets, because in practice investors have increasingly looked to have as many "tools in the tool box" when identifying potential hedges for debt market downturns.

Before beginning, there are four calculation details to note. First, the performance of each hedging vehicle is based on a base case expectation. In particular, we assume that the most likely market environment is that the S&P 500 is range-bound (70% chance that returns are stuck in the –2% to +2% range), but

EXHIBIT 68–27

Standard Deviation Movements in the S&P 500, 1997–2010

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of December 31, 2010. Monthly change.

with a meaningful chance (30%) that the S&P 500 falls by up to 15%. Hedge performance is based on these probabilities and magnitudes, and as we will show later alternative scenarios can change results meaningfully.

Second, in terms of the weighting of each hedge vehicle, notional sizes are determined in a risk equivalent context. That is, in dollar terms we calculate the P&L range for a $10 million investment in the Treasury market in each scenario that we evaluate. We then back out notional weightings for the other hedge vehicles to generate the same risk profile (P&L range).

Third, the expected P&L for each hedge is based on their betas relative to the S&P 500 since 2005 (daily observations). We calculate four separate betas for each hedging tool—fairly modest bullish moves in the SPX (gains of less than 7.5%), more extreme bullish moves (SPX gains of 7.5% or more), and we use the same approach to determine betas in bear markets (SPX declines of up to 7.5% and more than 7.5%). Finally, the horizon is 30 days.

We discuss four findings in particular:

1. Dramatic differences in payoff profiles
2. Variation of success
3. Possibility of our base case being wrong
4. Slippage

Payoff Profiles Can Vary Dramatically

In Exhibit 68–28 we present the P&L for the seven hedges. We find that in absolute dollar terms the effectiveness of the various hedges varies dramatically—the range of P&Ls was $40,000 as of January 2011.

EXHIBIT 68–28

P&L for Various Hedge Vehicles in Our Base Case Scenario (70% Chance of Being Range-Bound, 30% Chance of S&P 500 Falling by Up to 15%)

Source: SG Cross Asset Research.

Note: As of January 21, 2011. We assume a 30-day holding period, and the notional amount of each hedge is weighted so that each exhibits the same risk. We use theoretical (calculated) prices for options to calculate the return.

By this measure of effectiveness the Treasury market hedge (long cash or futures) was the best performer, as it earned money in a status quo scenario (coupon clip), but also benefited from a flight-to-quality in more bearish scenarios. Interestingly, the S&P put comes in the sixth place, in part because it is fairly expensive. The cash high-yield cash market came in the last place, in part because it is a fairly expensive hedge and can be driven by factors that can have less of an impact on equities (e.g., defaults).

There Are Many Variation of Success

But this does not mean that Treasuries are the best hedge per se. That is, a P&L of $42,000 may go a long way to offsetting any loss we may incur due to falling equity prices, but remember that the notional exposure required to generate this return is $10 million! In comparison, the put position only requires a notional exposure of $43,000. In the context of return on notional exposure, the put position would outperform dramatically, 33.8% versus 0.4% (Exhibit 68–29).

Some investors may not have any constraints in terms of how much notional exposure they can have to a particular position, or how much balance sheet that they can tie up with any particular trade, etc., but many do face some of these constraints and the best hedge for these market participants may be something less "capital-intensive."[3]

EXHIBIT 68–29

Return on Notional Exposure

Asset	P&L ($k)	Notional ($k)	Return (%)
Trsy	42.4	10,000	**0.4**
T30 Fut	42.3	6,700	**0.6**
HY Index	2.4	3,800	**0.1**
CDX.IG	20.8	8,400	**0.2**
CDX.HY	16.1	2,375	**0.7**
SPX Put	14.6	43.1	**33.8**
VIX Call	22.6	69.3	**32.6**

Source: SG Cross Asset Research.

Note: As of January 21, 2011.

3. We acknowledge that collateral requirements for Treasuries are modest, but we do not explicitly consider the impact of leverage in this analysis.

Possibility of an Incorrect Base Case

Another important consideration is performance should our base case scenario be incorrect. Recall that our base case was that a range-bound market was most likely (70%), but that there was a 30% chance that the S&P declines by up to 15%. How would performance look if the chance of improved valuations was much higher and stocks rallied instead of falling sharply?

In Exhibit 68–30 we present P&L for our various hedges in an environment in which stocks rally by 5%. Perhaps the most important point here is that the susceptibility to an incorrect market call is limited for some vehicles, but not for others. For example, the most that the S&P put can lose is the option premium ($43,000; note that this is different from the option cost shown in the exhibit which reflects the cost for only the one-month holding period). Conversely, the high-yield hedge (cash) loses $64,000, in part due to the coupon paid ($22,000) but also due to a mark-to-market loss of $42,000. Treasury hedges do well in this scenario, primarily because there is no upfront cost for the hedge—a coupon is *earned* with this hedge, not paid.

What about Slippage?

In the context of some risks the Treasury hedge appears to be particularly effective, but the tool can be especially vulnerable to others, such as slippage. That is, the historic relationship between stocks and Treasuries might be fairly strong, but the Treasury market can be far more sensitive to factors such as monetary policy and inflation expectations than the equity market. As a result slippage can be dramatic at some points in time.

EXHIBIT 68–30

P&L for Various Hedge Vehicles in a Moderately Bullish Scenario (S&P 500 up 5%)

Source: SG Cross Asset Research.

Note: As of January 21, 2011. We assume a 30-day holding period, and the notional amount of each hedge is weighted so that each exhibits the same risk. We use theoretical (calculated) prices for options to calculate the return.

EXHIBIT 68–31

S&P 500 versus 30-Year Treasury Price

Source of data: SG Cross Asset Research, Bloomberg.

Note: From January 15, 2009 to June 15, 2009.

To illustrate, suppose that an investor bought a 30-year Treasury position to protect against a potential stock market setback on January 15, 2009. Over the next several months, equities performed well, but Treasuries sold off far more than their beta (versus the S&P 500) would suggest primarily because the bond market began anticipating and pricing in more inflation. As a result, the hedge would have lost 25% over the next few months, which is significantly more than the stock market gain of 9.6% (Exhibit 68–31).

The key takeaway is that unfortunately, there does not seem to be a perfect hedging vehicle to minimize exposure to tail risk. Four key challenges tend to impact the effectiveness of most hedges—cost, correlation, slippage, and reliance on historical relationship. In effect, investors must weigh these challenges (and others) with their own market expectations, objectives, and constraints.

That said, we examined a variety of hedging vehicles in several different scenarios, and found that in the context of these challenges the CDX.IG and the VIX indexes can be particularly effective. Vehicles such as Treasuries can do well in most scenarios, but do have significant slippage risk, and the performance of some options (e.g., short-tenor, at-the-money S&P puts) can be constrained by cost.

FUNDED HEDGES (ALPHA TRADES)

In the previous section we examined unfunded hedges, which in some respects are comparable to the outright purchase of an insurance policy. The cost of the policy is obviously a concern, but not necessarily an investor's primary concern. In this section we introduce funded hedges, or package trades in which some long exposure is used to pay for the cost of insurance. As a result the net hedge cost declines, but there is a tradeoff as other challenges can become more intense and new ones introduced. For example, counterparty risk can be an important consideration when employing a funded hedge strategy.

EXHIBIT 68–32

Nasdaq vs. S&P 500, 1995–2000

Source of data: SG Cross Asset Research, Bloomberg.

The reason why many market participants use funded hedges tends to result from two factors. First is the impossibility of being able to accurately predict the timing of a tail event. In practice, at best one may be able to do is anticipate a higher (lower) probability of an event occurring over a given time frame. Second, the performance of many investors is measured against a benchmark index or relative to the performance of competitors over a fairly short time. As such, if a tail event does not occur fairly quickly, the relative performance of an investor using an *unfunded strategy* will likely be negative, at least by some metrics.

Suppose that back in early 1995 an equity investor that was benchmarked against the S&P 500 on an annual basis was worried about "irrational exuberance." She shorted the segment of the stock market that she believed was most irrational—the NASDAQ. Unfortunately for this investor, while the equity market may very well have been irrational, such irrationality lasted for five more years. By early 2000 the NASDAQ had rallied 500% from early 1995 levels, and this investor would have lagged her benchmark by over 300%, as seen in Exhibit 68–32.

In this section, we evaluate funded hedges in the context of two specific risks (sovereign risk, economic downturn), but before proceeding there are three important points to make:

1. *Focus, focus, focus:* As a rule of thumb, unfunded hedges tend to protect portfolios against a wider variety of events than funded hedges, and this is primarily because funded hedge packages have both long and short elements (as opposed to an unfunded hedge with just short exposure). Essentially, the goal of a funded package is to short an asset that is particularly sensitive to a specific problem, and go long an asset that is fairly immune.
2. *Use scenarios more than history:* In the previous section our analysis of hedge efficiency was to a large extent based on history—if the S&P

500 moves by X amount, then hedge XYZ can be expected to move by Y amount. But funded hedges rely more heavily on scenario analysis than historical relationships. In essence, the goal is to construct a package that provides an asymmetric payoff profile across a wide variety of potential scenarios with a tolerable amount of downside risk. In this regard, more qualitative analysis may be needed.

3. *Additional risk factors introduced:* Funded packages also have more "moving parts" than unfunded packages and as a result additional risks can come into play. For example, counterparty, mark-to-market, and liquidity risks, to name a few, can all be found in abundance in funded hedges.

Again, in this section we provide two examples of funded hedges. We first focus on a sovereign risk hedge, and then a hedging vehicle to protect against an economic downturn. We find that while funded hedges have more "moving parts" and potential risks than unfunded hedges do, these risks can often be managed and results very effective.

Sovereign Fiscal Imbalances

While for many decades the focus of fiscal solvency has been in the emerging markets, sovereign default has become a risk factor in many developed economies as well. Public debt levels have spiked since 2007 (Exhibit 68–33) and some do not believe that all governments have the political wherewithal to solve the challenge.

One lower cost strategy to protect against a potential sovereign credit event is to go long names with little direct risk to public sector fiscal imbalances and

EXHIBIT 68–33

Portugal and the U.S. Gross Debt Levels, 1996–2010

Source of data: SG Cross Asset Research, Bloomberg, IGCP.

Note: Gross debt level.

fairly limited near-term risk in general. The income from this portfolio could be used to pay for short exposure to issuers with significant direct exposure to the sovereign problem and/or other near-term challenges.

Consider the package presented in Exhibit 68–34. The names of the companies and countries in the long and short positions of the package cannot be disclosed, but the levels presented in the exhibit reflect the real life values as of September 2010. The short side of this package is composed of names that had at least some of the following characteristics as of late 2010:

1. A direct link to the weak credit profile of the public sector
2. Meaningful maturities coming due in the near term (total of $295 billion through 2012). Refinancing could be a significant challenge should sovereign fears rise further and market participants begin to worry about a spillover into the banking system.
3. More cyclical names that (as of September 2010) could be particularly vulnerable to an economic slowdown caused by sovereign concerns.

The cost of this portfolio at a time when sovereign fears were particularly intense (mid-September 2010) was 1170 bp, based on one-year CDS (as of September 14, 2010). To overcome this fairly prohibitive cost one could use a one-year first-to-default structure (FTD); FTD packages pay those with short exposure in the event that any one of the names in the structure defaults, but only one. There is no additional payment should two, three, or more names experience a credit event.

The benefit of using this structure is that it costs relatively little to establish a short position. As of mid-September 2010 the cost was approximately 70% of the portfolio's sum-of-spreads (1,170 bp). So an investor only would have to pay 819 bp to short exposure to the basket of vulnerable names (1,170 bp × 70% = 819 bp).

This short position can be funded with long exposure to select names that appear to have little near-term default risk. Part of the reason is simply because the names in the long position in Exhibit 68–34 have little or no debt coming due in the period 2010–2012. Three of the five names have no upcoming maturities through 2012, and in aggregate only about $240 million will mature during this period.

In addition, the average implied default rate is far lower for the long positions than for the short positions (0.7% versus 3.0% average implied default rates, assuming 40% recovery for corporates and 70% recovery for sovereign names as of September 14, 2010). The market did not perceive all that much near-term risk for the long candidates (again, as of September 2010).

The key point is that short exposures appear to be more vulnerable to spread-widening catalysts, and the position is positive carry (151 bp, as of September 2010).

EXHIBIT 68–34

Example of a First to Default Hedge for Sovereign Risk

Long Exposure (Single Name CDS)					Short Exposure (First-to-Default Package)			
Issuer	**1Y CDS Sprd (bp)**	**Notional**	**'10'–12 Debt Maturities**		**Issuer**	**1Y CDS Sprd (bp)**	**Notional**	**'10'–12 Debt Maturities**
Company A	170	$10 mm	**$0.04 bn**		Company F	265	—	**$2.2 bn**
Company B	152	$10 mm	**$0**		Company G	90	—	**$2.3 bn**
Company C	110	$10 mm	**$0.20 bn**	**vs.**	Country A	367	—	**$23.2 bn**
Company D	321	$10 mm	**$0**		Country B	243	—	**$263.4 bn**
Company E	119	$10 mm	**$0**		Company H	205	—	**$3.6 bn**
					Sum	**1170**	**$10 mm**	
						X 70%		
Income	**970**	**$50 mm**	**$0.24 bn**		**Cost**	**819**	**$10 mm**	**$295 bn**

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of September 14, 2010.

Potential Risks

This trade package can benefit in the event of a sovereign credit event, but it does have risks that should be considered. For example, an FTD is an over-the-counter derivative product and is subject to non-standard prices that a bank or other dealer may provide upon unwinding, and as such the package is vulnerable to illiquidity. This risk is tempered, however, because of the fairly short tenor of the package—worst case, an investor can hold to maturity (one-year).

The aggregate delta mismatch is also a risk, but there are several factors that help to offset it. Specifically, the short tenor of the package limits the impact in absolute dollar terms, and the range-bound spread environment that the market was in can help to limit the severity of mismatch as well. Exhibit 68–35 shows that the high-grade market had been trading in a very tight range from mid to late 2010. If spreads do not move, delta mismatches do not matter.

And the notional mismatch—$50 million versus $10 million—is also a potential challenge. But let's take a step back from the FTD package itself and consider the riskiness of the underlying constituents. From a credit perspective, which is more risky—a $100 million Treasury position or $10 million exposure to First Data (rated B3/B/B) paper? Large exposure to a low probability event or small exposure to a higher probability event? In a risk-adjusted context, one could argue that the Treasury position is less risky.

Marking-to-Market: The FTD Hedge

While there are more moving parts with these relatively complicated packages, they can be very efficient hedging vehicles. For example, we marked-to-market the FTD trade package three months after it was initiated (i.e., December 15, 2010). Exhibit 68–36 shows that this package was deeply in-the-money, the long

EXHIBIT 68–35

CDX.IG S14 One-Year Index Spread Level

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of September 14, 2010.

EXHIBIT 68–36

FTD Hedge Marked-to-Market

Long Exposure (Single Name CDs)					Short Exposure (First-to-Default Package)			
Issuer	**1Y CDS Sprd (bp)**	**Notional**	**'10'–12 Debt Maturities**		**Issuer**	**1Y CDS Sprd (bp)**	**Notional**	**'10'–12 Debt Maturities**
Company A	170	$10 mm	**$0.04 bn**		Company F	265	—	$2.2 bn
Company B	152	$10 mm	**$0**		Company G	90	—	$2.3 bn
Company C	110	$10 mm	**$0.20 bn**	**Vs.**	Country A	367	—	$23.2 bn
Company D	321	$10 mm	**$0**		Country B	243	—	$263.4 bn
Company E	119	$10 mm	**$0**		Company H	205	—	$3.6 bn
					Sum	**1170**	**$10 mm**	
Income	**970**	**$50 mm**	**$0.24 bn**		**Cost**	**819**	**$10 mm**	**$295 bn**
	↓ Tightened 429 bp					↓ Widened 109 bp		
Income	**541**	**$50 mm**	**—**		**Cost**	**928**	**$10 mm**	**—**

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of September 14 and December 15, 2010; for HEI, MEO, and WENDEL, exchange-rate of 1.2998 (Sep) and 1.3214 (Dec) used to calculate USD spreads.

portion of the portfolio being 429 bp tighter and the short portion being 109 wider. In dollar terms this translates into a gain of $2.3 million, which could go a long way to offsetting any sovereign-induced decline in a portfolio.

Economic Downturn

One of the biggest risks that portfolio managers in virtually all asset classes face is exposure to severe economic downturn. That said, we believe that "cheap" and effective economic downturn hedges can be found. In this section we present an example of a positive carry package with an asymmetric payoff profile that existed in the credit space when heading into the 2007 recession. The favorable payoff profile resulted in large part from a unique combination of sector specific characteristics and the shape of select CDS curves.

With regard to sector characteristics, in the credit market all sectors tend to suffer heading into and during the early portion of recessions, but the extent of suffering can vary sharply. To illustrate, Exhibit 68–37 highlights the total returns of cyclical and noncyclical sectors in the high-yield market in 2008. On average the cyclical sectors generated a total return of –32% in 2008, while the non-cyclicals were far more resilient (–16%). So from this perspective shorting select cyclical sectors may have been the most effective trade.

But which one should be shorted? For unique reasons at any given point in time some sectors may be even more vulnerable than others heading into an

EXHIBIT 68–37

Total Returns of Cyclical and Non-Cyclical Sectors in the High-Yield Market, 2008

Source of data: SG Cross Asset Research, Bloomberg.

economic downturn. As noted above, there were numerous challenges in the economic backdrop back in early 2007, but many of the challenges centered around a potential bubble in the housing market. So ideally, back in 2008 shorting cyclical companies with exposure to the housing market, such as the homebuilding space, might have been a good hedge.

But what about the cost? Turns out, the cost of shorting the typical homebuilder heading into the last recession was not prohibitive either. Despite appearing to be more vulnerable to a slowdown, on average spreads in the homebuilder space were about the same as those in most other sectors. Exhibit 68–38 shows that the typical homebuilder (292 bp) was essentially trading at the same level as the typical cyclical (298 bp) and the typical non-cyclical (273 bp).

The key point is that homebuilders appeared to be particularly vulnerable to an economic downturn yet spread levels were very much in-line with the typical names in the market. Affordability is a good starting point for an effective hedge.

But the challenge is to craft a trade package that does not cost much, if anything, and has an asymmetric payoff profile. In this regard we can take advantage of the fact that many homebuilders had very steep credit curves prior to the 2008 recession. For example, KB Homes, a benchmark issuer in the homebuilding space, had a three-year/five-year spread slope of 111 bp heading into the 2008 recession (Exhibit 68–39), relative to about 100 bp for the typical high-yield name.

The steep curve enabled a potential investor to duration-weight a curve flattener and still earn positive carry. In effect, one could buy (go short) $15 million

EXHIBIT 68–38

Spreads of Cyclical and Non-Cyclical Sectors in the High-Yield Market, 2007

Source of data: SG Cross Asset Research, Bloomberg.

Note: As of January 2, 2007.

EXHIBIT 68–39

KBH CDS Curve on March 15, 2007

Source of data: SG Cross Asset Research, Markit.

of three-year KBH protection and sell (go long) $10 million protection in the five-year tenor, and be duration-neutral and still earn 49 bp in carry (Exhibit 68–40). The curve flattener, when combined with the potential susceptibility of this name to an economic downturn and its fairly tight spread levels, resulted in a package with an asymmetric payoff profile.

Consider the following four scenarios:

1. *Status quo:* Again, the steep slope of the KBH credit curve enabled a potential hedger to implement a duration-weighted 3s/5s curve flattener (hedge ratio of about 1.5×) and still earn 49 bp (Exhibit 68–40). And such, results are modestly favorable in a status quo scenario, particularly in a ROE context (as the position requires little collateral).
2. *Coin flip:* If the economy did not slow down and valuations simply "bounce around" the position should be fairly immune because it is duration matched.
3. *Bullish:* The package would likely be susceptible if an economic downturn did not occur and spreads tightened, but this risk is mitigated in part by positive carry and already tight spread levels. How much tighter can the front-end get?
4. *Bearish:* As a rule of thumb, credit curves typically flatten sharply when default risk increases, and default risk rises when the economy slows as shown in Exhibits 68-41 and 68-42. This package is well positioned to benefit, not only due to the disproportionate change in CDS spreads (short-tenor spreads under more pressure than longer-tenor ones), but also because of the disproportionate amount of protection bought and sold ($15 million versus $10 million).

EXHIBIT 68–40

KBH 3Y/5Y Curve Flattener

Action	Curve	Notional Amt	Duration	Spread
BUY	3-yr	$15 mm	2.9	111bp
SELL	5-yr	$10 mm	4.4	215bp
Carry				**+49bp**
ROE				**19%**

Source of data: SG Cross Asset Research, Bloomberg, Markit.

Note: As of March 15, 2007. We assume a lower risk profile fund and calculate the initial margin to be $250k, based on the gross notional amount.

We price the KBH trade package after a one-year holding period (as of March 14, 2008). Exhibit 68–43 shows that the KBH curve inverted sharply—three-year protection widened 407 bp, while five-year protection increased 251 bp—and Exhibit 68–44 shows that this package generated a positive P&L of $0.3 million (ROE of 122%).

The key takeaway is that as a rule of thumb funded hedges have more "moving parts" and potential risks than do unfunded hedges. That said, the risks can often be managed, in our experience. In this section we examined using funded hedges to manage two specific risks—public sector fiscal imbalances and an economic downturn—and found positive carry hedges that in theory offered an asymmetric

EXHIBIT 68–41

GS 3Y/7Y Curve vs. U.S. Speculative-Grade Default Rate

Source of data: SG Cross Asset Research, Markit, Moody's.

Note: As of January 18, 2011. Default rates are LTM US Spec-grade data. It matched with one-year forward dates of GS CDS curve.

EXHIBIT 68–42

JCP 3Y/7Y Curve vs. GDP

Source: SG Cross Asset Research, Markit.

Note: As of January 18, 2011.

payoff profile. We then marked-to-market these packages, and found that theory was consistent with reality.

Trade-Specific Risks

As discussed, most hedges face, at least to some extent, four generic challenges. In addition, many packages also have trade-specific challenges/risks as well. For example, if an investor purchases protection via the CDX.IG index he/she may be exposed to mark-to-market risk. Investors that mark portfolios to market are subject to potentially large movements in P&L that may cause a position to trigger a stop/loss. As we discussed in an earlier section, in 2007 market volatility was

EXHIBIT 68–43

KBH CDS Curve on March 14, 2008

Source of data: SG Cross Asset Research, Markit.

EXHIBIT 68–44

Return on KBH Curve Flattener

Action	Curve	Notional Amt	Spread Change	Dollar Return
BUY	3-yr	$15 mm	+407bp	+$1.1 mm
SELL	5-yr	$10 mm	+265bp	–$0.8 mm
Net Return				**+$0.3 mm**
ROE				**122%**

Source of data: SG Cross Asset Research, Bloomberg, Markit.

Note: As of March 14, 2008. We assume a lower risk profile fund and calculate the initial margin to be $250k, based on the gross notional amount.

increasing and investors sought to buy protection in the CDS market on banks and brokers that they viewed as particularly vulnerable. But ensuing spread widening was certainly not one directional, and some investors could have been forced out of positions (stop loss) even if they ultimately finished in-the-money.

The sovereign hedge described previously most certainly has liquidity risk (i.e., bid/ask spread could widen sharply if the package holder tried to unwind the position) as well as counterparty risk. With regard to liquidity risk, an investor seeking to capture the P&L of a particular trade that is in-the-money should consider the sizing and appropriate execution costs upon entering and exiting a position *in a normal versus a stressed scenario*. As a subset of liquidity risk, positions that are purchased on margin are particularly susceptible, as changes in margin or collateral requirements during stressful market periods can be dramatic.

The important point is that there are a large number of trade-specific risks for which one must account. We do not attempt to identify or analyze all potential risks within various hedges, but we do walk through one specific example in this section. In particular, we calculate a potential cost of counterparty risk for the Bear Stearns hedge described earlier.

The Cost of Counterparty Risk

It may be possible to control counterparty risk via regular reviews of trading partners, collateral requirements, etc., but however controlled it can be, it probably cannot be completely eliminated. Earlier we walked through an example in which an investor bought CDS protection on Bear Stearns as a hedge. Using the same example, assume again that the investor bought five-year CDS protection on Bear in early March 2008 at 315 bp, but add the wrinkle that the position was

purchased from Lehman. The key question is whether or not Lehman will be around to provide compensation should Bear default. Note that Lehman CDS was trading at 228 bp at the time.

Counterparty risk is to a large extent a function of two factors:

1. The joint probability of default (i.e., Bear and Lehman both experience a default);
2. The size of a loss in the event of a default, which depends on recoveries for both Bear and Lehman; that is, if Bear defaults our investor would be owed a certain amount by Lehman, but if Lehman also defaults this claim probably would not be paid in full.

We rely on the following equation to calculate how much this counterparty risk costs in terms of basis points:

$$\begin{aligned}&\text{Counterparty risk}\\&= \text{Joint default probability} \times [100 \times (1 - \text{Recovery}_{\text{BSC}})\\&\times (1 - \text{Recovery}_{\text{LEH}}]/\text{Duration}_{\text{BSC}}\end{aligned}$$

If we assume recovery rates of 40% for both Bear and Lehman, and that five-year CDS spread levels are entirely compensation for credit risk, the implied default rate is 23.1% for Bear Stearns and 17.3% for Lehman. As such, the extra compensation that investors should receive for counterparty risk is about 36 bp as shown below:

$$\begin{aligned}\text{Joint default probability} &= \text{Default probability}_{\text{BSC}} \times \text{Defaulty probability}_{\text{LEH}}\\&= 23.1\% \times 17.3\% = 4.0\%\\\text{Counterparty cost} &= 4.0\ \% \times [100 \times (1 - 40\%) \times (1 - 40\%)]/\ 4.0 = 36\text{ bp}\end{aligned}$$

The key point is that the cost of Bear protection was probably higher than the nominal spread of 315 bp. By some metrics the cost of counterparty risk alone is 36 bp, pushing the true cost to 351 bp (315 bp + 36 bp).

KEY POINTS

- Tail events tend to occur more often than one might expect, in large part because (1) the actions of investors can be influenced by factors that are not necessarily related to investment efficiency, (2) market participants tend to move incrementally and over time risk profiles can increase dramatically, and (3) the financing of risk assets and/or operations tends to be transitory and the lack of stable access to financing can cause any modest change in valuations to snowball.
- If and when an investor decides to hedge, it is important to understand exactly what is to be hedged. One type of tail event (e.g., sovereign default) could require a very different type of hedge than another (e.g., BP oil spill).

- There is no perfect hedge. Four challenges that should be considered for most hedge vehicles are (1) correlation (i.e., the likelihood that a hedged asset and the hedging vehicle do not move in the same direction and magnitude), (2) cost, (3) potential slippage that can be induced by the sensitivity of the hedge or the hedged asset to a unique development, and (4) the reliance on history, since the relationship can be transitory over time. In addition, there can be a number of trade-specific risks that are important to consider as well (e.g., counterparty risk, liquidity, etc.). In effect, investors must weigh these challenges with their own market expectations, objectives, and constraints.
- Unfunded hedges are defined as those for which an investor is willing to dedicate a certain amount of capital to protect the portfolio. In some respects, unfunded strategies are comparable to insurance policies. The cost of the policy is obviously a concern, but it is not necessarily an investor's primary concern.
- An evaluation of seven unfunded hedges in the setting of declining equity prices finds that while there is no perfect hedge for all investors, various VIX and CDX.IG strategies can be efficient in a fairly wide range of scenarios. A tendency to exhibit large and asymmetric movements is an important characteristic of any hedging vehicle.
- Funded hedges are defined as packages in which some long exposure is used to pay for the cost of insurance. As a result, the net hedge cost declines, but there is a tradeoff as other challenges can become more intense and new ones introduced.
- Funded hedges typically become more popular when the timing of any potential negative catalyst is difficult to ascertain and when performance of investors is measured over a fairly short period of time. We find that while funded hedges have more "moving parts" and potential risks than unfunded hedges do, these risks can often be managed and hedge results can be effective.

PART
TEN

PERFORMANCE EVALUATION AND RETURN ATTRIBUTION ANALYSIS

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CHAPTER
SIXTY-NINE

PRINCIPLES OF PERFORMANCE ATTRIBUTION

ANTHONY LAZANAS, PH.D.
Managing Director
Barclays Capital

ANTÓNIO BALDAQUE DA SILVA, PH.D.
Director
Barclays Capital

CHRIS STURHAHN
Vice President
Barclays Capital

ERIC P. WILSON
Vice President
Barclays Capital

PAM ZHONG, CFA
Vice President
Barclays Capital

Performance measurement and attribution is an important function of portfolio management. It helps bring clarity to the sources of portfolio risk and performance, quantify the contributions of individual decision-makers and identify structural issues. Performance attribution algorithms typically follow either a sector-based allocation or a factor-based allocation methodology, but neither is sufficient to cope with the complexity of modern portfolio management. In this chapter, we first discuss the principles of performance attribution. We review the sector-based and factor-based attribution frameworks then describe a hybrid attribution model[1] that blends the two and has the flexibility to adapt to the particular

The authors would like to thank Lev Dynkin for introducing us to the concept of performance attribution, Jay Hyman for many insightful ideas over the years and Attakrtit Asvanunt who was instrumental in the development of many concepts in this chapter.

1. For another discussion of the hybrid performance attribution model also see Chapter 27 in Lev Dynkin, Anthony Gould, Jay Hyman, Vadim Konstantinovsky, and Bruce Phelps, *Quantitative Management of Bond Portfolios* (Princeton University Press, 2007).

management structure of most portfolios. The chapter finishes with the application of performance attribution, both as a portfolio management tool and a data quality tool. Where possible, we introduce the best practices for performance measurement and discuss practical considerations in real-world applications. Throughout the chapter, we utilize examples produced by the Barclays Capital Hybrid Performance Attribution (HPA) model[2] as implemented in POINT, the Barclays Capital portfolio analytics and modeling platform.[3]

PRINCIPLES OF PERFORMANCE ATTRIBUTION

Managing a global diversified portfolio of financial assets is a complex task that requires adopting views in different markets and implementing them with regular trading activities. Expressing and implementing views in a variety of markets that interact with each other in complex ways, makes it very difficult to quantify the contribution of each decision-maker to the performance of the portfolio. Performance attribution is a mathematical framework that attempts to split the total outperformance of a portfolio versus a benchmark into the contributions of individual decisions and actions.

Complex portfolios are typically managed by breaking down the investment process into a sequence of decisions made by different managers, each of whom specializes in a specific market or type of security. Traditionally, this process follows product and sector lines. Risk-factor-based portfolio management became popular with the advent of modern portfolio risk management and the realization that certain risks are common for multiple asset classes. Foreign exchange (FX) and interest rates are examples of risks that are now commonly being managed separately for the entire portfolio while product/sector experts focus on managing excess returns.

The total outperformance of a portfolio depends on the combined outcome of the decisions of all portfolio agents, as well as the market performance. Often, the effects of different agents' decisions depend on each other in a way that makes it difficult to disentangle them. A successful performance attribution algorithm will do so in a way that satisfies three important requirements:

- *Additivity*: The contribution of two or more agents combined is equal to the sum of the contributions from those agents.
- *Completeness*: The sum of all outperformance contributions is equal to the total portfolio outperformance.
- *Fairness*: The allocation of outperformance to different interacting agents is performed in a way that is perceived to be fair by all agents.

2. For details of the model see Anthony Lazanas, Chris Sturhahn, and Pamela Zhong, *The Barclays Capital Hybrid Performance Attribution (HPA) Model* (Barclays Capital Publications, October 2010).
3. Both Hybrid Performance Attribution and POINT are registered trademarks of Barclays Capital.

These requirements are important because performance attribution is often used to measure the skill level and determine the compensation of portfolio managers. The fair decomposition of portfolio outperformance must take into account the management structure of the portfolio. In addition, a good performance attribution model or system needs to successfully address multi-period compounding and have sufficient flexibility in order to meet the demands of modern portfolio management.

Multi-Period Attribution and Compounding

Generally speaking, a performance attribution model measures the exposure of a portfolio to various markets at the beginning of a period and then explains the contribution of each market to the performance of the portfolio over the period as the product of its exposure to the market times the market move. Since actively managed portfolios dynamically adjust exposures to various markets frequently, such performance attribution over a period of time will not capture the effect of active portfolio management.

For example, consider a portfolio that begins the attribution period with no exposure to a particular sector. During the period the sector rallied and in response the manager allocated positive exposure to the sector. Subsequently the sector lost all of its gains and ended the period flat. Since the portfolio had no exposure when the sector rallied but positive exposure when the sector retreated, the portfolio realizes losses over the period. An attribution system that looks at exposure at the beginning of the period (zero) and the return of the sector over the period (also zero) will not be able to explain the realized losses. A system using average exposure over the period will also fail to explain the losses since the return of the sector is zero over the period. On the other hand, a system that splits the attribution exercise in two (or more) subperiods and then combines the results of the subperiods to explain the total portfolio performance over the entire period will be able to identify the intra period exposure adjustment as the reason for the portfolio losses.

The length of the subperiods that an attribution system uses to explain performance over longer periods determines the frequency of the attribution system. Linking the returns of subperiods is called compounding. Timing affects investment performance, especially when intermediate cash flows occur. Since cash flows impact portfolio market value, the fundamental question is whether sub-period returns should be compounded without regard to the portfolio size during each subperiod (time-weighted compounding) or whether subperiod returns should be weighted by the portfolio market value in each period (money-weighted compounding). For example, consider a portfolio with a seed investment of $1,000,000 that earns a rate of return of 100% doubling its value for the first half of the year. Because of its success, the portfolio attracts additional investments of $100,000,000 and its market value becomes $102,000,000. Unfortunately, in the second half of the year it has losses of 10% ending the year with a value of $91,800,000. What is the annual return of the portfolio? Assuming the inflow

are immediately shown in the quality of the results. An example of this is discussed later in the chapter.

Flexibility

A practical performance attribution system must reflect the decisions that a portfolio manager makes during the normal course of the investment process. With a wide diversity among portfolio managers also comes a wide diversity of styles that are often mutually exclusive. No single specification of a performance attribution can describe all managers' preferences. In order to be useful, the model must also satisfy the following requirements:

- Measure the risk factors corresponding to the portfolio managers' decisions
- Independently measure the contributions of each factor in the portfolio management process
- Closely follow the published returns of the fund, and its benchmark
- Be available in a timely manner
- Have sufficient adaptability to explain both short and long time periods

In short, it must be useful to the portfolio manager in explaining and refining her decisions, quantifying the effects of the investment process.

MATHEMATICS OF PERFORMANCE ATTRIBUTION

Performance attribution algorithms typically follow either a sector-based allocation or a factor-based allocation methodology. Both methods follow the same framework which expresses the total outperformance of the portfolio over a benchmark $R^P - R^B$ as the sum of several components. The contribution of each component is determined by a portfolio manager's decision to allocate a different exposure than the benchmark to a particular market or factor, and the performance of the market or the factor itself. In this section, we first discuss sector-based and factor-based attribution under this simple framework, and then introduce a hybrid model that blends the two and has the flexibility to support virtually all types of portfolios and portfolio management styles. We will develop the mathematical framework of performance attribution assuming a generic set of sectors and factors. In Chapters 70 and 71 we will see the application of this framework in the performance attribution of fixed income portfolios.

Sector-Based Attribution

In its simplest form, portfolio management versus a benchmark is modeled as a two-step process that consists of market weight allocation to various sectors and

occurred in the middle of the year, money-weighted rate of return estimates the annual return by solving for the internal rate of return:

$$1,000,000 \times (1+r) + 100,000,000 \times (1+r)^{0.5} = 91,800,000 \Rightarrow r = -17.24\%$$

Time-weighted rate of return ignores the portfolio size and reports an annual return of:

$$r = (1+100\%) \times (1-10\%) - 1 = 80\%$$

Given the dramatic differences between the two methods when portfolio flows are significant relative to its current size, the choice between the two methods is an important decision. Whether the timing of cash flows should be reflected in return measures depends on whether the portfolio manager is responsible for the timing of the cash flows. If she is responsible, then money-weighted method should be used. In the case of mutual fund or pension fund managers who have no direct control of cash contributions and withdrawals, the time-weighted method is more appropriate. In the following three chapters we assume the time-weighted methodology.

Once the method for compounding returns is decided, the question of splitting multi-period returns into components (i.e., multi-period performance attribution) must be addressed. The difficulty arises from the fact that compounding is a nonlinear function and introduces interaction terms that must be allocated between different return components. For example, consider that the portfolio return is attributable to two components which both contribute 10% of return over two periods. The return of the first component is realized during the first period, and the return of the second component is realized over the second period. Time-weighted compounding will report total portfolio return of (1+10%) × (1+10%) – 1 = 21%. Each component contributes 10%, leaving 1% of total return that can be claimed by either component. A multi-period attribution system must adopt both return and outperformance compounding algorithms that retain the principles of additivity, completeness and fairness. Such algorithms are discussed in more detail in Chapter 71.

It is important that the frequency of the attribution system match the frequency of portfolio management decisions. If the attribution frequency is too low, as in the example above, part of the portfolio performance may remain unexplained. Conversely, if the attribution frequency is too high, the attribution model may attribute outperformance to portfolio management erroneously. Many fixed income portfolios are managed on a daily basis, especially with respect to their interest-rate exposures; therefore daily-frequency attribution models are commonly used for fixed income portfolios. Daily compounding generates the requirement for high-quality daily prices and analytics for all securities in a portfolio and its benchmark. Sophisticated attribution systems can be used as a magnifying glass for data quality. Any problems with the data

security selection within each sector. The classical performance attribution methodology is often referred as "Brinson model."[4] Portfolio return is the market value-weighted (w_s) sum of the individual sector returns, R_s:

$$R^P = \sum_s w_s^P R_s^P$$

Similarly, benchmark return is the weighted sum of benchmark sector returns:

$$R^B = \sum_s w_s^B R_s^B$$

This representation allows us to identify two key drivers of the total outperformance $R^P - R^B$: the differences in the sector allocations, w_s, and the differences in the returns, R_s earned within each sector. The outperformance achieved by reweighting the sectors is called "Asset Allocation," and the outperformance due to the intrasector return differences is called "Security Selection." To make the decomposition of the total outperformance complete, we need to add a third term, the "Interaction" effect, the joint effect of asset allocation and security selection.

Asset Allocation $$\sum_s \left(w_s^P - w_s^B\right) \cdot R_s^B \tag{69–1}$$

Security Selection $$\sum_s w_s^B \cdot \left(R_s^P - R_s^B\right) \tag{69–2}$$

Interaction $$\sum_s \left(w_s^P - w_s^B\right) \cdot \left(R_s^P - R_s^B\right) \tag{69–3}$$

Interaction terms arise every time two factors contribute to outperformance through a non-additive function such as the product. Interaction terms are philosophically undesirable, since the stated goal of performance attribution is to credit agents separately for their contribution. Thus, we attempt to merge interaction terms into other outperformance components that can be uniquely attributed to a single agent. The criteria for consolidation are usually dictated by the order in which decisions are made, or the relative size of the interaction term.

The standard assumption is that asset allocation precedes security selection (i.e., the portfolio is managed in a top-down fashion), so it is common to fold the interaction term into the latter:

Asset Allocation $$\sum_s \left(w_s^P - w_s^B\right) \cdot R_s^B \tag{69–4}$$

Security Selection $$\sum_s w_s^P \cdot \left(R_s^P - R_s^B\right) \tag{69–5}$$

4. Gary L. Brinson and Nimrod Fachler, "Measuring Non-U.S. Equity Portfolio Performance," *Journal of Portfolio Management*, 11, 3 (1985), pp. 73–76 and Gary L. Brinson Randolph. Hood and Gilbert Beebower "Determinants of Portfolio Performance," *Financial Analysis Journal*, 42, 4 4 (1986), pp. 39–44.

If, on the other hand, the expected returns of sectors in the portfolio are different than those in the benchmark (for example, because of manager skill or leverage), then it might be more appropriate to fold the interaction term into asset allocation instead. As a result, asset allocation would be given by $\sum_s \left(w_s^P - w_s^B\right) \cdot R_s^P$ and security selection would be given by $\sum_s w_s^B \cdot \left(R_s^P - R_s^B\right)$. It is easy to see that in both cases, the outperformance breakdown is complete; i.e., the sum of the two components is equal to the total outperformance.

The above formulas would assign positive contribution to asset allocation outperformance to any overweighted sector with positive benchmark sector return. Thus, if all sectors have positive benchmark returns, overweighting the sector with the worst return would still be considered a good decision. This is intuitively wrong in most portfolios, as the weight allocated to such sector would be better used in sectors with higher returns. Therefore, instead of using the absolute benchmark sector return in the above asset allocation formula, one can use the sector return relative to the benchmark return (which represents the weighted average return of all benchmark sectors):

$$\text{Asset Allocation} \qquad \sum_s \left(w_s^P - w_s^B\right) \cdot \left(R_s^B - R^B\right) \tag{69–6}$$

$$\text{Security Selection} \qquad \sum_s w_s^P \cdot \left(R_s^P - R_s^B\right) \tag{69–7}$$

Notice that while the contribution of each sector to asset allocation changes, the total asset allocation outperformance remains the same as long as $\sum_s w_s^P = \sum_s w_s^B$.

The constraint that the sum of the portfolio and the benchmark sector weights are equal to one necessitates the comparison of the benchmark sector returns with the overall benchmark return. If leveraging is allowed, such that there is no constraint on each sector's weight, then each overweighted sector with a positive return should indeed have a positive contribution to outperformance. In such a case, we do not need to compare the return of each sector to the return of the benchmark and Eqs. (69–4) and (69–5) apply. In practice, however, leverage constraints do exist (usually dictated by risk constraints), and neither the benchmark return nor zero is a generally appropriate choice for the hurdle rate for each sector. In the following discussion, we will use the term R^H generically for the hurdle rate. This formulation describes both above models while allowing for extra flexibility. A choice of $R^H = 0$ gives the original Brinson model in Eqs. (69–4) and (69–5), while a choice of $R^H = R^B$ gives the model in Eqs. (69–6) and (69–7).

Recursive Allocation

Most large portfolios have many management layers by which allocation decisions are made successively. For example, the global strategist can specify the allocation into global markets, the U.S. strategist can determine the allocation to major asset classes in the U.S. (equities, bonds, commodities, etc.), the fixed income strategist can determine the allocations into the various sectors, and so forth.

In such a case, what we called security selection above contains not only security selection, but also further asset allocation, as well as security selection for each subsector. In fact, each sector can be considered as a smaller portfolio for which the above performance breakdown equations can be applied recursively. For this reason we will use the term "Sector Management" instead of "Security Selection," and we will reserve the term "Security Selection" for the last layer of management when no further sector decomposition occurs.

For each sector, its contribution to the sector management from the level above, $w_s^P \cdot \left(R_s^P - R_s^B\right)$, is recursively split into the following components:

$$\text{Asset Allocation} \qquad w_s^P \sum_r \left(\frac{w_r^P}{w_s^P} - \frac{w_r^B}{w_s^B}\right) \cdot \left(R_r^B - R_s^H\right) \tag{69–8}$$

$$\text{Sector Management} \qquad \sum_r w_r^P \cdot \left(R_r^P - R_r^B\right) \tag{69–9}$$

Typically, the benchmark sector return R_s^B is used as the hurdle rate as for the calculation of asset allocation to subsectors. In this fashion, we can keep decomposing sector management outperformance until we reach the last layer of portfolio management. Since at each level the decomposition is complete, the total outperformance decomposition is also complete. This algorithm has two of the three required properties of performance attribution: additivity and completeness. As we will see in the following discussion, it also has sufficient flexibility to be applied under different management structures such that it is considered to be fair, thereby satisfying all three requirements of performance attribution.

The fundamental advantage of the sector-based attribution methodology is its flexibility. The ability to analyze portfolio allocations along an arbitrarily specified market partition makes it possible to customize the model to fit many different types of portfolios and management styles. The main disadvantage of this approach is that it analyzes yield-curve and spread returns within the same market partition using market value weights, something that does not correspond to standard fixed income portfolio management practice.

Factor-Based Attribution

The "sector-based" attribution is gradually losing ground to a "factor-based" decomposition of the investment universe, where the return of the security in the portfolio/benchmark is decomposed into the contributions of common risk factors plus a residual. The residual represents the return not captured by the risk factors. The coefficients of the factors, α_k, are called loadings or sensitivities of the portfolio to each factor, f_k. Typically, the decomposition is linear and is represented as:

$$R^P = \sum_k \alpha_k^P f_k^P + \varepsilon^P$$

Such risk factors for fixed income securities include interest rates, implied volatility, spreads, etc., and the loadings are the corresponding sensitivities to the exposure of each factor (option-adjusted duration, partial (key-rate) durations, Vega, spread duration, and related measures). Factor-based attribution essentially entails the decomposition of outperformance to the contribution of each risk factor.

$$R^P - R^B = \sum_k \left(\alpha_k^P - \alpha_k^B\right) \cdot f_k^P + (\varepsilon^P - \varepsilon^B) \tag{69–10}$$

Pure factor-based attribution systems attempt to use a set of factors that can explain all of the systematic return of a portfolio. In this case the excess return is idiosyncratic and therefore quite small for a well diversified portfolio. The disadvantages of this approach are that it does not attribute idiosyncratic returns of small portfolios to security selection decisions, and there is usually little flexibility in defining the risk factors. The latter shortcoming may be overcome with factor remapping,[5] which allows each portfolio manager to attain a personalized view of risk and return decomposition.

A Unified Framework for Performance Attribution

We will now combine the ideas we have developed in the preceding sections into a unified framework that blends the sector-based and the factor-based attribution. Models using this framework, such as the Barclays Capital Hybrid Performance Attribution model, are favored by portfolio managers since they can account for the complex management structures of large diversified portfolios. The framework offers enhanced flexibility in defining arbitrary hierarchical partitions along which sector allocation decisions are expressed. It allows the portfolio managers to achieve the best match to their investment decision-making process. It is a conceptually simple recursive algorithm that can be described in three steps: return splitting, factor return attribution, and recursive application. We explain these steps below.

Step 1: Return Splitting

The total return of the portfolio and the benchmark is split into the linear contributions of factors.[6]

$$R^P = \sum_k \alpha_k^P f_k^P \qquad R^B = \sum_k \alpha_k^B f_k^B$$

Note that residual is included here as one of the factors with a loading of one.

5. António Baldaque da Silva, "Risk Attribution with Custom-Defined Risk Factors," *Barclays Capital Publications*, August 2009.
6. Successive valuation used for the return splits is discussed in Chapter 70.

Step 2: Factor Return Attribution

The factors from step 1 are categorized as either common or allocated. We denote the set of common factors by C and the set of allocated factors by A and write the total outperformance as:

$$R^P - R^B = \left(\sum_{k\in C} \alpha_k^P f_k^P - \sum_{k\in C} \alpha_k^B f_k^B\right) + \left(\sum_{k\in A} \alpha_k^P f_k^P - \sum_{k\in A} \alpha_k^B f_k^B\right) \tag{69–11}$$

The outperformance from each factor is then handled separately. For each factor, we partition the investment universe into sectors[7] and decompose the outperformance from the factor.

$$\alpha_k^P f_k^P - \alpha_k^B f_k^B = \sum_s \alpha_{k,s}^P f_{k,s}^P - \sum_s \alpha_{k,s}^B f_{k,s}^B \tag{69–12}$$

Outperformance from common factors is explained using bottom-up aggregation, namely via net exposures to a factor at each level of the aggregation. Furthermore, if a factor is truly common, where the factor return in the portfolio is identical to the factor return in the benchmark, then the contribution of the factor to portfolio outperformance can be written as:

$$\alpha_k^P f_k^P - \alpha_k^B f_k^B = \sum_s \left(\alpha_{k,s}^P - \alpha_{k,s}^B\right) \cdot f_{k,s} \tag{69–13}$$

This breakdown allows the performance of the portfolio due to the common factors to be categorized and aggregated to the portfolio level. In this way, a more detailed explanation of the factor and its impact to the total portfolio is possible than if the return were split between sectors. For example, exposure to the yield-curve is typically managed at the portfolio level by determining first the overall duration over/underweight vs. the benchmark and then determining where on the yield-curve to take the extra exposure. The strategy may be designed to take advantage of flattening or steepening in the yield-curve, and only measurement of these effects at the portfolio or sub-portfolio level is meaningful.

Outperformance from allocated factors is explained using the following allocation methods: absolute allocation and relative allocation. We discuss each below.

Unlike common factors, allocated factors may have different realizations for different securities or sectors even if they broadly capture the same type of risk exposure. For example, credit-spread, whose level depends on the particular securities within a sector, is a factor of this type. In the absolute allocation framework, the total portfolio exposure to each factor is determined by all sector managers. Each sector manager may take a different view as to the expected direction of each factor. In this case, asset allocation is solely determined by the net sector exposure to a particular factor:

$$\text{Asset Allocation} \qquad \sum_s \left(\alpha_{k,s}^P - \alpha_{k,s}^B\right) \cdot f_{k,s}^B \tag{69–14}$$

$$\text{Sector Management} \qquad \sum_s \alpha_{k,s}^P \cdot \left(f_{k,s}^P - f_{k,s}^B\right) \tag{69–15}$$

7. A different partition may be used for each factor.

In the relative allocation framework, the total exposure to each factor is determined at the portfolio level (or the higher hierarchical level). The asset allocator subsequently determines the sector exposures to the factor subject to the constraint imposed by the portfolio exposure. Each sector may take a different view as to the relative movement of each factor against the overall benchmark factor return.

Asset Allocation
$$\alpha_k^P \cdot \sum_s \left(\frac{\alpha_{k,s}^P}{\alpha_k^P} - \frac{\alpha_{k,s}^B}{\alpha_k^B} \right) \cdot \left(f_{k,s}^B - f_k^H \right) \tag{69–16}$$

Sector Management
$$\sum_s \alpha_{k,s}^P \cdot \left(f_{k,s}^P - f_{k,s}^B \right) \tag{69–17}$$

Top-level Exposure
$$\left(\alpha_k^P - \alpha_k^B \right) \cdot f_k^H \tag{69–18}$$

Notice that in the relative allocation framework, the factor hurdle rate f_k^H essentially becomes a common factor.

Step 3: Recursive Application

The sector management terms from top-down allocations, $f_{k,s}^P - f_{k,s}^B$, can be now decomposed separately using the above algorithm recursively.

At the last stage of the decomposition, in which a sector is not decomposed further into subsectors, the sector management term becomes security selection. The top-down decomposition can be applied one last time to break down the security selection outperformance of a sector into the contributions of individual securities. In this case the management term is typically zero, since the factor driving the return of the same security in the portfolio and the benchmark is the same.

An Example of Hybrid Performance Attribution

To illustrate how this algorithm can be applied in practice, consider a very simple model in which the return of a security is split into two components: the time return that is measured by the yield of the security and a market return that is measured as the duration of the security times the negative of its yield change. This decomposition may not be complete, so it is reasonable to assume the presence of a residual.

$$R_i = Y_i \, \Delta t - D_i \, \Delta Y_i + \varepsilon_i \tag{69–19}$$

The portfolio (or benchmark) return is the weighted average return of the securities in the portfolio (or benchmark). The summation extends over a universe defined by the union of securities in the portfolio and benchmark. Securities not present in either get correspondingly zero weight.

$$\begin{aligned} R^P &= \sum_i w_i^P R_i = \sum_i w_i^P Y_i \, \Delta t - w_i^P D_i \, \Delta Y_i + w_i^P \varepsilon_i \\ R^B &= \sum_i w_i^B R_i = \sum_i w_i^B Y_i \, \Delta t - w_i^B D_i \, \Delta Y_i + w_i^B \varepsilon_i \end{aligned} \tag{69–20}$$

Aggregation of yield and duration is the usual weighted average; however, yield changes must be aggregated using duration contribution weights to retain their natural interpretation.

$$Y^P = \sum_i w_i^P Y_i \qquad Y^B = \sum_i w_i^B Y_i$$
$$D^P = \sum_i w_i^P D_i \qquad D^B = \sum_i w_i^B D_i \tag{69–21}$$

$$\Delta Y^P = \sum_i \frac{w_i^P D_i}{D^P} \Delta Y_i \qquad \Delta Y^B = \sum_i \frac{w_i^B D_i}{D^B} \Delta Y_i \tag{69–22}$$

We can now rewrite the portfolio and benchmark returns using top-level analytics:

$$R^P = Y^P \Delta t - D^P \Delta Y^P + \sum_i w_i^P \varepsilon_i$$
$$R^B = Y^B \Delta t - D^B \Delta Y^B + \sum_i w_i^B \varepsilon_i \tag{69–23}$$

Let us assume that time return (carry) and residual are allocated as common factors.

$$\text{Carry} \qquad (Y^P - Y^B) \cdot \Delta t \tag{69–24}$$

$$\text{Residual} \qquad \sum_i \left(w_i^P - w_i^B\right) \cdot \varepsilon_i \tag{69–25}$$

Market return is managed by allocating duration exposure $w_s^P D_s^P$ to a set of sectors and allowing managers to pick securities within each sector.

If the top-level portfolio duration is not constrained and is completely determined by the choices of the sectors' net duration exposures, we should use the absolute allocation algorithm by setting $\alpha_k \leftarrow D$, $\alpha_{k,s} \leftarrow w_s D_s$, $f_{k,s} \leftarrow -\Delta Y_s$. The duration and yield change of each sector in the portfolio and the benchmark are calculated in the same weighted average fashion we discussed above. Since the asset allocation agent is free to determine the duration exposure of each sector, there is no hurdle rate and the total outperformance is solely distributed between asset allocation and security selection.

$$\text{Asset Allocation} \qquad -\sum_s \left(w_s^P D_s^P - w_s^B D_s^B\right) \cdot \Delta Y_s^B \tag{69–26}$$

$$\text{Security Selection} \qquad -\sum_s w_s^P D_s^P \cdot \left(\Delta Y_s^P - \Delta Y_s^B\right) \tag{69–27}$$

On the other hand, if the net duration of the portfolio is actively managed, we need to use the relative allocation method. In this case, we set the hurdle rate equal to the benchmark yield change.

$$\text{Asset Allocation} \qquad -D^P \cdot \sum_s \left(\frac{w_s^P D_s^P}{D^P} - \frac{w_s^B D_s^B}{D^B}\right) \cdot \left(\Delta Y_s^B - \Delta Y^B\right) \tag{69–28}$$

Security Selection $$-\sum_s w_s^P D_s^P \cdot \left(\Delta Y_s^P - \Delta Y_s^B\right) \tag{69–29}$$

Top-level Exposure $$-(D^P - D^B) \cdot \Delta Y^B \tag{69–30}$$

APPLICATIONS OF PERFORMANCE ATTRIBUTION

Beyond its stated goal of attributing portfolio outperformance to the actions of agents, detailed and flexible performance attribution can bring clarity to the process of portfolio management by systematically exposing sources of risk and performance. By linking ex-post outperformance contributions to ex-ante views and management decisions, a manager can identify unanticipated sources of risk and return and adjust the management process accordingly. In addition, by providing the recursive decomposition of outperformance into the various contributing factors, it facilitates the discovery and correction of data errors that are not uncommon in large financial accounting systems. In the rest of this chapter we will illustrate such applications of performance attribution in the context of a particular portfolio.

Performance Attribution as a Portfolio Management Tool

Consider the following example. A portfolio manager has the mandate to track the Barclays Capital Global Aggregate G4 Index and has the latitude to implement certain market views in order to enhance the portfolio returns, as long as the standard deviation of portfolio minus benchmark returns (Tracking Error Volatility or TEV) stays below 40 bp per month. At a specific point in time, the manager is bullish on the Japanese yen, negative on the euro and neutral on the U.S. dollar and the British pound. She believes that global rates are falling. She has no sector views except in the U.S. markets, where she likes corporates but dislikes the securitized sector. According to her mandate and her views, she constructs a portfolio with the following characteristics:

- The portfolio has a 5% overweight (vs. the benchmark) in the yen, a 5% underweight in the euro and is flat in U.S. dollars and British pounds.
- The portfolio interest-rate option-adjusted duration (OAD) is about one year longer than that of the benchmark.
- Within the U.S. market, the portfolio has a 5% overweight in corporates, a 5% underweight in securitized, and is flat in the U.S. Treasury and government-related sectors.

We created this portfolio in the Barclays Capital POINT system and used the Global Risk Model in POINT to estimate the portfolio tracking error volatility relative to its benchmark as 32 bp per month. Since this is below the 40 bp per month risk budget the portfolio is acceptable.

EXHIBIT 69–1

Total Portfolio Outperformance

Global Outperformance (bp)	
Portfolio Return	188.7
Benchmark Return	150.0
Total Outperformance	**38.7**

Source: Barclays Capital POINT

We subsequently ran the POINT hybrid performance attribution model over one month and produced a detailed performance attribution report. This report begins by reporting the total portfolio and benchmark returns over the month (+188.7 bp and +150.0 bp respectively) as well as their difference, +38.7 bp, the total portfolio outperformance (Exhibit 69–1). The report then proceeds to decompose the total outperformance into the contributions of the various portfolio exposures and market performance. The decomposition is hierarchical to allow the portfolio manager to first get a broad understanding of the sources of outperformance and then dive into the specific details. In Exhibit 69–2, we see a first decomposition of the portfolio total outperformance on a global level into three components: FX Allocation and Hedging (+28.3 bp), Local Market Allocation (–8.7 bp), and Local Market Management (+19.1 bp). In Exhibit 69–3, the Local Market Management component is further decomposed into contributions from Yield-Curve exposures (+20.6 bp), Asset Allocation (+0.2 bp) and Security Selection (–1.7 bp).

Outperformance from Currency Exposures

The +28.3 bp outperformance from FX allocation and hedges indicates that the manager's FX views were broadly correct. In Exhibit 69–4 we can see that,

EXHIBIT 69–2

Global Outperformance Summary

Global Outperformance Summary (bp)	
FX Allocation and Hedging	28.3
Local Market Allocation	–8.7
Local Market Management	19.1
Total	**38.7**

Source: Barclays Capital POINT

EXHIBIT 69–4

FX Outperformance Breakdown

	FX Rate Begin	FX Rate End	Avg Depo Rate (%)	FX + Depo Return (bp)	Excess over Base Currency Depo	Portf Weight	Bmark Weight	P-B Mean	P-B Min	P-B Max	FX Allo-cation	FX / Local Cross Term
USD	1.0000	1.0000	0.23	2.1	0.0	45.5	45.6	–0.1	–0.2	0.0	0.0	0.0
EUR	1.3028	1.2710	0.28	–242.1	–244.1	23.2	28.1	–4.9	–5.0	–4.9	12.0	0.1
JPY	0.0115	0.0119	0.12	321.5	319.4	25.6	20.5	5.0	5.0	5.1	16.1	0.0
GBP	1.5661	1.5369	0.57	–181.5	–183.5	5.8	5.8	0.0	–0.1	0.0	0.0	0.1
Total						**100.0**	**100.0**				**28.1**	**0.2**

Source: Barclays Capital POINT

EXHIBIT 69–3

Local Market Management Details

Local Market Management Details (bp)	
Yield-Curve	20.6
Asset Allocation	0.2
Security Selection	–1.7
Total	**19.1**

Source: Barclays Capital POINT

consistent to the manager's predictions, the yen rallied and the euro fell versus the U.S. dollar. The analysis also shows that the portfolio maintained a net exposure of +5% in the yen and –5% in the euro with little drift. In particular, the yen outperformed the U.S. dollar by 319.4 bp in the period, a figure that includes the change in the FX spot rate and the short-term interest rate differentials between the two currencies.[8] Since the yen is overweighted by 5% on average, a quick calculation estimates the outperformance contribution as 5% × 319.4 = +16.0 bp. This calculation is not exact, since the attribution model used in this example employs daily frequency and compounding as we have discussed previously. Such simple calculations are acceptable when the net exposure does not fluctuate significantly over the attribution period and will be used throughout this example. In this case the reported yen contribution of +16.1 bp in Exhibit 69–4 is within 1 bp of the result of simple calculation.

Similar analysis can be carried out for the underweight to weakening euro which contributes outperformance of +12.0 bp. The fact that the British pound also weakened generates no outperformance because the portfolio net exposure to the British pound was designed to be zero. Finally, the completeness of FX outperformance decomposition is ensured by accounting for the interaction effect between FX and local returns. The cross-term is normally small. In this case, it is only +0.2 bp.

Outperformance from Allocation to Local Markets

Allocation to local markets evaluates a portfolio manager's decision to under-/overweight a local bond market. In this example its contribution is –8.7 bp. Exhibit 69–5 shows the major contributors to be the yen and euro markets. By attempting to overweight the yen and underweight the euro using cash instruments (i.e., without using FX forwards), the portfolio also took on an overweight in the yen local market and an underweight in the local euro-zone market. The yen market overweight is not a good decision since its local return over the deposit rate is

8. See Chapter 71 for a detailed discussion

EXHIBIT 69–5

Local Market Allocation Report

	Local Market Returns (bp)				Market Weight (%)						
	Benchmark Local Market Returns (bp)				Average		Overweight			Outperformance (bp)	
Currency Market	Total Return	Depo Rate Return	Return over Depo	Portfolio Local	Portf	Bmark	Mean	Min	Max	Local Market Allocation	Local Management
USD	129.8	2.1	127.8	161.6	45.5	45.6	–0.1	–0.2	0.0	0.0	14.6
EUR	241.7	2.5	239.2	269.0	23.2	28.1	–4.9	–5.0	–4.9	–3.7	6.3
JPY	65.3	1.1	64.2	74.8	25.6	20.5	5.0	5.0	5.1	–5.0	2.4
GBP	445.5	5.1	440.5	371.5	5.8	5.8	0.0	–0.1	0.0	0.0	–4.2
Total	**166.0**	**2.2**	**164.1**	**176.3**	**100.0**	**100.0**				**–8.7**	**19.1**

Source: Barclays Capital POINT

EXHIBIT 69–6

Breakdown of Local Outperformance per Local Market

	U.S. Dollar	Euro	Japanese Yen	British Pound	Total
Portfolio Weight (%)	**45.5**	**23.2**	**25.6**	**5.8**	**100.0**
Local Management (bp)	**14.6**	**6.3**	**2.4**	**–4.2**	**19.1**
Yield-Curve	11.2	17.9	3.0	–11.5	20.6
Asset Allocation	–2.5	1.5	–0.1	1.3	0.2
Security Selection	5.9	–13.3	–0.5	6.2	–1.7

Source: Barclays Capital POINT

only +64.2 bp, much lower than the benchmark local return over deposit of +164.1 bp. Therefore, it generates an underperformance that can be approximately calculated as (64.2 – 164.1) × 5% = –5.0 bp, as reported in the second to last column. The euro market underweight is not good either, since the local market had a return of +239.2 bp, significantly higher than the benchmark return of +164.1 bp. It results in an underperformance estimated as (239.2 – 164.1) × –5% = –3.8 bp. The actual contribution is –3.7 bp, as reported in the second to last column and together with the –5.0 bp of the yen market contribution fully explain the Local Markets Allocation outperformance component.

Separation of the FX and Local components of global markets allows the measurement of outperformance under several styles of management. In some portfolio management structures, the FX exposure of the portfolio is managed separately from the local market exposure of the portfolio using derivative instruments such as FX forwards. However, in our example, the exposures to the local markets might be thought as incidental to the manager's FX views and a result of not properly differentiating the views on FX versus the views on the local market performance. In this case, it might make sense to combine the two contributions and allocate 28.3 – 8.7 = +19.6 bp of outperformance to the views on the currency markets.

Outperformance from Management of Local Markets

Once the allocation into each local market is determined, local market management measures how well the portfolio performed versus its benchmark within the same local market. From Exhibit 69–3, we already know that the dominant contributor is yield-curve exposures with +20.6 bp. Exhibit 69–6 offers more details by each local market.

We can see that positive yield-curve outperformance came primarily from the U.S. dollar and the euro markets, whereas the British pound curve exposure

resulted in a loss of –11.5 bp. We also see that asset allocation was not a significant driver of performance. Security selection decisions within each local market were significant, although the net result across all currencies was small at –1.7 bp. In particular, the selections within the U.S. dollar and British pound portion of the portfolio contributed positively, +5.9 bp and +6.2 bp respectively, but the selections within the euro portion of the portfolio negated these gains by contributing –13.3 bp.

Outperformance Due to Yield-Curve Exposure

Focusing on the large yield-curve outperformance contribution, the manager wants to understand how her directive to go long duration by one year globally was implemented, and analyze the impact on each individual market. Exhibit 69–7 shows the yield-curve outperformance breakdown for the U.S. dollar portion of the portfolio.

Individual market reports are unscaled by the value of the holdings in each market in order to evaluate single-market managers on an equal basis. Looking at each market in absolute terms allows us to reveal useful information about the management within each market, even for markets that constitute a small portion of the overall portfolio and their contributions to total portfolio outperformance are not significant. To translate the absolute unscaled numbers contained in the local reports into their contributions to total portfolio outperformance, one has to multiply such numbers by the corresponding market weight in the portfolio. In this example, the currency weights can be found in the Global Outperformance by Currency report in Exhibit 69–6; they are 45.5% for the U.S. dollar, 23.2% for the euro, 25.6% for the yen, and 5.8% for the British pound market.

The yield-curve report in Exhibit 69–7 contains a lot of information, but the manager can quickly see that the U.S. Treasury curve experienced bull-flattening with long rates falling in excess of 40 bp (third column from the left). She can also see that the portfolio is generally long duration by about 0.5 years (4.66 vs. 4.18). This is consistent with the general desire to be long duration, and with rates generally falling, it creates outperformance. More precisely, the yield change at the average maturity point of the benchmark is –31.6 bp. Multiplied by the (negative of) the average duration overweight of 0.48 years results in approximately +15.2 bp of outperformance contribution. The daily algorithm calculates that this number is actually +14.6 bp (top of the second to last column) by taking into account that duration exposure fluctuated during the period. The total U.S. dollar curve outperformance, accounting for the re-shaping of the yield-curve and the contributions from carry, is calculated to be +24.6 bp. Most of the additional outperformance comes from a butterfly position on the curve, where an overweight of the 20 year point of about 1.36 years is partially offset with underweighting the 5, 10, and 30 year points. Since the 20 year point is the one with the largest yield drop (–48.7 bp), this butterfly position results in additional outperformance. The algorithm calculates and reports the excess contribution of each curve point separately.

EXHIBIT 69–7

Yield-Curve Outperformance Breakdown for U.S. Dollar

	Yield			Curve-Matched Market Weight (%)			Duration (yrs)			Outperformance (bp)		
	Level (%)		Change	Average		O/W	Average		O/W	Yield-Curve		
USD	Portf	Bmark	(bp)	Portf	Bmark	Avg	Portf	Bmark	Avg	Carry	Change	Total
Parallel Shift												
Average	1.311	1.245	–31.6	99.7	100.0	–0.3	4.66	4.18	0.48	–0.3	14.6	14.3
Key Rates & Cash												
Cash	0.241	0.241	–1.3	–18.2	–11.2	–7.0	0.00	0.00	0.00	1.0	0.0	1.0
6m	0.179	0.179	1.3	35.3	32.4	2.8	0.18	0.16	0.01	–0.3	–0.5	–0.8
2y	0.534	0.534	–5.2	42.3	35.6	6.7	0.84	0.71	0.13	–0.5	–3.5	–4.0
5y	1.628	1.628	–26.1	19.8	24.9	–5.1	0.96	1.21	–0.25	–0.4	1.4	1.0
10y	3.055	3.055	–45.7	7.1	12.1	–5.0	0.64	1.09	–0.45	–1.0	–6.6	–7.6
20y	3.795	3.795	–48.7	12.3	3.2	9.1	1.83	0.47	1.36	1.6	23.8	25.3
30y	4.000	4.000	–42.1	1.1	2.9	–1.8	0.21	0.54	–0.33	–0.3	–3.8	–4.1
Rest of Curve & Convexity												
										0.0	–0.6	–0.6
Total Yield-Curve Levels & Shifts												
										–0.3	**24.9**	**24.6**

Source: Barclays Capital POINT

The manager should be concerned that such a large component of total outperformance comes from an inadvertent position in the re-shaping of the U.S. curve (about +4.7 bp, estimated as the non-parallel U.S. curve outperformance 24.6 – 14.3 = +10.3 bp, times the U.S. dollar market weight of 45.5%) and should seek to control exposure to the various parts of yield curves more carefully.

Exhibit 69–8 displays the yield-curve reports for the other three currencies. The euro curve outperformance analysis is very similar to the U.S. dollar one. There is duration overweight of about 1 year, as well as a butterfly position. Like the U.S. dollar curve, the euro curve also bull-flattens, resulting in (unscaled) outperformance of +77.4 bp and a contribution to total outperformance of +17.9 bp (remember that the average portfolio weight of the euro market is 23.2%). The yen has an even bigger duration overweight, about 2.7 years, but the curve movement is not as dramatic, with average yields falling about 7 bp. The portfolio contains significant curve reshaping positions as well, with the 20 year point being overweighted by more than 3 years, while the 20 year point is underweighted by about 1.7 years. Nevertheless, the yen curve change is not sufficiently pronounced and generates only +11.8 bp of (unscaled) outperformance, contributing +3.0 bp to the total outperformance (the average portfolio weight of the yen market is 25.6%). The picture is completely different for the British pound. Here, the portfolio has a significant duration underweight of about 3.8 years, combined with a strong bull-flattening move of the British pound yield-curve (a yield change of –44.9 bp at the long end). This underweight results in a dramatic (unscaled) underperformance of –199.2 bp. The small average portfolio weight of the British pound market (5.8%) prevents this from being a major drag in the portfolio performance but even so its contribution to total outperformance is a significant –11.5 bp.

At this point, it should be clear to the portfolio manager that understanding and managing the detailed exposure to the yield-curve of each currency is of paramount importance for proper control of the portfolio performance. She may also decide that global curve management is so important that it has to be managed before any local allocation and management decisions are made. In this case, a different attribution algorithm must be used, one that excludes yield-curve outperformance from the Local Market Allocation and Local Management Components. A detailed discussion on this type of analysis can be found in Chapter 71.

Asset Allocation and Security Selection

The manager now shifts her attention to the remaining sources of outperformance. First, she wants to understand how her views on the performance of U.S. assets panned out. From the "Global Outperformance by Currency" report of Exhibit 69–6, she already knows that U.S. dollar asset allocation contributed –2.5 bp to total outperformance. Exhibit 69–9 displays the U.S. Dollar Asset Allocation report, where we can see that most of the underperformance is caused by the overweight to corporate bonds. Remember that all numbers in this page are un-weighted; that is, they have to be scaled by the 45.5% portfolio weight of the

EXHIBIT 69–8

Yield-Curve Outperformance Breakdown for Euro, Japanese Yen, and the British Pound

	Yield			Curve-Matched Market Weight (%)			Duration (yrs)			Outperformance (bp)		
	Level (%)		Change	Average		O/W	Average		O/W	Yield-Curve		
EUR	Portf	Bmark	(bp)	Portf	Bmark	Avg	Portf	Bmark	Avg	Carry	Change	Total
Parallel Shift												
Average	2.030	1.698	–50.2	100.0	100.0	0.0	6.68	5.62	1.05	2.9	54.2	57.1
Key Rates & Cash												
Cash	0.279	0.279	0.0	–13.1	–14.5	1.3	0.00	0.00	0.00	0.2	0.0	0.2
6m	0.381	0.381	0.6	4.0	16.2	–12.2	0.02	0.08	–0.06	1.8	3.1	5.0
2y	0.771	0.771	–22.6	39.5	37.4	2.2	0.79	0.74	0.04	–1.4	–1.3	–2.6
5y	1.726	1.726	–43.1	22.0	33.7	–11.7	1.07	1.64	–0.57	–1.2	4.0	2.8
10y	2.708	2.708	–57.3	40.1	18.5	21.6	3.65	1.68	1.97	0.8	14.1	14.9
20y	3.377	3.377	–64.7	7.5	5.8	1.7	1.16	0.89	0.26	–0.1	3.5	3.4
30y	3.324	3.324	–69.6	0.0	3.0	–3.0	0.00	0.59	–0.59	–0.1	–11.5	–11.6
Rest of Curve & Convexity												
										0.0	8.3	8.3
Total Yield-Curve Levels & Shifts												
										2.9	**74.4**	**77.4**

(Continued)

EXHIBIT 69–8

Yield-Curve Outperformance Breakdown for Euro, Japanese Yen, and the British Pound (*Continued*)

	Yield			Curve-Matched Market Weight (%)			Duration (yrs)			Outperformance (bp)		
	Level (%)		Change	Average		O/W	Average		O/W	Yield-Curve		
JPY	Portf	Bmark	(bp)	Portf	Bmark	Avg	Portf	Bmark	Avg	Carry	Change	Total
Parallel Shift												
Average	0.822	0.617	–7.0	100.0	100.0	0.0	9.54	6.85	2.69	0.7	18.5	19.2
Key Rates & Cash												
Cash	0.126	0.126	–1.2	–6.6	–13.2	6.6	0.00	0.00	0.00	–0.5	0.0	–0.5
6m	0.124	0.124	–1.3	–0.3	15.3	–15.6	0.00	0.08	–0.08	1.2	0.4	1.6
2y	0.145	0.145	–3.3	19.2	33.9	–14.7	0.38	0.68	–0.29	1.0	1.3	2.3
5y	0.344	0.344	–5.3	51.8	19.7	32.1	2.58	0.98	1.59	–1.0	–3.0	–4.0
7y	0.616	0.616	–12.2	2.6	14.9	–12.3	0.18	1.03	–0.85	–0.6	–4.6	–5.1
10y	1.034	1.034	–5.1	–1.1	16.2	–17.3	–0.11	1.57	–1.67	–1.5	3.2	1.7
20y	1.776	1.776	–8.1	27.5	10.0	17.5	4.85	1.77	3.09	1.2	2.7	3.9
30y	1.876	1.876	–7.6	6.9	3.1	3.8	1.65	0.75	0.90	0.2	0.7	0.9
Rest of Curve & Convexity												
										0.0	–8.1	–8.1
Total Yield-Curve Levels & Shifts												
										0.7	**11.1**	**11.8**

(*Continued*)

EXHIBIT 69–8

Yield-Curve Outperformance Breakdown for Euro, Japanese Yen, and the British Pound (*Continued*)

	Yield			Curve-Matched Market Weight (%)			Duration (yrs)			Outperformance (bp)		
	Level (%)		Change	Average		O/W	Average		O/W	Yield-Curve		
GBP	Portf	Bmark	(bp)	Portf	Bmark	Avg	Portf	Bmark	Avg	Carry	Change	Total
Parallel Shift												
Average	1.990	2.833	–44.9	100.0	100.0	0.0	4.78	8.58	–3.81	–5.0	–172.4	–177.4
Key Rates & Cash												
Cash	0.573	0.573	–0.4	–11.7	–10.5	–1.2	0.00	0.00	0.00	–0.3	0.0	–0.3
6m	0.579	0.579	–5.3	5.2	11.2	–5.9	0.03	0.06	–0.03	1.8	1.2	3.0
2y	0.936	0.936	–22.1	53.3	21.1	32.2	1.06	0.42	0.64	–2.9	–14.7	–17.7
5y	2.205	2.205	–43.4	24.7	24.8	–0.1	1.19	1.19	0.00	1.2	–0.1	1.2
10y	3.417	3.417	–46.7	28.4	23.0	5.4	2.51	2.03	0.48	1.9	0.9	2.7
20y	4.210	4.210	–49.5	0.0	14.9	–14.9	0.00	2.14	–2.14	–1.1	–10.1	–11.2
30y	4.277	4.277	–44.9	0.0	15.5	–15.5	0.00	2.74	–2.74	–0.6	0.1	–0.5
Rest of Curve & Convexity												
										0.0	0.9	0.9
Total Yield-Curve Levels & Shifts												
										–5.0	**–194.2**	**–199.2**

Source: Barclays Capital POINT

U.S. market allocation in order to convert them into contributions to total portfolio outperformance. In particular, the 5% overweight sought to U.S. corporate bonds during the portfolio construction is represented here as an overweight of 10.9% (30.9% – 19.8% = 11.1%, approximately equal to 5%/45.5%), and the –2.5 bp of underperformance is reported as –5.5 bp (approximately equal to –2.5 bp/45.5%). The corporate sector contributes –5.2 bp, something that can be explained by the significant underperformance of the corporate sector in the benchmark (–70.2 bp) relative to the benchmark itself (–22.0 bp). The approximate calculation results in 11.1% × (–70.2 + 22.0) = –5.35 bp, close to the –5.2 bp reported. The Treasury and government-related sectors have no contribution to asset allocation, as their weights are matched exactly between the portfolio and the benchmark, as designed. Finally, the securitized sector has minimal contribution to asset allocation, despite the significant underweight, because its performance (–19.0 bp) is close to that of the benchmark (–22.0 bp).

The same report also lists the contribution of each sector to security selection. We see that once again, the corporate sector is the dominant contributor with +11.1 bp out of the total +13.0 bp of security selection in the U.S. dollar market. To further understand the sources of security selection outperformance, the manager studies the detailed U.S. Dollar Security Selection report displayed in Exhibit 69–10. This report lists the chosen securities in each sector and their excess-of-curve return. We can see that the manager responsible for security picks in the U.S. corporate sector has indeed picked mostly securities whose excess returns beat the benchmark. One notable exception is the 6.45% 2037 Comcast bond, which represents 10.1% of the portfolio holdings in this sector (an overweight of 10% versus the benchmark) and which experienced –280.0 bp of excess return (much worse than the benchmark, which lost only 70.2 bp).

To estimate the contribution of the bond to the security selection outperformance coming from U.S. corporate bonds, one must take into account the weight of the corporate sector in the U.S. portfolio, which is 30.7%, to get 30.7% × 10% × (–280.0 + 70.2) = –6.4 bp. After scaling by the 45.5% weight of the U.S. portfolio, we calculate the contribution of the particular Comcast bond to global outperformance as 45.5% × –6.4 bp = –2.9 bp. This is quite significant and highlights the importance of name selection in a portfolio with a relatively small number of positions.

The manager also takes a look at the details of security selection in the euro market, which, as reported in Exhibit 69–6, reduces the total outperformance by a significant 13.3 bp. The report in Exhibit 69–11 lists the security selection outperformance as –57.4 bp (which scaled by the market weight of the euro market of 23.2% is equal to –13.3 bp) and identifies Italian government bonds as the main culprits. The fact that, absent any specific direction otherwise, the euro government sector was constructed by mostly Italian government bonds, leading to significant underperformance because of sovereign credit deterioration in Italy, indicates that the manager should attempt to take control of country exposure within the euro sector.

EXHIBIT 69–9

U.S. Asset Allocation Breakdown

Partition Bucket	Market Weight (%)					Excess to Curve Return (bp)		Outperformance (bp)	
	Average		Overweight					Asset Alloc.	Security Select.
	Portf	Bmark	Average	Min	Max	Portf	Bmark		
Total	**100.0**	**100.0**				**–14.6**	**–22.0**	**–5.5**	**13.0**
Treasury	31.7	31.7	0.1	–0.1	0.2	–4.7	–2.2	0.0	–0.8
Government-Related	14.3	14.3	0.0	0.0	0.1	17.6	–7.7	0.0	3.7
Corporate	30.7	19.8	10.9	10.7	11.0	–33.5	–70.2	–5.2	11.1
Securitized	22.8	33.4	–10.7	–10.9	–10.6	–23.3	–19.0	–0.3	–1.0
Cash	0.5	0.8	–0.3	–0.5	0.0	0.0	0.0	–0.1	0.0

Source: Barclays Capital POINT

EXHIBIT 69–10

U.S. Security Selection Breakdown

Bucket/Issue	Issuer	MV (%)		Excess to Curve Return (bp)*		Security Selection (bp)
		Portf	Bmark	Portf	Bmark	
USD		100.0	100.0	–14.6	–22.0	13.0
Treasury		31.7	31.7	–4.7	–2.2	–0.8
912828MQ	US TREASURY NOTES	54.9	0.9	–1.0	–1.0	0.2
912810FF	US TREASURY BONDS	19.5	0.2	–1.1	–1.1	0.1
912810FP	US TREASURY BONDS	25.6	0.4	–15.5	–15.5	–1.1
Bmark Securities	Not in Portfolio		98.5		–2.1	0.0
Govt-Related		14.3	14.3	17.6	–7.7	3.7
46513EFF	ISRAEL STATE OF	14.3	0.1	68.0	68.0	1.5
31359MRK	FEDERAL NATL MTG ASSN	62.0	0.1	9.0	9.0	1.5
31359MTP	FEDERAL NATL MTG ASSN	22.0	0.1	7.5	7.5	0.5
RUSSIA	RUSSIA GLOBAL	1.7	1.6	43.3	9.3	0.1
Bmark Securities	Not in Portfolio		98.2		–8.0	0.0

(Continued)

EXHIBIT 69–10

U.S. Security Selection Breakdown (*Continued*)

Bucket/Issue	Issuer	MV (%)		Excess to Curve Return (bp)*		Security Selection (bp)
		Portf	Bmark	Portf	Bmark	
Corporate		30.7	19.8	–33.5	–70.2	11.1
MS	MORGAN STANLEY DEAN WITTER	10.0	1.8	57.7	–72.1	3.9
RABOBK	RABOBANK	11.5	0.5	39.0	47.5	3.7
JPM	JP MORGAN CHASE & CO	13.9	2.3	3.7	–108.6	3.4
UBS	UNION BANK OF SWITZERLAND	10.0	0.5	22.2	7.4	2.7
AXP	AMERICAN EXPRESS CO	10.4	0.8	9.7	–41.5	2.5
WDCAU	WESTFIELD CAPITAL CORP	5.8	0.2	59.9	–12.1	2.3
GS	GOLDMAN SACHS GROUP	9.7	2.3	–33.3	–104.9	1.3
DTV	DIRECTV HOLDINGS/FING	9.5	0.3	–76.9	–123.4	–0.3
WLP	WELLPOINT INC–GLOBAL	9.2	0.2	–133.8	–118.6	–1.8
CMCSA	COMCAST CORPORATION	10.1	1.0	–280.0	–143.7	–6.3
Bmark Securities	Not in Portfolio		90.1		–68.7	–0.4
Securitized		22.8	33.4	–23.3	–19.0	–1.0
FNA05003	FNMA Conventional Long T. 30yr	21.3	2.0	14.2	14.2	1.5
FNA04403	FNMA Conventional Long T. 30yr	11.2	0.4	6.0	6.0	0.6

(Continued)

EXHIBIT 69–10

U.S. Security Selection Breakdown (*Continued*)

Bucket/Issue	Issuer	MV (%)		Excess to Curve Return (bp)*		Security Selection (bp)
		Portf	Bmark	Portf	Bmark	
FGB04403	FHLM Gold Guar Single F. 30yr	10.3	0.2	–21.0	–21.0	–0.1
FNA04409	FNMA Conventional Long T. 30yr	19.7	5.8	–26.5	–26.5	–0.2
GNA04403	GNMA I Single Family 30yr	8.6	0.0	–50.7	–50.7	–0.6
GNF04403	GNMA I Single Family 15yr	29.0	0.0	–52.7	–52.7	–2.2
Bmark Securities	Not in Portfolio		91.5		–19.4	0.1
Cash		0.5	0.8	0.0	0.0	0.0
USD-Unsettled	CASH-U.S. Dollar-Unsettled	52.3		0.0		0.0
USD-Settled	CASH-U.S. Dollar-Settled	47.7	62.0	0.0	0.0	0.0
Bmark Securities	Not in Portfolio		38.0		0.0	0.0

Source: Barclays Capital POINT

In the Govt.-Related and Corporate sectors results are aggregated by ticker although calculations occur at the security level. Since each ticker might be represented by a different set of bonds in the portfolio vs. the benchmark, the Excess to Curve Return for each ticker differs between the portfolio and the benchmark.

EXHIBIT 69–11

Euro Security Selection Breakdown

Bucket/Issue	Issuer	MV (%)		Excess to Curve Returns (bp)		Security Selection (bp)
		Portf	Bmark	Portf	Bmark	
EUR		100.0	100.0	–121.0	–69.7	–57.4
Treasury		44.0	55.4	–275.8	–122.4	–66.6
IT0003644769	ITALY (REPUBLIC OF)	4.7	0.5	–270.5	–270.5	–2.7
BE0000308172	BELGIUM (KINGDOM OF)	38.5	0.3	–149.7	–149.7	–3.9
IT0004594930	ITALY (REPUBLIC OF)	5.6	0.5	–321.9	–321.9	–4.5
IT0004513641	ITALY (REPUBLIC OF)	18.3	0.5	–253.7	–253.7	–10.5
IT0004009673	ITALY (REPUBLIC OF)	15.8	0.6	–433.4	–433.4	–20.7
IT0004356843	ITALY (REPUBLIC OF)	17.1	0.5	–420.6	–420.6	–21.6
Bmark Securities	Not in Portfolio		97.0		–116.2	–2.7
Government-Related		7.5	15.3	–119.4	–6.3	–8.2
POLAND	POLAND (REPUBLIC OF)	100.0	2.1	–119.4	–82.6	–8.1
Bmark Securities	Not in Portfolio		97.9		–4.7	–0.1
Corporate		43.8	17.6	18.4	–23.0	18.2
GE	GE CAPITAL CORP	24.0	2.4	54.4	–8.7	8.0
TELEFO	TELEFONICA EMISONES SAU	11.8	1.1	49.1	16.9	3.6
RBS	ROYAL BANK OF SCOTLAND	6.8	1.6	108.4	43.4	3.5

(Continued)

EXHIBIT 69–11

Euro Security Selection Breakdown (*Continued*)

Bucket/Issue	Issuer	MV (%)		Excess to Curve Returns (bp)		Security Selection (bp)
		Portf	Bmark	Portf	Bmark	
IBESM	IBERDROLA	22.7	0.7	1.1	10.6	2.2
BAC	MERRILL LYNCH & CO INC	13.2	1.7	5.5	–74.1	2.0
IMTLN	IMPERIAL TOBACCO FIN PLC	16.7	0.5	0.9	34.1	1.6
C	CITIGROUP INC	4.8	1.4	–181.4	–137.0	–2.7
Bmark Securities	Not in Portfolio		90.5		–22.8	–0.1
Securitized		4.4	11.7	11.3	26.3	–0.7
ES0312298237	AYT CEDULAS CAJAS GLOBAL	100.0	0.2	11.3	11.3	–0.7
Bmark Securities	Not in Portfolio		99.8		26.3	0.0
Cash		0.3	0.0	0.0	0.0	0.0
EUR-Unsettled	CASH-European Monetary Unit-Unsettled	0.0		0.0		0.0
EUR-Settled	CASH-European Monetary Unit-Settled	100.0	100.0	0.0	0.0	0.0

Source: Barclays Capital POINT

By now, the manager has a good understanding of most major contributors to the outperformance of the portfolio and has also reached some useful conclusions regarding the management of a small global portfolio.

- Yield-curve exposure is the dominant risk factor and must be managed explicitly in each currency.
- It is not sufficient to manage yield-curve exposure using just the duration. Exposure to curve re-shaping must also be controlled carefully.
- It may make sense to manage yield-curve exposure globally and not allow it to be determined by local allocation and management decisions.
- Name risk is very significant in a small portfolio; exposure to corporate issuers must be scrutinized and questionable names should be excluded.
- Country risk in certain areas such as the euro-zone must be managed separately.

Further insight can be gained by using a mode of performance attribution in which returns and outperformance are fully decomposed using all available analytics from pricing models. In this model, any part of outperformance that cannot be explained by analytics is reported as residual. This Fully Analytical model will be explained in detail in Chapter 70. Using this model, we get the local management details shown in Exhibit 69–12.

Comparing it with the report of Exhibit 69–3 we see that Local Market Management Details panel has changed. While the yield-curve contribution remains at +20.6 bp, asset allocation is now –0.9 bp instead of +0.2 bp, and security selection is now –2.2 bp instead of –1.7 bp. New terms have appeared, in particular Implied Volatility with +0.9 bp contribution, Mortgage with –3.7 bp

EXHIBIT 69–12

Local Market Management Details from a Fully Analytical Model

Local Market Management Details (bp)	
Yield-Curve	20.6
Implied Volatility	0.9
Asset Allocation	–0.9
Security Selection	–2.2
Mortgage	–3.7
Residual	4.4
Total	**19.1**

Source: Barclays Capital POINT

contribution, and Residual with a prominent +4.4 bp. The Fully Analytical model also offers more clarity into sources of outperformance beyond the yield-curve, allowing users to understand the sources of the various types of outperformance; it will be discussed in detail in Chapter 70. In this example we will review only the Euro Security Selection report shown in Exhibit 69–13. We can see that not only is the portfolio concentrated on Italian government bonds, but that it also contains bonds of very long maturity, further overweighting the entire European government sector in terms of spread duration exposure. This may lead the manager to draw yet another conclusion: The spread duration exposure of sectors with credit risk must be carefully controlled.

Performance Attribution as a Data Quality Tool

A comprehensive and detailed performance attribution system serves as a magnifying lens for data quality problems and allows users to pinpoint and correct such issues quickly.

The report of Exhibit 69–13 shows that one particular Italian government bond (Issue IT0004513641) is almost single-handedly responsible for the entire reported residual. Indeed, it contributes +17.4 bp of residual to the euro portfolio, which, when scaled by the euro portfolio market weight of 23.2%, results in +4.0 bp of portfolio-level residual (out of the total of +4.4 bp reported in Exhibit 69–12). A diligent manager will promptly investigate such residuals. They may mean one of the following four things:

- Incorrect total returns. This can be caused by missing or incorrect prices, transaction errors, incorrect corporate actions, etc.
- Missing or inaccurate analytics produced in the security valuation process
- Attribution model deficiencies wherein certain contributing factors are not captured by the factor return decomposition
- Issues with the attribution algorithm or its implementation

All four are extremely important for the portfolio manager to know. Over time, model deficiencies will presumably be corrected, leaving data quality problems in the form of bad returns or bad analytics to be the primary cause of attribution residuals.

In the case of this portfolio, a quick investigation reveals that the offending bond had a coupon payment of 2.50% that has been recorded twice. The price of the bond on the coupon payment date was approximately 110; therefore, one would expect a residual of +227.3 bp at the bond level. Indeed, after taking into account the net weight of the bond, the residual contribution of the bond to the euro portfolio is $44.0\% \times (18.3\% - 0.5\%) \times 227.3 = +17.8$ bp, very close to the +17.4 bp of reported residual. Re-running the report after correcting the double entry produces a mostly identical report (Exhibit 69–14) to the one before (Exhibit 69–12), except that the return of the portfolio is lower by the correction

EXHIBIT 69–13

Euro Security Selection Report

			Outperformance (bp)				
			Security Selection		Other		
Bucket/Issue	Issuer	MV (%) Portf	Spread Carry	Spread Change	Pricing	Residual	Total
EUR		100.0	2.9	–53.7	0.6	17.2	–33.0
Treasury		44.0	1.5	–59.3	0.6	16.9	–40.3
BE0000308172	BELGIUM	38.5	–0.2	6.2	0.0	0.0	6.1
IT0003644769	ITALY	4.7	0.1	–2.2	0.0	0.0	–2.0
IT0004594930	ITALY	5.6	0.1	–3.6	0.0	0.0	–3.5
IT0004513641	ITALY	18.3	0.6	–22.3	0.6	17.4	–3.7
IT0004356843	ITALY	17.1	0.5	–16.8	0.0	–0.1	–16.4
IT0004009673	ITALY	15.8	0.3	–17.1	0.0	–0.1	–16.9

Source: Barclays Capital POINT

amount (+4.2 bp), the outperformance is +34.5 bp instead of +38.7 bp, and the residual term has been reduced correspondingly from +4.4 bp to +0.2 bp.

Data problems have the potential to affect the quality of outperformance measurement of a portfolio significantly, as well as its breakdown to the various sources. Proper use of an analytics-based attribution platform can help identify and correct potential issues promptly.

EXHIBIT 69–14

Results from the Fully Analytical Model after the Data Correction

a. Total Portfolio Outperformance

Global Outperformance (bp)	
Portfolio Return	184.5
Benchmark Return	150.0
Outperformance	**34.5**

b. Global Outperformance Summary

Global Outperformance Summary (bp)	
FX Allocation & Hedging	28.3
Local Market Allocation	–8.7
Local Market Management	14.9
Total	**34.5**

c. Local Market Management Details

Local Market Management Details (bp)	
Yield-Curve	20.6
Implied Volatility	0.9
Asset Allocation	–0.9
Security Selection	–2.2
Mortgage	–3.7
Residual	0.2
Total	**14.9**

Source: Barclays Capital POINT

KEY POINTS

- Performance measurement and attribution is an important function of the investment process. It helps bring clarity to the sources of portfolio risk and performance and identify the contributions of individual decision-makers.
- A successful performance attribution algorithm should satisfy three important requirements: additivity, completeness, and fairness.
- A good attribution system should have a calculation and compounding frequency that corresponds to the dynamics of modern portfolio management. This normally means daily frequency for an actively managed fixed income portfolio.
- A good attribution system should have the flexibility to accommodate the wide range of portfolio management styles. The best attribution is an analysis that best matches the portfolio management decision making process.
- Performance attribution algorithms typically follow either a sector-based allocation or a factor-based allocation, but neither is sufficient to cope with the complexity of modern portfolio management.
- Algorithms that combine the sector-based and the factor-based attribution have the flexibility to adapt to the particular management structure of most fixed income and equity portfolios.

CHAPTER
SEVENTY

PERFORMANCE ATTRIBUTION FOR PORTFOLIOS OF FIXED INCOME SECURITIES

ANTHONY LAZANAS, PH.D.
Managing Director
Barclays Capital

ANTÓNIO BALDAQUE DA SILVA, PH.D.
Director
Barclays Capital

CHRIS STURHAHN
Vice President
Barclays Capital

ERIC P. WILSON
Vice President
Barclays Capital

PAM ZHONG, CFA
Vice President
Barclays Capital

In contrast to the simple and opaque nature of equities, fixed income securities can be thought of as structured investments which promise to pay a stream of cash flows. The magnitude of cash flows can be fixed, or may depend on observable variables (e.g., realized inflation, principal prepayments of mortgage loans, or the price of the security itself for securities with call/put features). This quasi-formulaic nature of fixed income securities allows their present value to be expressed as a (generally stochastic) function of economic variables—most prominently interest rates and credit spreads—which can be calibrated to observed market prices of reference securities to generate a "pricing model." In other words, a pricing model is a function that expresses the present value of a

The authors would like to thank Lev Dynkin for introducing us to the concept of performance attribution, Jay Hyman for many insightful ideas over the years and Attakrtit Asvanunt who was instrumental in the development of many concepts in this chapter.

fixed income security (or derivative contract) as a function of economic variables. This function can be also used to estimate the sensitivities of the present value to changes in the underlying variables. Such sensitivities, generically called *analytics* and known as *greeks* in the options world or *duration/convexity* in the bond world, can and are being used as loadings to the pricing factors driving returns during performance decomposition and attribution of fixed income portfolios.

In this chapter we discuss in detail how the performance of a portfolio of fixed income securities relative to a benchmark can be analyzed using the hybrid performance attribution algorithm described in the Chapter 69. The hybrid methodology that combines factor-based attribution with the traditional Brinson method is particularly appropriate for fixed income securities whose return usually includes a significant component driven by a common factor, interest rates. In this chapter, we will focus on attribution over a single period only. As discussed in Chapter 69, a single period is one business day for the majority of fixed income systems. Methods for compounding single period attribution results over longer periods of time will be discussed in detail in Chapter 71.

We begin the discussion by using a generic pricing model in order to split the return of a fixed income security into the contributions of the various factors driving the security return. We discuss in detail the treatment of the most important factors such as interest rates, implied volatility and credit spreads. Two important asset classes with special characteristics, mortgage-backed securities and inflation-linked bonds, are discussed separately. We then show how the flexible hybrid attribution framework can be applied in several ways to accommodate various types of fixed income portfolios and styles of portfolio management.

In this chapter we restrict the analysis to single-currency portfolios. The complications arising from investing in multiple currencies will be discussed in the Chapter 71. All performance attribution reports have been generated using the Barclays Capital Hybrid Performance Attribution (HPA) model[1] as implemented in POINT, the Barclays Capital portfolio analytics and modeling platform.[2]

RETURN SPLITTING

Securities with deterministic cash flows are priced by discounting the cash flows off a reference yield-curve. When future cash flows are not known but can be reasonably predicted by modeling them as functions of economic variables (most commonly interest rates) and security characteristics, more complex statistical diffusion models are used. Such models produce a set of projected interest rate paths that are consistent with the current yield-curve and the market implied

1. For details of the model, see Anthony Lazanas, Chris Sturhahn, and Pamela Zhong, *The Barclays Capital Hybrid Performance Attribution (HPA) Model* (Barclays Capital Publications, October 2010).
2. Both Hybrid Performance Attribution and POINT are registered trademarks of Barclays Capital.

volatility of liquid interest-rate options. Projected cash flows on each path are discounted at the corresponding discount factors, and the present value of the security is calculated as the average present value across all interest-rate paths. In this case, the present value of a security is a function of interest rates, their implied volatility and possibly other variables in the model.

A pricing model produces the "model value" of a security. In the case of securities such as derivatives that are traded over-the-counter, the model value is usually used to mark-to-market positions in the security. When a security is publicly traded, its market price generally does not agree with the model price. To make them equal, model parameters are calibrated to match the market price. For example, in the case of bonds, this usually entails additional discounting of cash flows at a flat rate across all maturities. In the majority of models, in which cash flows are discounted at a risk-free reference yield-curve (the government or swap yield-curve in a particular currency), this additional discounting rate is the well-known option-adjusted spread (OAS), which captures the extra discounting required to account for credit, liquidity and other types of risks. Analytics produced by such a model are therefore known as option-adjusted analytics.

Generically, a pricing model can be expressed with the following formula:

$$MarketValue = f\,(Time,\ YC,\ Vol,\ Other,\ OAS)$$

Here, *YC* stands for yield-curve, *Vol* for implied volatility, and *Other* for any other market factors or parameters that the pricing model is using.

For a single-currency portfolio, the analysis begins with splitting the return of each portfolio position into the contributions of various factors. Most pricing systems provide the first-order sensitivity of the market value of a position to the underlying risk factors. Sometimes second-order sensitivities to particular factors (such as interest-rate convexity) are also reported. Using these sensitivities, the return of a particular position is approximated as a linear combination of the contributions of each pricing factor, for example:

$$R \approx \frac{\partial f}{\partial Time}\Delta Time + \frac{\partial f}{\partial YC}\Delta YC + \frac{1}{2}\frac{\partial^2 f}{\partial YC^2}\Delta YC^2 + \frac{\partial f}{\partial Vol}\Delta Vol + \frac{\partial f}{\partial OAS}\Delta OAS$$

Although some pricing systems do provide additional sensitivities (e.g., spread convexity, or sensitivities to some of the "other" pricing factors such as prepayment speed for mortgage securities) most of the times the difference between the actual return of a position (as reported in the accounting system of the portfolio) and the above approximation is non-negligible. Such difference, usually referred to as *Residual*, is attributable to sensitivities to unaccounted model inputs and parameters, higher-order terms, cross-terms between factors, and very often in practice, data and calculation errors. Analyzing the residual and understanding whether it is legitimate or a result of data or calculation error is an important function of a performance attribution system. To help achieve that, sophisticated performance attribution systems use an alternative scenario-based

decomposition of returns, which by design is complete, i.e., has no residual. The return splitting exercise in such systems has two stages:

Stage I: Scenario-based return decomposition into broad categories

Stage II: Analytics-based return decomposition into fine categories

In Stage I, the scenario decomposition of one-period return[3] begins with the market value of the position at the beginning of the period and then moves one parameter at a time to the end-of-period value until all of the parameters have changed and the end-of-period market value is obtained. At each step, the market value of the security is obtained by fully recalculating its market value by changing one input parameter at a time. This stage divides the return into broad categories, as described in Exhibit 70–1.

Of course, this is not the only possible decomposition. Coarser or finer decompositions are also possible, but this particular one is a good compromise between computational complexity and informational content for most fixed income portfolios. In Stage II, the sensitivities of the security to various pricing model inputs (analytics) are used to decompose the return further. The combination of the two decompositions allows the residual to be split among the major return constituents providing more insight about its potential sources.

EXHIBIT 70–1

Typical Scenario-Based Return Decomposition

Surprise Return	The difference of actual cash flows and notional changes from model predictions
Time Return	The effect of elapsing time
Yield-Curve Change Return	The effect of changes in the yield-curve
Implied Volatility Change Return	The effect of changes in the implied volatility surface
Other Market Return	The effect of changes in any other market parameters
Spread Change Return	The effect of changes in the option-adjusted spread

3. As discussed in Chapter 69, attribution over longer periods of time requires compounding attribution results over smaller periods. The length of a single period should be consistent with the management style of the portfolio. Actively managed portfolios should use a short period, typically one day. Buy and hold portfolios should use longer periods such as one month or even one year. The algorithm we describe here can be applied for arbitrary period lengths. Nevertheless, bear in mind that using pricing analytics to manage exposure typically indicates an active management style which more often than not requires daily portfolio actions and therefore daily compounding of attribution results.

We will now discuss in more detail the various return constituents in the typical decomposition of Exhibit 70–1.

Surprise Return

Surprise return is relevant to securities whose cash flows and amount outstanding are not deterministic. For example, for mortgage-backed securities, it is prepayments that generate the random behavior of cash flows and amount outstanding; for inflation-linked securities, it is the dependence of cash flows on the reference inflation index. Security valuation models make assumptions about inputs to pricing models and use such projections to value securities until realized values are known. The return explained by running scenarios or using model analytics is the return that would be realized if the uncertain parameters were consistent with the model predictions. If the realized values of the parameters are different from the projected ones, the difference between the actual return and the return explained by the model is captured as surprise return.

Mortgage Prepayments Surprise Return

As an example, consider a mortgage-backed security that is trading at a price of 105 and zero accrued. The prepayment model projects a 2.4% prepayment over the next month (25% CPR), thus predicting a return due to prepayments of –11.4 bp.[4] If the actual prepayment is lower, say 1.3% (15% CPR) resulting in a prepayment return of –6.2 bp, the difference of +5.2 bp will be registered as prepayment surprise return. The model-expected –11.4 bp of prepayment return will be part of the time return component.

Inflation Surprise Return

As another example, consider an inflation-linked security that is trading at a price consistent with projected inflation for next month of 3.0%. If the actual inflation announcement is 3.5% it will give +4.2 bp[5] of inflation surprise return to account for the larger inflation accretion accumulated over the month relative to the projected inflation rate. This return is separate from any return resulting from presumably increased future inflation expectations caused by the higher-versus-expectations announcement. Such return is captured separately as inflation spread change as will be described below.

Time Return

Time return is the deterministic component of the return, i.e., the return predicted by the pricing model if market parameters remain unchanged.[6] For most fixed income securities, time return can be decomposed into yield-curve carry, spread carry and volatility decay. Inflation-linked securities also have inflation accretion

4. –11.4 bp = (par-105) * 2.4% / 105.
5. The exact calculation is (3.5%/12 – 3.0%/12) / (1 + 3%/12) = 4.16 bp
6. We discuss the definition of "unchanged" for the yield-curve later in this chapter.

and inflation spread carry. These time return components can be measured using analytics, as we will describe in detail in following sections.

Yield-Curve Change Return

Changes of interest rates affect securities returns primarily through the change of discount factors. In addition, some securities have cash flows that are modeled as functions of interest rates (mortgage-backed, floating-rate securities). The component of return that is due to the fluctuation of the yield-curve is captured by the yield-curve change return component. The exposure of the security value to the yield-curve is captured by its sensitivity to parallel shifts of the yield-curve, the option-adjusted duration (OAD), movements of a specified set of points (key-rate points) representing the yield-curve, the key-rate durations (KRDs), and its second-order sensitivity, option-adjusted convexity (OAC). In daily frequency attribution models the potential daily change of yields is limited (moves above 15 bp are very uncommon); therefore, the convexity contribution is typically much smaller than the duration contribution. For this reason, the effect of yield-curve convexity does not need to be explicitly measured.[7]

Yield-Curve Change Return Decomposition

How total yield-curve change return is broken down between duration and convexity depends to a large extent on the frequency at which the duration exposure of a portfolio is managed. In this example a daily frequency is assumed, consistent with the practice of the majority of portfolio managers. To understand the frequency implications, consider a portfolio with interest-rate duration of 5 and an interest-rate convexity of –2. Assume that over the two weeks, interest rates keep falling at 10 bp per business day for a total of 100 bp. The duration-convexity formula explains portfolio returns caused by changes in interest rates:

$$R^{\Delta YC} = -OAD \cdot \Delta r + \frac{1}{2} \cdot (OAC/100) \cdot \Delta r^2$$

where both the returns and the rates change are expressed in basis points.

Applying this formula for the entire two weeks results in the following:

Duration Return:	$-5 \times (-100) =$	+500 bp
Convexity Return:	$0.5 \times (-2/100) \times (-100)^2 =$	–100 bp
Total Return:		+400 bp

On the other hand, applying the formula daily generates quite a different breakdown. The daily algorithm must take into account additional complexities such as the duration drift of the portfolio, as well as compounding. It is not sufficient

7. For currencies with high volatility of yields, convexity can become a significant determinant even for daily returns. In such a case, it is straightforward to include convexity as an explanatory variable to the algorithm.

to simply calculate the daily duration and convexity return as $-5 \times (-10) = +50$ bp and $0.5 \times (-2/100) \times (-10)^2 = -1$ bp, respectively, and just aggregate over 10 days to get +500 bp duration return and –10 bp convexity return, for a total return of +490 bp. Instead, the daily duration drift of the portfolio due to falling interest rates must be estimated first. Using the definitions of duration and convexity, the duration change due to a change in interest rates can be estimated as:

$$\Delta OAD = (OAD^2 - 100 \cdot OAC) \cdot \Delta r / 10{,}000$$

where duration and convexity have the usual units and change of rates is measured in basis points. Due to the high convexity of the portfolio, over the course of the 10 days the duration of the portfolio shrinks by about 2 years. In addition, both the total return of the portfolio and the contributions of duration and convexity must be compounded daily (see Chapter 71 for details). After both adjustments, the total return calculation and breakdown are as follows:

Duration Return:	+408 bp
Convexity Return:	–10 bp
Total Return:	+398 bp

The total return is very close to the one estimated by analytics at the beginning of the period, but the breakdown between duration and convexity is dramatically different. In the daily model, the convexity contribution is much smaller than the duration contribution.

Daily attribution models typically use only the key-rate durations to explain the contribution of yield-curve changes. Any yield-curve change return (as estimated by the scenario-based total yield-curve change return) in excess of what can be explained by the key rates captures the contribution of the yield-curve movements between the key-rate points, as well as the convexity and other second-order terms and can be reported separately.

Implied Volatility Change Return

Securities with optionality require reference implied volatilities to calibrate the interest rate diffusion pricing model. In the fixed income world, most models use the Black swaption implied volatility surface[8] as input and calculate the sensitivity of the security value to the changes in implied volatility with a single analytic, Vega, which is the price change of the security for a 1% parallel shift in the Black implied volatility surface. Vega does not capture the effects of non-parallel

8. Swaptions are options on interest-rate swaps that are being priced using an extension of the classic Black-Scholes model, see Fischer Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy* 83 (1973), pp. 637-654. The volatility input in the Black-Scholes model that is consistent with the market price of such swaptions is commonly referred to as *Black volatility*. Swaptions are specified with two parameters, the tenor of the option and the maturity of the underlying swap. Therefore, the set of swaptions traded in the market is represented with a two-dimensional matrix, hence the term *volatility surface*.

movements of the implied volatility surface or the effect of yield-curve moves on the diffusion parameters of the interest-rate diffusion model.[9] Clearly, it does not sufficiently represent the sensitivity of the security value to changes in implied volatility surface. Some advanced models are capable of generating partial Vegas, e.g., sensitivities to exposures at multiple points of the volatility surface, or, alternatively, to a vector of parameters that can be used to parametrically fit the volatility surface. In such cases a more detailed decomposition of implied volatility change return is possible.

If only parallel Vega is available, capturing the total effect of implied volatility changes through scenarios is imperative. The scenario-based implied volatility change return can then be decomposed into a parallel shift component that is equal to the product of Vega and the average volatility shift, and a remainder that contains the effects of nonparallel volatility movements as well as the effects of changes of other inputs and parameters used in the volatility model.

Other Market Return

Although yield-curve and implied volatility are the most important factors in the pricing models of most fixed income instruments, they do not capture every aspect of the cash flows, and more factors may be required. Securities or derivatives with cash flows that depend on external factors, such as prepayments or inflation levels, may use additional inputs to the pricing model. Changes in such inputs will generate return that is not attributable to yield-curve or implied volatility surface changes. The effects of the changes of all others factors are captured together as Other Market Return.

For example, the model-projected cash flows of mortgage-backed securities may depend on market mortgage rates, as well as additional model-specific parameters such as home price appreciation expectations or swap spreads. All of these parameters contribute to Other Market Return. The breakdown to the various factors follows an instrument specific algorithm and depends on the availability of specific analytics.

Spread Change Return

The effect of OAS changes to return is captured in the spread change return component. Sensitivity to spread movements is measured directly using both spread duration (OASD) and spread convexity (OASC). The large spread moves often observed in the market make it necessary to use spread convexity. The difference

9. In the simple lognormal model, the stochastic component of the relative interest rate changes is proportional to a scalar, the log-normal (Black) volatility; therefore no dependence on interest rates exists. Other models that better capture the true behavior of interest rates make the stochastic term a function of black volatilities, as well as the level of interest rates or other model parameters.

between the sum of spread return captured by OASD and OASC and the scenario-based spread return contributes to the residual return component.

Reporting the return split of individual securities and sectors in a portfolio and a benchmark is very useful for the portfolio manager as it provides a detailed understanding of the sources of exposures and returns in the portfolio. When reporting return splits, attribution systems may re-organize the various components of returns. In particular, the Barclays Capital HPA model which we use for illustrations in this chapter, re-groups the return components along risk-factors as shown in Exhibit 70–2. Sample return splits for a few securities can be found in Exhibit 70–3.

EXHIBIT 70–2

Return Splitting Components

Splits by Return Categories		Splits by Return Factors	
Surprise	Mortgage Prepay Surprise	Yield-Curve	Yield-Curve Carry
	Inflation Surprise		Key Rate Changes
Time Return	Yield-Curve Carry		Rest of Yield Curve Change
	Spread Carry	Implied Volatility	Volatility Decay
	Volatility Decay		Parallel Black Volatility Change
	Inflation Accretion		Rest of Volatility Change
	Inflation Spread Carry	Spread	Spread Carry
	Spread Carry		Spread Duration
	Time Residual		Spread Convexity
Yield-Curve Change	Key Rate Changes	Mortgage	Mortgage Prepay Surprise
	Rest of Yield Curve Change		Mortgage Spread Change
Implied Volatility Change	Parallel Black Volatility Change		Other Mortgage Factors
	Rest of Volatility Change	Inflation	Inflation Surprise
Other Change	Mortgage Spread Change		Inflation Accretion
	Other Mortgage Factors		Inflation Spread Carry
	Inflation Spread Change		Inflation Spread Change
Spread Change	Spread Duration	Residual	Spread Residual
	Spread Convexity		Time Residual
	Spread Residual		

Source: Barclays Capital

EXHIBIT 70–3

Security Return Splits

Sector		Treasury	Govt-Related	Corporate	Securitized
Identifier		912810FP	XS0114288789	20030NAM	FNA04409
Coupon		5.4	7.5	6.5	4.5
Maturity		2/15/2031	3/31/2030	3/15/2037	2/1/2039
Ticker		US/T	RUSSIA	CMCSA	FNMA
Total Return		702.6	253.4	366.8	75.0
Yield-Curve	**Carry**	33.6	23.3	32.5	13.2
	Change	684.5	186.8	614.2	88.3
Volatility	**Decay**	0.0	0.0	0.0	6.7
	Parallel	0.0	0.0	0.0	–108.0
	Reshaping	0.0	0.0	0.0	61.3
OAS	**Carry**	0.2	16.8	17.0	1.8
	Change Duration	–12.1	27.0	–300.1	–34.4
	Change Convexity	0.1	5.3	2.8	1.5
Mortgage	**Prepayments**	0.0	0.0	0.0	6.2
	Mortgage Spread	0.0	0.0	0.0	45.8
Residual		–3.6	–5.7	0.3	–7.7

Source: Barclays Capital POINT

OUTPERFORMANCE BREAKDOWN

Having split the returns in such detail based on analytical exposures to market factors, one might be tempted to proceed with bottom-up aggregation of outperformance per factor. However, neither does every portfolio manager use the factor approach to management, nor do all agree on which factors should represent portfolio risk. Many portfolios are managed by sectors or asset classes where top-down decomposition of outperformance is more appropriate, as the returns of the portfolio and the benchmark in each asset class or sector may differ. A flexible hybrid approach for performance attribution can be useful for both methods by allowing users to flexibly split total return into two parts: that driven by common factors for the entire portfolio and that in excess of common factors, which is further explained by asset allocation/security selection based on a user-defined hierarchical partition of the investment universe into sub-universes that we will refer to with the term "partition buckets."

Common components are explained by bottom-up aggregation as the difference of the exposure of the portfolio and the benchmark multiplied by the factor return. For example, yield-curve exposure is captured by duration, thus the outperformance explained by yield-curve movement would be the duration overweight of the portfolio (over the benchmark) multiplied by the negative of the yield-curve change. Excess of common or allocated components is explained by top-down decomposition using a user-defined hierarchical partition and the recursive algorithm discussed in Chapter 69, as will be detailed below.

This approach has the ability to accommodate different portfolio management styles. It also allows users to compare different ways of analyzing returns and outperformance and can lead to a better understanding of what drives portfolio outperformance. For example, many high-yield managers do not like to split total return into yield-curve, implied volatility and spread components, citing the high negative correlation between yield-curve and implied volatility return versus spread return. Instead, they prefer to manage total return as a whole. And even when they do wish to separate out yield-curve return and manage the excess-to-yield-curve return, they usually do not rely on spread duration and spread convexity to measure their exposure. However, when spreads were very tight in 2005, many high-yield managers began experimenting with spread duration-based management.

While any return split component could be considered as a bottom-up common return component or as an excess return component that participates in the top-down allocation algorithm, the following three common configurations support most portfolio management decision-making structures: Total Return Model, Excess Return Model, and Fully Analytical Model.

The *Total Return Model* is the simplest model, where the total return is considered a single allocated factor. In other words, there is no common factor, and the total return is explained by top-down decomposition using market value weights and a user-defined security partition.

The *Excess Return Model* takes advantage of the return splitting algorithm to separate the factors contributing to return into common and allocated factors.

Returns from common factors are explained by bottom-up aggregation using appropriate analytic weights (e.g., OAD, Vega, market beta, and the like.). For fixed income portfolios yield-curve and/or implied volatility are typically considered as common factors. Returns from other factors (excess-over-common factor returns) are explained by top-down decomposition as in the Total Return Model.

The *Fully Analytical Model* is the most detailed model. It takes full advantage of the return splitting algorithm and the hybrid allocation algorithm, where each factor can be explained either by the top-down or the bottom-up aggregation using appropriate weights.

The following sections discuss these different types of models in more detail.

TOTAL RETURN MODEL

The Total Return model is the most basic performance attribution model and follows the classical, sector-based, asset allocation/security selection framework. It is appropriate for portfolios whose managers make decisions solely based on the total returns of the securities. A typical usage is a portfolio whose managers are allocating the capital based on their views of the sector and security returns, rather than risk factors. The model is generic in that the allocation buckets can be defined via a user-defined partition using any of the hundreds of security attributes available. Allocations such as geography, size, and momentum can be used, essentially mimicking factor-based allocation. The partition should be defined to mimic the management structure of the portfolio.

The Total Return model uses the relative allocation method of the top-down decomposition algorithm as explained in Chapter 69, where sector market value weight w_s is the allocation weight $\alpha_{k,s}$, total return of sector s is the only factor return $f_{k,s}$, and total return of the benchmark is the hurdle rate.

Asset Allocation
$$w^P \cdot \sum_s \left(\frac{w_s^P}{w^P} - \frac{w_s^B}{w^B} \right) \cdot \left(TR_s^B - TR^B \right) \tag{70–1}$$

Sector Management
$$\sum_s w_s^P \cdot \left(TR_s^P - TR_s^B \right) \tag{70–2}$$

Top-Level Exposure
$$(w^P - w^B) \cdot TR^B \tag{70–3}$$

Absent leverage, the top-level weights of the portfolio and the benchmark are both equal to one, so the top-level exposure term is always zero.

Let us now re-visit the attribution example of the Chapter 69 to illustrate how results change according to the attribution model used. We remind the reader that in Chapter 69 we analyzed the outperformance of a multi-currency portfolio versus the Barclays Capital Global Aggregate G4 Index over a period of one month.

Here, we will focus only on the U.S. Dollar portion of the portfolio which achieved a +32.1 bp outperformance[10] versus the U.S. Dollar portion of the index.

Using the Total Return model and assuming that the asset allocation universe consists of the major asset classes in the U.S. Dollar fixed income markets, the total portfolio outperformance is split into +18.9 bp of asset allocation and +13.2 bp of security selection as shown in Exhibit 70–4.

The contribution of each asset class to both asset allocation and security selection is calculated based on the total return of each asset class in the portfolio and the benchmark using Eqs. (70–1) and (70–2) and reported in Exhibit 70–5.

The corporate sector contributes +7.4 bp to the outperformance, since it has been overweighted by about 10.9% (portfolio average weight: 30.7%, benchmark average weight: 19.8%) and its performance in the benchmark (+196.1 bp) is much higher than the performance of the benchmark itself (+129.8 bp). The approximate[11] calculation yields 10.9% × (196.1 – 129.8) = +7.2 bp, close to the +7.4 bp reported. The contribution to security selection is also shown and captures the performance advantage of the portfolio versus the benchmark, weighted by the portfolio weight of each sector. For the corporate sector, this calculation yields 30.7% × (107.9 – 196.1) = –27.1 bp, close to the –27.3 bp reported.

The analysis above assumed that asset allocation occurs only at the major asset class level (Treasuries, Government-Related, Corporates, Securitized, and Cash). It is likely that within each major asset class a second level of allocation to asset class subsectors will occur. For example, within the Securitized sector further allocation to the Residential Mortgages (RMBS) sector, the Commercial

EXHIBIT 70–4

Outperformance Breakdown Using the Total Return Model

Outperformance (USD)		Outperformance Details	
Portfolio Return (bps)	161.6	Asset Allocation	18.9
Benchmark Return (bps)	129.5	Security Selection	13.2
Outperformance (bps)	**32.1**		

Source: Barclays Capital POINT

10. This number can be approximated from the reported numbers in Exhibit 69–6 of Chapter 69 as the ratio of the outperformance contribution of the U.S. Dollar portfolio (+14.6 bp) divided by the U.S. Dollar portfolio weight (45.5%). The calculation is not exact because the weight of the dollar portfolio fluctuates over the monthly attribution period.
11. The calculation is approximate because the algorithm used by the Barclays Capital HPA model that generated this report employs daily compounding. This calculation would be exact for single-day results.

EXHIBIT 70–5

Asset Allocation Using the Total Return Model

Partition Bucket	Market Weight (%) Average Port	Market Weight (%) Average Bench	Return ex Common Factors Port	Return ex Common Factors Bench	Outperformance (bps) Asset Allocation	Outperformance (bps) Security Selection
Total	100.0	100.0	161.6	129.8	18.9	13.2
Treasury	31.7	31.7	315.4	201.1	0.0	36.3
Government-Related	14.3	14.3	123.9	129.5	0.0	–0.8
Corporate	30.7	19.8	107.9	196.1	7.4	–27.3
Securitized	22.8	33.4	49.1	27.1	11.0	5.1
Cash	0.5	0.8	0.0	0.0	0.5	0.0

Source: Barclays Capital POINT

Mortgages (CMBS) sector, the Asset-Backed (ABS) sector, and Covered Bonds may be desirable. As discussed in Chapter 69, a flexible attribution algorithm should support multiple decision levels. In our example, we introduce a second level of asset allocation by using asset class subsectors as defined by the Barclays Capital Global Aggregate Index classification scheme. In this case the Total Return model applied recursively reports a dramatically different breakdown between asset allocation and security selection as reported in Exhibit 70–6. Asset allocation shrinks from +18.9 bp to +2.9 bp, while security selection grows from +13.2 bp to +29.2 bp.

Intuitively, the finer the partition used for asset allocation the more emphasis is put on asset allocation decisions versus security selection decisions. In the limit, if the buckets of the asset allocation partition are individual securities, then the entire outperformance is reported as asset allocation. Conversly, if the asset allocation partition contains only one bucket, the entire outperformance is reported as security selection. Notice though that the transition between the two limits is not monotonic since individual partition buckets may contribute positively or negatively to both asset allocation and security selection. Such flexibility to define the asset allocation levels used in the breakdown of total outperformance is an important characteristic of an attribution system as it can support multiple styles of portfolio management. It is important that the partition used for performance attribution corresponds to the decision structure used for the management of a particular portfolio.

To understand the differences between single-level and two-level asset allocation, examine the two-level asset allocation details shown in Exhibit 70-7. In the Level-1 report, there are two columns for asset allocation, a top-level one (labeled simply Asset Allocation) which is identical to the asset allocation from the simple partition (+18.9 bp) and a Further Allocation column that captures subsequent allocation decisions (–16.0 bp). Their sum is +2.9 bp, the asset allocation reported in the summary report. Level-2 reports illustrate the details of the asset allocation into subsectors within each of the major asset classes. Asset classes for which no subsectors are defined (such as Treasuries and Cash) do not get Level-2 reports and do not contribute to Further Allocation.

EXHIBIT 70–6

Outperformance Breakdown Using the Total Return Model (Two-Level Asset Allocation)

Outperformance (USD)		Outperformance Details	
Portfolio Return (bps)	161.6	Asset Allocation	2.9
Benchmark Return (bps)	129.5	Security Selection	29.2
Outperformance (bps)	**32.1**		

Source: Barclays Capital POINT

EXHIBIT 70–7

Two-Level Asset Allocation Using the Total Return Model

Level 1: Portfolio Market Weight: 100.0

Partition Bucket	Market Weight (%) Average Port	Market Weight (%) Average Bench	Return ex Common Factors Port	Return ex Common Factors Bench	Outperformance (bps) Asset Allocation	Outperformance (bps) Further Allocation	Outperformance (bps) Security Selection
Total	100.0	100.0	161.6	129.8	18.9	–16.0	29.2
Treasury	31.7	31.7	315.4	201.1	0.0		36.3
Government-Related	14.3	14.3	123.9	129.5	0.0	–4.7	3.9
Corporate	30.7	19.8	107.9	196.1	7.4	–8.6	–18.7
Securitized	22.8	33.4	49.1	27.1	11.0	–2.6	7.6
Cash	0.5	0.8	0.0	0.0	0.5		0.0

Level 2: Government-Related: Portfolio Market Weight: 14.3

Partition Bucket	Market Weight (%) Average Port	Market Weight (%) Average Bench	Return ex Common Factors Port	Return ex Common Factors Bench	Outperformance (bps) Asset Allocation	Outperformance (bps) Further Allocation	Outperformance (bps) Security Selection
Government-Related	100.0	100.0	123.9	129.5	–4.7		3.9
Agency	98.3	70.5	121.7	94.3	–1.4		3.9
Local Authority		6.8		330.7	–2.0		0.0
Sovereign	1.7	12.6	253.4	232.7	–1.6		0.0
Supranational		10.0		113.5	0.2		0.0

(Continued)

EXHIBIT 70–7

Two-Level Asset Allocation Using the Total Return Model (*Continued*)

Level 2: Corporate: Portfolio Market Weight: 30.7

Partition Bucket	Market Weight (%) Average Port	Market Weight (%) Average Bench	Return ex Common Factors Port	Return ex Common Factors Bench	Outperformance (bps) Asset Allocation	Outperformance (bps) Further Allocation	Outperformance (bps) Security Selection
Corporate	100.0	100.0	107.9	196.1	–8.6		–18.7
Industrial	19.6	51.1	171.3	214.6	–1.8		–2.6
Utility		10.4		251.2	–1.8		0.0
Financial Institutions	80.4	38.5	92.4	157.0	–5.1		–16.1

Level 2: Securitized: Portfolio Market Weight: 22.8

Partition Bucket	Market Weight (%) Average Port	Market Weight (%) Average Bench	Return ex Common Factors Port	Return ex Common Factors Bench	Outperformance (bps) Asset Allocation	Outperformance (bps) Further Allocation	Outperformance (bps) Security Selection
Securitized	100.0	100.0	49.1	27.1	–2.6		7.6
RMBS	100.0	92.2	49.1	15.9	–0.2		7.6
ABS		0.6		101.2	–0.1		0.0
CMBS		6.4		181.3	–2.3		0.0
Covered		0.8		35.5	0.0		0.0

Source: Barclays Capital POINT

Let us focus again on the corporate sector which shows –8.6 bp of underperformance contribution from Further Allocation. Its Level-2 decomposition table explains why: the portfolio had a large overweight to financial institutions, an underweight to industrials and no allocation to utilities. While both industrials and utilities outperformed the corporate benchmark, financials had a lower performance of +157.0 bp than the +196.1 bp of the aggregate corporate sector. Therefore, all three sectors have negative contribution to outperformance, with the largest (–5.1 bp) coming from financial institutions. Once again, this can be approximated with the recursive application of Eq. (70–1) as follows: 30.7% × (80.4% – 38.5%) × (157.0 – 196.1) = –5.0 bp close to the –5.1 bp reported. The security selection numbers represent security selection within each sub-sector.

EXCESS RETURN MODEL

The Excess Return model uses the return splitting algorithm to extract common factor returns from the total return and considers the remainder as excess return. In the fixed income world, portfolio managers like to manage their exposures to common factors such as the movement of the yield-curve and implied volatility surface separately from their other investment decision choices. For example, consider a manager who chooses to hedge the overall exposure to the yield-curve and makes investment decisions purely based on expectations of excess-to-curve returns. In this case, she would like to see the total outperformance breakdown into yield-curve and excess return so that she can assess the effectiveness of the hedge, as well as the asset allocation/security selection choices separately.

The outperformance due to exposure to common factors, which we will discuss in detail below, is explained by bottom-up aggregation. The excess return outperformance is explained by top-down decomposition using the relative allocation model of the Chapter 69, with sector excess returns and sector market value weights as in the Total Return model.

Asset Allocation
$$w^P \cdot \sum_s \left(\frac{w_s^P}{w^P} - \frac{w_s^B}{w^B} \right) \cdot \left(ER_s^B - ER^B \right) \tag{70–4}$$

Sector Management
$$\sum_s w_s^P \cdot \left(ER_s^P - ER_s^B \right) \tag{70–5}$$

Top-Level Exposure
$$(w^P - w^B) \cdot ER^B \tag{70–6}$$

Once again, if neither the portfolio nor the benchmark is leveraged, the top-level weights are equal to one and the top-level exposure term is equal to zero.

Exhibit 70–8 shows the outperformance breakdown when using the Excess Return model and the two-level asset allocation in the previous example. The left-hand side table shows the results when only interest rates are treated as common return factors. Most of the outperformance (+24.6 bp) comes from the yield-curve exposure. Asset allocation is responsible for –2.2 bp and security selection

EXHIBIT 70–8

Outperformance Breakdown Using the Excess Return Model

Excess of Yield-Curve		Excess of Yield-Curve and Implied Volatility	
Outperformance Details		**Outperformance Details**	
Yield-Curve	24.6	Yield-Curve	24.6
Asset Allocation	–2.2	Implied Volatility	1.9
Security Selection	9.7	Asset Allocation	–4.0
		Security Selection	9.6

Source: Barclays Capital POINT

for +9.7 bp. The right-hand side table shows the results when, in addition to interest rates, implied volatility is also treated as a common factor. The Implied Volatility term contributes +1.9 bp to outperformance, altering the asset allocation contribution to –4.0 bp and the security selection contribution to +9.6 bp.

Outperformance Due to Yield-Curve Exposure

As discussed at the beginning of this chapter, the pricing framework for most fixed income securities essentially amounts to projecting future cash flows and discounting them at projected paths of interest rates. Government, swap, or municipal AAA interest rate yield curves can be used as the reference yield-curve, depending on the type of the security.

The yield-curve contribution to outperformance includes yield-curve change, the effect of interest rate changes, and yield-curve carry, the effect of the change of yield-curve discount factors or interest rate-related projected cash flows with the passage of time assuming that rates stay unchanged. There exist two different philosophies with respect to the definition of what constitutes a change in interest rates, and they result in different breakdowns between yield-curve carry and yield-curve change; however, the total yield-curve effect (their sum) is identical under both methodologies.

Methodology I: Rolling on Forwards

A yield-curve is deemed unchanged if the rates realize the values implied by the forward rates in the previous period. For example, if we look at an unchanged yield-curve one month into the future, the 1-year rate is equal to the one month forward 1-year rate calculated from today's yield-curve. In this methodology, a yield-curve change is calculated with respect to the projected forward rates, and carry always accrues at the short rate.

This method is not very popular (particularly among cash investors) because it introduces significant complexity in the estimation of yield-curve change return—the most important component of fixed income returns. In addition, forward rates are not particularly good predictors of the realized path of interest rates, further reducing the appeal of this method.

Methodology II: Parallel Translation

A yield-curve is deemed unchanged if the level and shape of the yield-curve remains unchanged. For example, if we look at an unchanged yield-curve one month into the future, the 1-year rate is equal to the 1-year rate in today's yield-curve. In this methodology, a yield-curve change is calculated with respect to today's yield-curve, and carry accrues at a different rate for each cash-flow.

Further, the representation of the yield-curve (e.g., par rates, zero rates, forward rates) is important and affects the breakdown of total yield-curve return between carry and change. If instantaneous forward rates are used to represent the yield-curve, then each cash-flow accrues carry at a rate equal to the forward rate corresponding to the cash-flow date. Securities with deterministic cash flows accrue carry at a rate equal to the average of the forward rates corresponding to the date of each cash-flow, weighted by the present value of each cash-flow. Unfortunately, the forward rate representation is not very popular since forward rates are not directly observable in the market. Investors prefer the better understood zero or par rates to represent a yield-curve. Under both representations, the calculation of the curve carry of a set of cash flows is complicated. From the discussion above it is evident that the breakdown of yield-curve return and outperformance into curve carry and curve change is somewhat subjective. Portfolio managers should have the flexibility to choose a methodology which is consistent with their style of management.

Since interest rate yield curves are infinite-dimension objects, we need to represent them with a finite set of parameters. The simplest method is to choose a small discrete set of yield-curve points (key-rate points) dispersed along the yield-curve. The premise is that the dynamics of the yield-curve can be represented with the dynamics of the key rates with a high degree of accuracy. Intermediate yield-curve points are assumed to move as a linear combination of the moves of adjacent key rates. A typical set of key rates used includes the 6-month, 2-year, 5-year, 10-year, 20-year and 30-year points for most currencies. Other curve points that also appear are the 1-month, 3-month, 1-year, 3-year, 7-year, 12-year, 15-year, 25-year and 40-year points. Some managers prefer to represent the curve using factors that are defined as linear combinations of curve points. The prototype for such representation is the level-slope-butterfly set of factors, a representation implied by the principal component analysis of yield curves. The choice of yield-curve representation depends on the type of yield-curve exposure a portfolio is taking as well as the capabilities of the underlying analytics system.

Although the key rates or level-slope-butterfly representation of the yield-curve is highly accurate from a risk perspective (captures more than 99% of its

variance), there may be deviations from a return perspective, especially if a small number of points are used. Indeed, there are periods where, for example, the three-year U.S, Treasury rate moves very differently than what is implied from the two-year and five-year rates. Analytics (key-rate durations) explain the bulk of yield-curve outperformance. Scenario-based outperformance calculations are used to capture any residual outperformance from intermediate yield-curve points and convexity.

Yield-Curve Carry

As discussed above, yield-curve carry calculations are complex even for bullet securities under par- or zero-rate representation of yield curves. An approximation method for the calculation of yield-curve carry, called the Curve Matching Portfolio (CMP) method, can be used to simplify these calculations.

The basic idea is to define a set of par and/or zero-coupon reference bonds whose yield-curve carry can be easily computed analytically, and then construct a carry-matching portfolio of such bonds for each portfolio or benchmark security. The matching algorithm attempts to create a portfolio that earns the same yield-curve carry as the security.

Matching par bonds are made to have a coupon equal to the par key rate of the corresponding maturity and a price of par (100). The payment frequency and day count convention match those used for yield-curve construction. As a result, all matching par bonds on the day of construction have an option-adjusted spread of zero by construction. Zero-coupon bonds do not pay coupons, but have yields matching the zero rates for maturities matching each point.

A curve matching portfolio consisting of reference bonds and cash is created for each security in the portfolio and benchmark such that the cash-flow profile of the portfolio matches the one for the bond. Since dealing with bond cash flows (which are often nondeterministic) is generally difficult, some algorithms use key-rate durations to represent the concentration of cash flows around each key-rate point. Therefore matching the key-rate durations of the curve-matching portfolio and the bond is an approximate way to match their cash-flow profiles and thus the curve carry. Cash is added or subtracted from the matching portfolio to make sure that it has the same present value with the bond. The amount of cash needed to replicate any particular bond can vary according to the duration profile and price of the bond. For example, if only par bonds are used in the matching portfolio of a bond with a higher coupon than the current par rate, leverage must be used in the matching portfolio (borrowing at the short rate to fund the future cash flows) to match the cash-flow profile of the bond. This leads to a negative amount of cash in the matching portfolio.

A common choice for the set of matching reference bonds is to use one par or zero bond per key-rate point. The weights of each reference bond (and cash) are aggregated over all positions in the portfolio and benchmark. Let us represent with ω_j^P and ω_j^B weights allocated to reference bond and cash in the curve-matching portfolio of the portfolio and benchmark respectively, with j spanning

all key-rate points and cash. If we approximate the carry return of each reference bond and cash as its yield (by definition the corresponding key rate level) multiplied by the attribution period length $y_j \Delta t$, the yield-curve carry outperformance can be broken down per key-rate point contribution as $\sum_j \left(\omega_j^P - \omega_j^B\right) \cdot y_j \cdot \Delta t$. If we define the average portfolio or benchmark yield as the average of all key rates using the CMP portfolio weights, the above formula can be re-written as $\left(y_{avg}^P - y_{avg}^B\right) \cdot \Delta t$. The excess yield-curve carry contribution of each key rate over the average carry can be defined, but the sum over all key rates will be zero.

Generally, yield-curve carry can be broken down using the following equations:

Outperformance from average carry $$\left(y_{avg}^P - y_{avg}^B\right) \cdot \Delta t \tag{70–7}$$

Key rate contributions $$\sum_j \left(\omega_j^P \left(y_j - y_{avg}^P\right) - \omega_j^B \left(y_j - y_{avg}^B\right)\right) \cdot \Delta t \tag{70–8}$$

If the average yield is set to zero for both portfolio and benchmark, then the average carry term is zero and the yield-curve carry outperformance is attributed to each key rate. If the average yield is calculated using the CMP weights for portfolio and benchmark, then the average carry is equal to the total carry contribution and the sum of the excess key rate contributions is equal to zero. Other choices for the average yield are also possible.

Yield-Curve Change

Yield-curve change outperformance is a result of duration profile differences between the portfolio and the benchmark and the change in the yield-curve. The scenario-based return decomposition described earlier is used to compute the total yield-curve change return and hence the outperformance. Then, by using the analytics (OAD and KRDs), the total yield-curve change outperformance is decomposed further into a parallel shift component, a curve reshaping (at the key-rate points) component, the rest of yield-curve contribution and the effects of convexity.

The outperformance from parallel yield-curve shift is computed by applying the bottom-up aggregation, using key-rate durations as loadings and key rate changes as factors. Similar to yield-curve carry, the notion of an average yield change (parallel shift) can be used to control how the yield-curve change outperformance is distributed between the key rate contributions and the parallel shift term.

Outperformance from avg. parallel shifts $$-(OAD^P - OAD^B) \cdot \Delta y_{avg} \tag{70–9}$$

Outperformance from reshaping $$-\sum_j \left(KRD_j^P - KRD_j^B\right) \cdot (\Delta y_j - \Delta y_{avg}) \tag{70–10}$$

If the average yield change is set to zero, the yield-curve change outperformance will be attributed to each key rate separately. If the average yield change is set equal to an appropriately defined parallel shift, the key rate terms capture the outperformance in excess of the parallel shift; i.e., the yield-curve reshaping effect on outperformance.

Since we represent the shape of the yield-curve by key-rate points, there will always be a small fraction of yield-curve change outperformance not captured by the above methodology, as explained at the beginning of this section. Exhibit 70–9 illustrates the change not captured by the key rates.

This final piece of the yield-curve change outperformance, calculated as the difference between total yield-curve change return from the scenario-based decomposition and the sum of the average parallel shift and reshaping return, includes the change in excess of key rates as well as return from convexity and other higher-order terms.

Exhibit 70–10 displays a yield-curve attribution report as produced by the Barclays Capital HPA model.[12] The total yield-curve outperformance of +77.4 bp is broken into +2.9 bp of curve carry and +74.4 bp of curve change. Each is further broken down into an average curve contribution, the excess-to-average contributions of each key-rate point and the rest of the curve and convexity effect. The key rate levels and their changes over the attribution period (one month in this example) as well as the portfolio exposures in terms of curve matching portfolio weights and key-rate durations are displayed to help users better understand the reported outperformance breakdown.

To illustrate how this can be done we will focus on curve carry. The average yield of the portfolio and the benchmark are calculated as the yield of the corresponding yield-curve–matching portfolios. Since the portfolio is longer than the benchmark (as indicated by its higher duration) in an upward sloping yield-curve, its average yield is higher than the benchmark (2.030% versus 1.698%).

EXHIBIT 70–9

Approximation of Yield-Curve Change by Key Rates

Source: Barclays Capital

12. The portfolio and benchmark used in this report are the Euro-denominated portions of the global portfolio used in the example of Chapter 69.

EXHIBIT 70–10

Yield-Curve Report

	Yield				Yield-Curve–Matched Market Weight (%)		Duration (yrs)		Outperformance (bps)		
	Level (%)		Change		Average		Average		Explained by Yield-Curve		
	Port	Bench	Port	Bench	Port	Bench	Port	Bench	Carry	Change	Total
Total									**2.9**	**74.4**	**77.4**
Average	2.030	1.698	–50.2	–50.2	100.0	100.0	6.7	5.6	2.9	54.2	57.1
Key Rates & Cash									0.0	12.0	12.0
Cash	0.279	0.279	0.0	0.0	–13.1	–14.5	0.0	0.0	0.2	0.0	0.2
6m	0.381	0.381	0.6	0.6	4.0	16.2	0.0	0.1	1.8	3.1	5.0
2y	0.771	0.771	–22.6	–22.6	39.5	37.4	0.8	0.7	–1.4	–1.3	–2.6
5y	1.726	1.726	–43.1	–43.1	22.0	33.7	1.1	1.6	–1.2	4.0	2.8
10y	2.708	2.708	–57.3	–57.3	40.1	18.5	3.6	1.7	0.8	14.1	14.9
20y	3.377	3.377	–64.7	–64.7	7.5	5.8	1.2	0.9	–0.1	3.5	3.4
30y	3.324	3.324	–69.6	–69.6	0.0	3.0	0.0	0.6	–0.1	–11.5	–11.6
Rest of Yield-Curve and Convexity									0.0	8.3	8.3

Source: Barclays Capital POINT

The corresponding average yield-curve carry contribution can be approximated[13] using Eq. (70–7) as the excess yield of the portfolio times the elapsed time of one month, (2.030% – 1.698%) × (1/12) = +2.8 bp, close to the +2.9 bp shown. The additional contributions of key-rate points can be estimated using Eq. (70–8). For example, the 2-year point contributes approximately [39.5% × (0.771% – 2.030%) – 37.4% × (0.771% – 1.698%)] × (1/12) = –1.3 bp, close to the –1.4 bp shown.

Outperformance Due to Implied Volatility Exposure

For fixed income securities with optionality, pricing models are typically calibrated to reflect the Black swaption implied volatility surface prevailing in the market. Therefore, changes in implied volatility create returns on the embedded option that must be attributed correctly in performance attribution. Similar to how the contribution of yield-curve changes are measured, both scenario- and analytics-based calculations are used to break down the contribution of implied volatility changes to outperformance. The outperformance due to exposure to implied volatility is typically calculated in terms of volatility decay, parallel shift of the implied volatility surface, and surface reshaping.

Volatility Decay

Volatility decay captures the change in option value due to the lapse of time. The return from volatility decay is difficult to capture exactly, as it requires re-simulating interest rate paths and pricing securities using two separate time variables (one for diffusion and the other for discounting). However, volatility decay return can be approximated by subtracting all other components of the total time return, such as yield-curve and spread carry. Outperformance due to volatility decay is the difference between the weighted average volatility decay return of the portfolio and the benchmark.

Implied Volatility Change

The outperformance due to implied volatility change is a result of the difference in volatility exposures of the portfolio and the benchmark and the change in the implied volatility surface. The exposure to parallel shift is measured by Vega, and the parallel shift return is equal to Vega multiplied by the average implied volatility change over the entire surface. The implied volatility surface reshaping return, as well as additional terms that represent other parameters entering the fitting of the implied volatility surface can be calculated as the scenario-based total implied volatility return minus the return from the parallel shift.

Exhibit 70–11 shows a sample implied volatility report[14] produced by the Barclays Capital HPA model. Volatility outperformance is broken down into the contributions of the major asset classes in the portfolio and benchmark.

13. Remember that these formulas hold for attribution over a single period while the example goes over a month using a daily compounding attribution algorithm.
14. The portfolio and benchmark in this report are the U.S. dollar portions of the global portfolio used in the example of Chapter 69.

EXHIBIT 70–11

Implied Volatility Report

	Volatility		Market Weight (%)		Parallel Vol Exposure		Outperformance (bps)			
			Average		Average		Explained by Volatility			
	Initial Level (%)	Total Change (%)	Port	Bench	Port	Bench	Decay	Parallel	Reshaping	Total
Total							**–0.5**	**6.2**	**–3.8**	**1.9**
Treasury	30.6	5.71	31.72	31.66	0.00	0.00	0.0	0.0	0.0	0.0
Government-Related	30.6	5.71	14.32	14.29	0.00	–0.03	0.0	0.2	–0.2	0.0
Corporate	30.6	5.71	30.71	19.85	–0.12	–0.01	0.1	–0.6	0.9	0.3
Securitized	30.6	5.71	22.76	33.42	–2.49	–3.60	–0.6	6.6	–4.5	1.5
Cash	0.0	0.00	0.49	0.78	0.00	0.00	0.0	0.0	0.0	0.0

Source: Barclays Capital POINT

The report contains the initial implied volatility level and its change over the attribution period for each asset class.[15] In this example, implied volatility exposure occurs only in the government-related, corporate, and securitized sectors. The ability of an issuer to call a bond and the prepayment option of mortgage-backed securities give issuers of such bonds optionality, therefore long exposure to implied volatility. Conversely, holders of such bonds are short volatility, as the negative exposure numbers indicate. By being long the corporate and short the securitized sector, the portfolio is implicitly underweighted volatility in the corporate sector and overweighted volatility in the securitized. Since on average implied volatilities increased 5.71% during this month, the corporate sector contributes negatively to parallel volatility outperformance (–0.6 bp), and the securitized sector contributes positively (+6.6 bp). Overall, the portfolio is long volatility since the volatility exposure of the securitized sector is much bigger than that of the corporate and government-related sectors. The total parallel volatility change outperformance contribution is +6.2 bp. The total contribution of changes in the implied volatility surface is calculated from the return splits scenarios, as described above. From that, the surface reshaping (net of the parallel shift) contribution as well as the effects of other parameters and factor of the volatility model are calculated as –3.8 bp. Finally, a net long volatility portfolio will suffer loss of return because of volatility decay. In this case, it has been calculated to be –0.5 bp. Putting it all together, the total contribution of implied volatility to the outperformance of the dollar portfolio is calculated to be +1.9 bp.

FULLY ANALYTICAL MODEL

The Fully Analytical model offers the flexibility to match the increasing diversity in portfolio management structures. It takes full advantage of the return splits by isolating returns from each factor individually. The model can accommodate either bottom-up aggregation or top-down decomposition, depending on how the factor exposures are managed in the portfolio. It is suitable for portfolios with multiple asset classes, as they often have exposures to different market risk factors. For example, consider a portfolio consisting of corporate bonds, mortgage-backed securities and inflation-linked bonds. While all of these securities are exposed to changes in interest rates and possibly implied volatility, mortgage securities have additional exposure to prepayment risk and mortgage spreads, and inflation-linked securities have additional exposure to their reference

15. Although in this report the average volatility of each bucket is reported to be the same, generally each security is exposed to different points of the volatility surface. It is difficult to estimate a single point representing the reference point for each security hence this report is using the simplistic approach where all securities are exposed to the same point for parallel shift calculations. Since the total effect of implied volatility changes is captured using scenario-based returns breakdown this choice only affects the breakdown between the average volatility change and the reshaping components.

inflation indices. Similar to how the yield-curve risk is managed, managers of mortgage and inflation-linked securities tend to manage these additional risk factors separately. The ability to break down outperformance due to specific factor exposure can be very valuable to the managers for explaining the impact of their portfolio decisions.

Furthermore, the Fully Analytical model allows portfolio managers to use measures other than market value as allocation weight. This is particularly useful for managers who allocate their capital to various sectors based on risk exposures rather than market values. For instance, a manager taking views on sector spread movement may think of over/underweight in terms of option-adjusted spread duration (OASD). In the credit space, the concept of duration-times-spread (DTS) has been gaining traction in recent years as an alternative measure of spread risk exposure.[16] As a result, credit portfolio managers may prefer to use OASD or DTS as allocation weight in performance attribution.

For illustrative purposes here, we will use the Fully Analytical model with the following choices: Yield-curve and implied volatility are considered common factors and their outperformance contribution is explained using bottom-up aggregation as previously described. The outperformance from mortgage and inflation factors as well as residuals are also explained using bottom-up aggregation and the details of their decomposition is described in the following sections. These factors are calculated per security and can be aggregated to buckets of the selected partition. Outperformance from spread is calculated in a top-down fashion using analytics-based exposure weights for spread change outperformance but market value weights for spread carry outperformance, as described in detail below.

Outperformance Due to Spread

Outperformance from spread is explained using top-down decomposition into asset allocation and security selection per user-defined hierarchical partition or sector. All three components of spread outperformance (carry, spread duration, and spread convexity) are decomposed separately using the top-down decomposition algorithm. Spread carry outperformance is decomposed by applying the absolute allocation algorithm using market value weights and carry returns. We consider two different methods for the decomposition of the spread change outperformance: top-level and sector-level.

Top-Level Spread Model

The top-level spread model assumes that there is a decision to over/underweight the spread duration exposure of the portfolio against the benchmark at the portfolio

16. See Arik Ben Dor, Lev Dynkin, Patrick Houweling, Jay Hyman, Erik van Leeuwen, and Olaf Penninga, *A New Measure of Spread Exposure in Credit Portfolios* (Barclays Capital Publications, February 2010).

level (top level). Subsequent decisions to allocate spread duration exposure to various sectors are made relative to the portfolio spread duration. This implies that allocation weight is measured by the ratio of the spread duration contribution of each sector ($w_s OASD_s$) over the portfolio spread duration. In other words, we apply the relative allocation method of the top-down algorithm of the Chapter 69 using $\alpha_k \leftarrow OASD$, $\alpha_{k,s} \leftarrow w_s OASD_s$, $f_{k,s} \leftarrow -\Delta OAS_s$ and $-\Delta OAS^B$ as hurdle rate.

Asset Allocation $$-OASD^P \cdot \sum_s \left(\frac{w_s^P OASD_s^P}{OASD^P} - \frac{w_s^B OASD_s^B}{OASD^B} \right) \cdot \left(\Delta OAS_s^B - \Delta OAS^B \right) \quad (70\text{–}11)$$

Security Selection $$-\sum_s w_s^P OASD_s^P \cdot \left(\Delta OAS_s^P - \Delta OAS_s^B \right) \quad (70\text{–}12)$$

Spread Duration Mismatch $$-(OASD^P - OASD^B) \cdot \Delta OAS^B \quad (70\text{–}13)$$

Here, the Top-Level Exposure term has been renamed Spread Duration Mismatch.

Sector-Level Spread Model

In contrast to the top-level model, the sector-level model assumes no such spread duration decision at the portfolio level. Instead, each asset allocation decision is made without any top-level restriction. In this case, the appropriate allocation weight is the absolute, rather than relative, spread duration contribution. Furthermore, the hurdle rate is set to zero, as sector views are expressed on the absolute (rather than relative) changes in sector spreads. In other words, the absolute top-down decomposition is applied using $\alpha_{k,s} \leftarrow w_s OASD_s$ and $f_{k,s} \leftarrow -\Delta OAS_s$.

Asset Allocation $$-\sum_s \left(w_s^P OASD_s^P - w_s^B OASD_s^B \right) \cdot \Delta OAS_s^B \quad (70\text{–}14)$$

Security Selection $$-\sum_s w_s^P OASD_s^P \cdot \left(\Delta OAS_s^P - \Delta OAS_s^B \right) \quad (70\text{–}15)$$

Exhibit 70–12 shows the USD Local Management outperformance decomposition of the US Dollar portfolio discussed earlier in this chapter using the Fully Analytical model with either top-level or sector-level spread duration management. We assume two-level allocation of spread exposure, first to major asset classes and then to subsectors of each asset class. In both models a new category, Mortgage,[17] has appeared and is responsible for –8.2 bp of outperformance. In both models, the security selection contribution is +9.3 bp. The difference comes from the treatment of spread duration exposure. The top-level model treats it as a portfolio-level decision (essentially a common return factor) contributing –1.8 bp of outperformance under the label Spread Duration Mismatch, while asset allocation is listed as +5.0 bp. The sector-level model makes spread duration exposure

17. We will discuss this term in more detail below.

part of the allocation decision and essentially combines the two terms, reporting asset allocation of +3.2 bp.

Exhibit 70–13 contains the Asset Allocation report to major asset classes (first level of allocation) using the sector-level model. Outperformance from asset allocation and security selection from each partition bucket is displayed, along with other useful information such as OAS and the changes in OAS, OASD, OASC, and market value weights.

The asset classes with the biggest contribution to spread change asset allocation outperformance are securitized with +4.4 bp and corporate with –1.7 bp. These numbers can be explained as follows. The securitized sector has an underweight of –0.3 years in terms of spread duration (0.8 years versus 1.1 years as seen in the top panel), while benchmark spreads in this sector widened 15.9 bp. Note that since we use the sector-level model, the hurdle rate is zero; therefore, we do not need to compare the spread widening of each sector with that of the benchmark. The approximate calculation estimates the contribution as –0.3 × –15.9 = +4.8 bp, relatively close to the +4.4 bp shown.

Spread carry contributes +1.5 bp to asset allocation, coming mostly from the corporate sector, which has high spread (+186.5 bp versus +57.1 bp for the benchmark) and is market value overweighted (30.7% versus 19.8%). The approximate calculation is (30.7% – 19.8%) × (186.5 – 57.1) × (1/12) = +1.2 bp.

EXHIBIT 70–12

Outperformance Breakdown Using the Fully Analytical Model

Fully Analytical Model (Top-Level)		Fully Analytical Model (Sector-Level)	
Outperformance Details		**Outperformance Details**	
Yield-Curve	24.6	Yield-Curve	24.6
Implied Volatility	1.9	Implied Volatility	1.9
Asset Allocation	5.0	Asset Allocation	3.2
Security Selection	9.3	Security Selection	9.3
Spread Duration Mismatch	–1.8	Mortgage	–8.2
Mortgage	–8.2	Residual	1.3
Residual	1.3		

Source: Barclays Capital POINT

Columns for further allocation[18] representing the contribution of spread exposure allocation to subsectors are also included.

Exhibit 70–13 also provides information to confirm the USD spread duration mismatch term from the top-level model (Exhibit 70–12, left panel). Indeed, the portfolio is slightly longer than the benchmark in terms of spread duration (4.7 versus 4.5 years), and benchmark spreads widened by 8.3 bp on average. Multiplying the spread overweight by the negative of the benchmark spread change yields $+0.2 \times (-8.3) = -1.7$ bp close to the –1.8 bp shown in Exhibit 70–12.

Mortgage Factors

The present value of mortgage-related securities depends on additional factors such as prepayments and mortgage rates. Some common additional factors are described below.

Prepayment Surprise Outperformance

Securities involving prepayments are priced using model predictions of future cash flows. Over a month, the realized prepayment rate is generally different from the one predicted by the model. The difference gives rise to a return component that is not captured by analytics; this return can be computed separately as Prepayment Surprise return. In the Barclays Capital Global Aggregate G4 index which is the benchmark in this example, prepayments are recognized on the first of the month based on a predicted rate (which, if different from the model-predicted one, will generate surprise return). Over the course of the month, the actual prepayment rate can be more accurately predicted and used to adjust the returns, leading to more days where the surprise return is non-zero. Once the actual rate is known and returns are adjusted to reflect it, no more surprise return for that particular month will occur. Note that portfolio accounting conventions with respect to recognizing realized prepayments may vary. If they are different from the benchmark conventions, the attribution system will report prepayment surprise outperformance that is not economic but accounting in nature.

Mortgage Spread Change Return

A common factor that affects the cash flows of all mortgage securities is the difference between the model-implied mortgage rate and the actual mortgage rate observed in the market. This difference is called the mortgage spread and the

18. It is interesting to note that further allocation must use the relative spread duration allocation model, since the spread duration of each major asset class has been determined at the first level of allocation. The spread duration allocation to subsectors must be consistent with the pre-determined spread duration of the asset class.

EXHIBIT 70–13

Asset Allocation Report for the Sector-Level Fully Analytical Model

	OAS (bps)				OASD (yrs)		Market Weight (%)		OASD Contr. (yrs)	
	Average		Change		Average		Average		Average	
Partition Bucket	Port	Bench	Port	Bench	Port	Bench	Port	Bench	Port	Bench
Total	74.2	57.1	5.5	8.3	4.7	4.5	100.0	100.0	4.7	4.5
Treasury	0.8	–1.3	0.5	0.5	6.5	5.2	31.7	31.7	2.1	1.6
Government-Related	80.4	65.1	–2.4	3.7	3.7	4.0	14.3	14.3	0.5	0.6
Corporate	182.5	186.5	11.8	14.1	4.4	6.2	30.7	19.8	1.4	1.2
Securitized	28.1	33.4	13.1	15.9	3.4	3.2	22.8	33.4	0.8	1.1
Cash	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.8	0.0	0.0

(Continued)

EXHIBIT 70–13

Asset Allocation Report for the Sector-Level Fully Analytical Model (*Continued*)

	Outperformance (bps)					
	Asset Allocation			Further Allocation		
Partition Bucket	Spread Carry	Spread Change	Total	Spread Carry	Spread Change	Total
Total	1.5	2.6	4.1	0.3	–1.2	–0.9
Treasury	0.0	–0.3	–0.3			
Government-Related	0.0	0.1	0.1	–0.2	0.1	0.0
Corporate	1.2	–1.7	–0.4	0.9	0.1	1.0
Securitized	0.2	4.4	4.6	–0.4	–1.5	–1.9
Cash	0.0	0.0	0.0			

Source: Barclays Capital POINT

price sensitivity of a security to this spread is the mortgage spread duration. The return due to mortgage spread change is usually estimated with a first order approximation as the product of the mortgage spread duration and the negative of the change in the mortgage spread, i.e., $-MtgRtDur \cdot \Delta MtgSpread$. The outperformance is the difference between the weighted average mortgage spread return of the portfolio and the benchmark.

Other Mortgage Factors

A number of other parameters such as home price appreciation projections and swap spreads may also be used in mortgage pricing models. In the scenario-based return splits, all such parameters are accounted for in Other Market Return scenario. For mortgage securities, the difference between the other market return and the mortgage spread return captures the return from factors for which no analytics are available. If this difference is significant, it is an indication that additional analytics are required to better understand the sources of risk and performance of mortgage securities under the particular valuation model.

Exhibit 70–14 displays a portion of a detailed position-level outperformance contribution report for the US Dollar portfolio discussed earlier in this chapter. The contribution of each position is broken down per factor. Outperformance components that are allocated in a top-down fashion such as spread carry and spread change are listed under "Security Selection." Components aggregated in a bottom-up fashion such as mortgage factors and residual are listed under "Other." Exhibit 70–14 is focused on the securitized sector, which is solely responsible for the –8.2 bp of underperformance attributable to mortgage factors. This report can be very useful to help managers drill down to the position level and understand the drivers of outperformance per individual factor.

Inflation Factors

Inflation-linked securities have cash flows linked to a specified price index. For example, the principal and interest payment of U.S. Government Inflation-Linked bonds (TIPS) are linked to the Consumer Price Index for All Urban Consumers (CPI-U), non–seasonally adjusted. The value and the return of inflation-linked securities depend on realized inflation as well as on expectations of future inflation during the lifetime of the security.

The analysis of the risk and performance of inflation-linked securities is subject to debate. One school of thought prefers to treat them as independent of nominal interest rates and express risk and performance as a function of real rates (nominal rates minus inflation expectations). In this type of analysis, the return of inflation-linked securities comes from changes of real rates, as well as time return, which is a combination of real rate carry and realized inflation accretion.

Another school of thought prefers to decompose real rates into the difference of nominal interest rates and inflation expectations such that nominal interest rate risk and contribution to outperformance is accounted consistently across

EXHIBIT 70–14

Position-Level Report Using the Fully Analytical Model

	Outperformance					
	Security Selection		Other			
Bucket/Issue	Spread Carry	Spread Change	Prepayments	Mortgage Spread	Residual	Total
Securitized	0.3	3.7	–1.2	–7.0	1.4	–2.7
RMBS	0.3	3.7	–1.2	–7.0	1.6	–2.5
FNA05003	0.0	1.2	0.6	2.6	–0.3	3.8
FNA04403	0.0	1.1	0.2	1.3	–0.2	2.4
FNA04409	0.0	1.0	0.2	1.2	–0.2	2.1
FGB04403	0.0	0.7	0.1	1.1	–0.1	1.7
GNA04403	0.0	0.5	0.0	0.7	0.0	1.2
GNF04403	0.2	–1.3	0.1	0.3	0.7	–0.1

Source: Barclays Capital POINT

all types of bonds. The numbers shown below are calculated following the latter approach.[19] Inflation expectations are captured by a negative discounting spread (similar to OAS), which is called inflation spread. The return of inflation-linked securities is explained by changes in nominal interest rates and inflation spreads. The time return is captured by the nominal interest rate carry reduced by the negative inflation spread carry and increased by realized inflation accretion. Since realized inflation is announced only once a month, an assumption about the projected inflation of the current month is required to ensure smooth daily inflation accretion. When realized inflation is announced, it is generally different from projected inflation, producing a return that cannot be otherwise accounted for. This kind of return of inflation-linked securities is called inflation surprise and is accounted separately. Inflation surprise return is also present when current month inflation projections change.

Exhibit 70–15 shows the Fully Analytical model's security return splits for the Barclays Capital Inflation Linked US TIPS index for the period from July 16, 2010 to August 13, 2010. These dates correspond to the CPI-U announcement dates for the index level as of the end of June and July, respectively; therefore, the index should show a realized inflation return equal to the rate of inflation realized during July (but only becoming known on August 13).

The total return of the index was +169.9 bp, with the majority coming from nominal interest rates exposure (+27.7 bp carry and +184.6 bp of yield-curve change). Inflation related return was negative at –40.6 bp, most of it coming from falling inflation expectations (captured under inflation spread change as –29.7 bp). Inflation accretion during July was –3.0 bp, indicating that at the beginning of the month, the market actually expected a small amount of deflation at an annualized rate of $-0.03\% \times 12 = -0.36\%$. The positive inflation surprise of +5.3 bp indicates that the realized inflation was actually positive, although quite low. The total realized inflation return is +2.3 bp, the sum of inflation accretion (at the market expected rate) and inflation surprise. From that, July realized annualized inflation can be calculated to be approximately $+0.023\% \times 12 = +0.28\%$. Indeed, the CPI reading for June was 217.965 and the one for July 218.011, implying an inflation rate for July of 218.011/217.965 –1= 2.11 bp or +0.25%. The inflation spread carry term of –13.1 bp reduces the yield-curve carry of +27.7 bp that was credited to the index due to exposure to nominal rates. The difference of the two can be thought of as the carry earned by the index due to exposure to real rates, i.e., nominal rates reduced by inflation expectations.

Another interesting thing to note is that inflation expectations did not fall uniformly across all maturities. Indeed, short bonds exhibited positive inflation spread return, indicating increasing inflation expectations over the next three years or so. This is also the case for very long bonds, with the 30 year bond showing increasing inflation expectations. Inflation expectations fell only for bonds

19. This approach is detailed in Anthony Lazanas and Jeremy Rosten, *Risk Modelling and Performance Attribution for Inflation-Linked Securities* (Lehman Brothers Publications, October 2005).

EXHIBIT 70–15

Return Splits of Inflation-Linked Securities

		Yield-Curve		Inflation					
Bucket/Issue	Maturity	Carry	Change	Accretion	Carry	Surprise	Spread Change	Residual	Total Return
Total		27.7	184.6	–3.0	–13.1	5.3	–29.7	–1.9	169.9
9128277J	1/15/2012	6.4	5.9	–3.0	–6.5	5.2	30.4	–1.0	37.5
912828GN	4/15/2012	7.1	8.9	–3.0	–6.1	5.2	31.5	–0.6	43
912828AF	7/15/2012	7.8	12.5	–3.0	–7.5	5.2	34.4	–0.2	49.2
912828HW	4/15/2013	11.5	29.6	–3.0	–8.7	5.2	19.4	1.1	55
912828BD	7/15/2013	12.7	36.6	–3.0	–8.5	5.2	26.4	1.7	71.1
912828BW	1/15/2014	15.7	55.1	–3.0	–8.5	5.2	14.5	2.7	81.8
912828KM	4/15/2014	17.4	66.7	–3.0	–10.0	5.2	–7.7	2.9	71.6
912828CP	7/15/2014	19	77.3	–3.0	–9.6	5.2	–0.2	2.8	91.5
912828DH	1/15/2015	22.9	103.4	–3.0	–9.9	5.3	–6.6	2	114
912828MY	4/15/2015	25.5	120	–3.0	–12.2	5.2	–31.5	1.4	105.3
912828EA	7/15/2015	26.8	128.6	–3.0	–11.0	5.3	–21.2	0.4	125.8
912828ET	1/15/2016	28.6	154.3	–3.0	–11.5	5.3	–29.4	0.6	144.9
912828FL	7/15/2016	29.8	176	–3.0	–12.5	5.3	–49.4	0.7	146.8
912828GD	1/15/2017	31.4	199.3	–3.0	–12.6	5.3	–63.7	0.3	156.9
912828GX	7/15/2017	32.4	217.5	–3.0	–13.7	5.3	–66.4	0.1	172.1

(Continued)

EXHIBIT 70–15

Return Splits of Inflation-Linked Securities (*Continued*)

		Yield-Curve		Inflation					
Bucket/Issue	Maturity	Carry	Change	Accretion	Carry	Surprise	Spread Change	Residual	Total Return
Total		27.7	184.6	–3.0	–13.1	5.3	–29.7	–1.9	169.9
912828HN	1/15/2018	34.5	245	–3.0	–14.2	5.3	–80.5	0.1	187.1
912828JE	7/15/2018	35.7	265.4	–3.0	–15.2	5.3	–88.9	–0.1	199.3
912828JX	1/15/2019	35.8	272.4	–3.0	–15.2	5.3	–88.9	–0.4	205.9
912828LA	7/15/2019	36.7	289.4	–3.0	–16.0	5.3	–93.2	–0.7	218.5
912828MF	1/15/2020	37.8	309	–3.0	–16.4	5.3	–105.6	–0.9	226.3
912810FR	1/15/2025	39.9	337	–3.0	–17.4	5.4	–66.1	–8.1	287.7
912810FS	1/15/2026	39.9	335.1	–3.0	–17.6	5.3	–89.8	–8.7	261.3
912810PS	1/15/2027	38.7	320.3	–3.0	–17.6	5.4	–62.0	–8.4	273.3
912810PV	1/15/2028	38.2	315.7	–3.0	–17.9	5.4	–33.9	–8.3	296.2
912810FD	4/15/2028	36	292.1	–3.1	–16.8	5.3	–34.6	–7.5	271.5
912810PZ	1/15/2029	36	292.8	–3.0	–17.7	5.3	–30.9	–7.3	275.3
912810FH	4/15/2029	34.7	279	–3.1	–16.9	5.4	–14.2	–6.6	278.3
912810FQ	4/15/2032	33.6	237.5	–3.0	–17.7	5.3	11.5	–7.0	260.1
912810QF	2/15/2040	35.5	107.3	–3.0	–19.1	5.2	59.6	–9.0	176.4

Source: Barclays Capital POINT

with maturities between 3.5 and 20 years. This indicates that inflation portfolio managers need to pay more attention to the term structure of expected inflation exposure and use more detailed analytics that provide partial sensitivities to the inflation term structure.

SELECTING AN APPROPRIATE ATTRIBUTION MODEL

From the above discussion, it should be clear that many variants of attribution models exist and that a portfolio manager must choose one that best corresponds to the decision structure during portfolio management. The results from several models applied to the U.S. dollar–denominated portion of the portfolio/benchmark from Chapter 69 are summarized in Exhibit 70–16. All models assume two-level asset allocation, first to major asset classes and then to subsectors of each asset class.

Essentially, models differ with respect to what factors of return are managed at the portfolio level via allocations of appropriate exposures (factor-based management) and which component of return is managed via allocation to sectors and security selection within each sector (sector-based management).

Each successive model brings one additional common factor. The Excess of Yield-Curve model introduces yield-curve exposure as a common factor; the Excess of Yield-Curve and Implied Volatility model introduces implied volatilities; the Fully Analytical model with sector-level allocation of spread exposure

EXHIBIT 70–16

Outperformance Contributions Using Various Models

	Total Return	Excess of Yield-Curve	Excess of Yield-Curve and Vol	Fully Analytical (Sector-Level)	Fully Analytical (Top-Level)
Total	32.1	32.1	32.1	32.1	32.1
Yield-Curve		24.6	24.6	24.6	24.6
Implied Volatility			1.9	1.9	1.9
Spread Duration Mismatch					–1.8
Asset Allocation	2.9	–2.2	–4.0	3.2	5.0
Security Selection	29.2	9.7	9.6	9.3	9.3
Mortgage				–8.2	–8.2
Residual				1.3	1.3

Source: Barclays Capital POINT

introduces all other factors for which there exist explanatory analytics (mortgage factors only, in this particular portfolio) as well as residual; and the Fully Analytical model with top-level allocation of spread exposure introduces top-level spread duration as a common factor.

Flexibility is a very important feature of attribution algorithms. Portfolio management styles differ, and an attribution platform must have sufficient richness so that a model representing each management style can be chosen. In addition, running multiple versions of the performance attribution algorithm may help portfolio managers reveal exposures that they have been implicitly taking and help them improve their management process.

KEY POINTS

- The total return of a security can be broken down to the contributions of various risk factors such as yield curve, volatility, spread, mortgage, and inflation—based on the variables used in the pricing model for that security type.
- Various models can be applied to allocate these components of return in different ways to correspond to the management structure of a portfolio.
- The Total Return Model considers all return as a single allocated factor and divides the difference in performance versus a benchmark into allocation to sectors and sector performance using market value weightings.
- The Excess Return Model extracts common factors, such as yield-curve and volatility, and allocates outperformance from excess return using a top-down algorithm into asset allocation and security selection. Relative performance from common factors is determined using bottom-up aggregation.
- The Fully Analytical model allows any return split component to be extracted as a common factor for bottom-up aggregation. Alternative weights, such as spread duration, can be used in allocation calculations to provide a risk-weighted view.
- It is most effective to choose a primary performance attribution model that matches the management structure of the portfolio. This provides a more effective evaluation of the performance due to exposure to the factors used in the decision making process.

CHAPTER
SEVENTY-ONE

ADVANCED TOPICS IN PERFORMANCE ATTRIBUTION

ANTHONY LAZANAS, PH.D.
Managing Director
Barclays Capital

ANTÓNIO BALDAQUE DA SILVA, PH.D.
Director
Barclays Capital

CHRIS STURHAHN
Vice President
Barclays Capital

ERIC P. WILSON
Vice President
Barclays Capital

PAM ZHONG, CFA
Vice President
Barclays Capital

The principles of performance attribution are outlined in Chapter 69 and a detailed attribution analysis for fixed income portfolios is discussed in Chapter 70. This chapter explores topics that more complex portfolios or analysis may encounter in practice. In particular, we start looking at the attribution exercise in a multicurrency context. Given the fact that the majority of multicurrency portfolios have some type of foreign exchange (FX) hedging overlay, being able to accurately separate the performance due to active FX positions from that due to hedging is a complex but important exercise. Another important topic discussed in this chapter concerns the treatment of returns and outperformance due to the use of derivatives or leverage in the portfolio. Their presence may change the nature of the basis used to define returns, so we discuss in more detail how to change the analysis in order to maintain the integrity of the performance attribution. This chapter finishes with the discussion of other practical considerations that performance attribution exercises often encounter. These include issues such as multi-period compounding, transaction handling, and missing or incorrect input data.

MULTICURRENCY ATTRIBUTION

In Chapter 70, we used performance attribution to examine the portfolio at the local market level, that is, associated with a particular currency market. Multicurrency portfolios add an additional layer of complexity to the portfolio management structure. For instance, there may be decisions made at the global level to determine capital allocation across different local markets or the FX exposures to those markets. In this section, we describe in more detail how one can decompose total global outperformance in terms of FX allocation, local market allocation and local market management.

To study the FX component of the portfolio's return, we need to define first the base currency of analysis, the currency in which we define the portfolio's return. Note that by definition, securities denominated in the base currency do not have FX exposure or return.

FX Return Splitting

Since most portfolio managers prefer to manage FX risk separately from all other risk exposures, the first step in return splitting of non-base-currency-denominated securities is to separate the FX component of return from the local component of return. The base currency total return of security i ($^{b}R_i$) can be expressed in terms of its local currency return (R_i) and the spot FX return of the currency in which the security is denominated, F_i .[1]

$$^{b}R_i = F_i + R_i F_i + R_i \tag{71–1}$$

Here, we assume that all positions with cash flows or dependencies on interest rates in multiple currencies (such as FX swaps, FX forwards) have been decomposed into legs that have exposure only to the market parameters of a single currency. Note the presence of a cross-term that is the product of the FX return and the local currency return. This can be accounted separately, but in most cases it is combined with the FX return under the assumption that the FX return is typically much larger than local currency returns. While this is generally true for fixed income securities, it may not be true for portfolios that invest in asset classes with higher volatility, such as equities or commodities.

To separate the performance due to FX exposures from the performance due to local management, we need to include the cash deposit return of each currency in the FX return.[2] Indeed, a cash investment in any foreign currency will

1. This formula is applicable to fully funded securities only. When leverage is present, such as in derivatives, it needs to be adjusted appropriately.
2. Brian D. Singer, and Denis S. Karnosky, "The General Framework for Global Investment Management and Performance Attribution," *Journal of Portfolio Management* (Winter 1995), pp. 84–92.

earn the FX return plus the local cash deposit return over the attribution period, R_i^{depo}, without incurring any local risk.

$$^{b}R_i = \left(F_i + R_i^{depo}\right) + R_i F_i + \left(R_i - R_i^{depo}\right) \tag{71–2}$$

The total return of the portfolio can then be written as the sum of returns from "local markets" that correspond to the first allocation layer of a multicurrency portfolio. Although single-currency markets provide the natural breakdown for FX returns, there is no reason to impose the same breakdown for local returns. In fact many managers allocate local return exposure to markets based on geography, asset class, or industry, rather than currency. We will denote the local return allocation markets with m and we will generally assume that they are not necessarily single-currency markets. Single-currency markets will be denoted with c and will be used for the allocation of the FX component of return, as well as the cross term.

$$^{b}R^P = \sum_c {}^{b}w_c^P \cdot \left(F_c + R_c^{depo}\right) + \sum_c {}^{b}w_c^P R_c^P F_c + \sum_m {}^{b}w_m^P \cdot \left(R_m^P - R_m^{depo,P}\right) \tag{71–3}$$

The three terms in Eq. (71–3) correspond to FX, FX/local cross-term, and local returns, respectively. Here, ${}^{b}w_c^P$ and ${}^{b}w_m^P$ represent the "base-currency portfolio market value weights," i.e., the market value of positions in currency c or market m over the market value of the portfolio, both expressed in base currency units. Note that within single-currency markets the cash deposit rate return and the FX return are the same for all securities and therefore the same for the portfolio and the benchmark. However for a generic market m that may span several currencies, the cash deposit rate return $R_m^{depo,P}$ is defined as the weighted average return over all market securities. Since the composition of the market generally differs across portfolios and benchmarks we need to use the designation P to identify a specific portfolio.

FX Hedging

FX hedging—the overlay of FX derivatives with the intent to change the FX exposure profile of a portfolio without affecting its local markets exposures—is a common practice in multicurrency portfolios. It enables managers to disentangle the portfolio construction process between the FX experts and the local market managers. The most common instruments used for hedging are FX forwards, typically with short tenors (e.g., one month) and rolled regularly. Longer tenors are sometimes used to reduce rolling costs.

Despite the intent to leave the local exposures unchanged, in practice FX hedging instruments have side effects that must be accounted for in a complete attribution framework. In what follows we detail two such effects.

Exposure to Local Interest Rates

Ideal FX hedges earn the cash rate in each currency and have zero interest rate duration. In practice, FX hedging instruments do have exposure to the short end of local interest rate curves. This effect is highlighted during market crises, when short rates exhibit significant volatility. Typically, this return is considered part of the hedging return, as it comes from an unintended exposure to local rates through the instruments used to hedge the portfolio and is not part of the local rates strategy decisions.

Cash Balance Effect

As FX rates fluctuate, the mark-to-market of FX forwards becomes nonzero, essentially representing a cash balance (positive or negative). Unless such cash balance is reinvested regularly, it represents an unintended allocation to cash (which is equivalent to leveraging if the balance is negative). This effect can be significant and needs to be highlighted in performance attribution. To that end, one possible solution is to capture this effect explicitly as the difference of the actual portfolio return minus the hypothetical return that would be achieved if the FX hedges cash balance were reinvested daily in the portfolio. Similar to the exposures to local rates, this effect should also be reported as part of the hedging return.

Once these side effects have been accounted for, the effect of FX hedges is restricted to the FX component of the total return and the cross-term; the local component of return remains unchanged.

Outperformance from FX Allocation and Hedging

FX outperformance is defined as the part of total outperformance that is due to fluctuations of the exchange-rates between the base currency and all non-base currencies present in the portfolio or the benchmark. The first two terms of Eq. (71–3), pure FX and the FX/local cross-term, contribute to FX outperformance. We look at them separately in what follows.

Let's denote the effective portfolio exposure to each spot FX rate after hedging with ${}^{b}h_c^P$ and the benchmark one with ${}^{b}h_c^B$. Then, we can represent the *pure FX outperformance* contribution to the portfolio outperformance as follows:

$$ {}^{FX}R^P - {}^{FX}R^B = \sum_c {}^{b}h_c^P \cdot \left(F_c + R_c^{depo}\right) - \sum_c {}^{b}h_c^B \cdot \left(F_c + R_c^{depo}\right) $$

We can now apply the relative allocation model of the top-down decomposition algorithm described in Chapter 69 to get the hedged FX allocation as:

$$ \sum_c \left({}^{b}h_c^P - {}^{b}h_c^B\right) \cdot \left(F_c + R_c^{depo} - R_b^{depo}\right) \tag{71–4} $$

To derive Eq. (71–4), we specifically set the following variables using the notation from Chapter 69: $\alpha_{k,s} = {}^{b}h_c$, $\alpha_k = \sum_c {}^{b}h_c = 1$, $f_{k,c} = F_c + R_c^{depo}$ and

$f_k^H = R_b^{depo}$. The allocation in Eq. (71–4) is typically used to measure pure FX allocation. However, a similar decomposition can be made to the FX outperformance without the hedges. The un-hedged FX allocation would be:

$$\sum_c \left({}^b w_c^P - {}^b w_c^B\right) \cdot \left(F + R_c^{depo} - R_b^{depo}\right) \tag{71-5}$$

Let's now discuss the *FX-local cross-term return*. For simplicity, let's focus only on the portfolio and split it into the original portfolio (P, with weights w) and the portfolio of hedges (H, with weights w–h). As per Eq. (71–3), we know that the portfolio cross-term return is $\sum_c {}^b w_c^P R_c^P F_c^P$. However, the hedge portfolio H pays the deposit rate R_c^{depo} in each currency. Therefore, the net return for the hedged portfolio ($P + H$) is:

$$\sum_c \left({}^b w_c^P R_c^P - \left({}^b w_c^P - {}^b h_c^P\right) \cdot R_c^{depo}\right) \cdot F_c^P$$

We can therefore see that hedges do contribute to the cross-term between FX and local returns. The contribution of the FX-local cross-term return to the outperformance of a portfolio versus a benchmark is calculated as:

$$\sum_c \left({}^b w_c^P R_c^P - {}^b w_c^B R_c^B\right) \cdot F_c^B + \left(\left({}^b w_c^P - {}^b h_c^P\right) - \left({}^b w_c^B - {}^b h_c^B\right)\right) \cdot R_c^{depo} \cdot F_c^B \tag{71-6}$$

Since this term is the product of two returns, its size is usually smaller than either of the two. However over time, the contributions of the cross-term can accumulate (similar to a convexity term) and become significant relative to the local and FX returns. Moreover, the FX cross-term can be a significant component of total return when FX and local returns have opposite signs and similar magnitudes. For example, if FX return is +5% and local return is –4%, the total return is 5% – 4% + 5% × –4% = 0.80%. Without the cross-term the total return would have been 1.00%, so the cross-term of –0.20% reduces total return by 25%. In the extreme, if the two returns are opposite but equal in magnitude, the entire total return is due to the cross-term. While in the majority of the cases the FX/local cross-term is insignificant, it is preferable to account for it explicitly.

In addition to the first two terms of Eq. (71–3) we just explored, the local return and market value effects of the hedging instruments, as well as their trading returns, should be accounted for separately. This allows us to separate any returns from the hedging instruments from the local returns and outperformance that we explore in the next stage of attribution.

Outperformance from Allocation to Local Markets

After the contributions of FX exposure and hedging are taken out, the remaining outperformance is given by:

$${}^L R^P - {}^L R^B = \sum_m {}^b w_m^P \cdot \left(R_m^P - R_m^{depo,P}\right) - \sum_m {}^b w_m^B \cdot \left(R_m^B - R_m^{depo,B}\right) \tag{71-7}$$

There are many different ways to decompose this outperformance into the contributions of the various decision-makers. The most straightforward is to assume that the first decision layer is the allocation of market value exposure to various local markets. After this, each local market is managed separately versus a corresponding benchmark. We can apply the top-down decomposition algorithm from Chapter 69 to define the local market allocation outperformance as:

$$\sum_m \left({}^b w_m^P - {}^b w_m^B\right) \cdot \left(\left(R_m^B - R_m^{depo,B}\right) - \left(R^B - R^{depo,B}\right)\right) \tag{71-8}$$

And the local market management outperformance as:

$$\sum_m {}^b w_m^P \cdot \left(\left(R_m^P - R_m^{depo,P}\right) - \left(R_m^B - R_m^{depo,B}\right)\right) \tag{71-9}$$

Specifically, we use the following notation from Chapter 69 to construct the equations above $\alpha_{k,s} = {}^b w_m$, $\alpha_k = \sum_c {}^b w_m = 1$, $f_{k,s} = R_m - R_m^{depo}$ and $f_k^H = R^B - R^{depo,B}$. Note that this breakdown is equivalent to the *Total Return model* presented in Chapter 70.

If each local market contains securities denominated in the same currency then Eq. (71–9) is simplified to $\sum_c {}^b w_c^P \cdot \left(R_c^P - R_c^B\right)$. The local outperformance within each currency $R_c^P - R_c^B$ can then be decomposed using the general methodology and any of the models described in Chapter 70. If on the other hand local markets span across currencies, then only the *Total Return Model* (see Chapter 70) is directly applicable for the analysis of local market management outperformance. The use of models that require a reference interest-rate curve for the analysis is not straightforward.

Factor-Based Local Markets Allocation

Market value-weighted allocation to markets hides many of the complexities of the decision process of investing across markets. Indeed, allocation of exposure to local markets consists of the aggregation of exposure to each risk factor that drives market returns, such as yield-curve, implied volatility, spreads, and so forth. To better quantify how much risk is taken in a particular local market, we can describe the allocation decision using the appropriate exposure to each risk factor, e.g., interest rate duration for yield-curve, Vega for implied volatility and spread duration for spreads, etc.

Following the methodology described in Chapter 69, we can rewrite Eq. (71–7) by decomposing local returns into the contributions of risk factors as follows:

$$
{}^{L}R^{P} - {}^{L}R^{B} = \sum_{k}\sum_{m_k} {}^{b}w^{P}_{m_k}\alpha^{P}_{k,m_k} f^{P}_{k,m_k} - \sum_{m} {}^{b}w^{P}_{m} R^{depo,P}_{m}
$$

$$
-\left(\sum_{k}\sum_{m_k} {}^{b}w^{B}_{m_k}\alpha^{B}_{k,m_k} f^{B}_{k,m_k} - \sum_{m} {}^{b}w^{B}_{m} R^{depo,B}_{m}\right) \tag{71-10}
$$

As implied by the notation m_k, each factor may use a different set of local markets. We can now separate local outperformance into allocation, management and leverage using different weights for each factor. Specifically, the outperformance due to allocation is:

$$
\sum_{k}\left(\sum_{m_k}\left({}^{b}w^{P}_{m_k}\alpha^{P}_{k,m_k} - {}^{b}w^{B}_{m_k}\alpha^{B}_{k,m_k}\right)\cdot\left(f^{B}_{k,m_k} - f^{H}_{k}\right)\right) - \sum_{m}\left({}^{b}w^{P}_{m} - {}^{b}w^{B}_{m}\right)\cdot R^{depo,B}_{m} \tag{71-11}
$$

While the one due to management is:

$$
\sum_{k}\left(\sum_{m_k} {}^{b}w^{P}_{m_k}\alpha^{P}_{k,m_k}\cdot\left(f^{P}_{k,m_k} - f^{B}_{k,m_k}\right)\right) - \sum_{m} {}^{b}w^{P}_{m}\cdot\left(R^{depo,P}_{m} - R^{depo,B}_{m}\right) \tag{71-12}
$$

Finally, the top-level allocation, or leverage, can be represented as:

$$
\sum_{k}\left(\sum_{m_k} {}^{b}w^{P}_{m_k}\alpha^{P}_{k,m_k} - \sum_{m_k} {}^{b}w^{B}_{m_k}\alpha^{B}_{k,m_k}\right)\cdot f^{H}_{k} \tag{71-13}
$$

Example: Curve Allocation to Local Markets

As an example of the decomposition we just described, consider a portfolio manager that centrally manages the global interest-rate positioning of the portfolio. In this context, we can use the above methodology to separate the local performance of a portfolio into a global curve allocation and excess (of global curve) outperformance. The portfolio manager can use key rate durations to control her exposure to the former and market value weight to control exposure to the latter. We will select the local markets for the decomposition of global interest rates outperformance in a way that each market c corresponds to a unique interest-rate curve. Most of the time this decomposition is equivalent to single currency markets decomposition, yet occasionally this is not the case. For example, it might be preferable to use individual country government curves when analyzing a portfolio of euro-denominated bonds. This methodology allows us to answer successively:

- What was the contribution of the global duration position of the entire portfolio (Global Duration Mismatch)?

- What was the contribution of taking interest rate exposure (sovereign exposure) outside of our reference currency (Local Curve Advantage)?
- What was the contribution of taking other risk exposure in each currency (Excess of Curve Allocation)?

In this example, we will further separate the curve return into two components, a *curve carry* and a *curve change* return. To account for *curve carry* in a way that is consistent with Eq. (71–7), we subtract the deposit return from the outperformance of curve carry. The carry exposure to each individual key-rate point i in each curve c is constructed using the curve-matching portfolio (CMP) weights $\omega_{c,j}$ as described in Chapter 70. The idea behind the CMP is to represent each bond in the portfolio or benchmark as a portfolio of "par bonds" whose curve carry is easy to compute analytically. We can then calculate the carry associated with the portfolio or benchmark using the carry of the corresponding CMP. Let us also denote the curve carry return from each individual key-rate point with $R_{c,j}^{carry} = y_{c,j}\Delta t$. From Eqs. (71–11) to (71–13), using the transformations $\alpha_{k,m_k} = \omega_{c,j}$, $f_{k,m_k} = R_{c,j}^{carry} - R_c^{depo}$ and setting the hurdle rate equal to the excess carry return of a reference currency (typically the base currency of the analysis) $f_k^H = R_{ref,j}^{carry} - R_{ref}^{depo}$, we get the following decomposition.

The local curve carry allocation is given by

$$\sum_c \sum_j \left({}^b w_c^P \omega_{c,j}^P - {}^b w_c^B \omega_{c,j}^B\right) \cdot \left(\left(R_{c,j}^{carry} - R_c^{depo}\right) - \left(R_{ref,j}^{carry} - R_{ref}^{depo}\right)\right) \tag{71-14}$$

The local curve carry management by

$$\sum_c \sum_j {}^b w_c^P \omega_{c,j}^P \cdot \left(\left(R_{c,j}^{carry} - R_c^{depo}\right) - \left(R_{c,j}^{carry} - R_c^{depo}\right)\right) = 0 \tag{71-15}$$

And the global curve carry over deposit as

$$\sum_c \sum_j \left({}^b w_c^P \omega_{c,j}^P - {}^b w_c^B \omega_{c,j}^B\right) \cdot \left(R_{ref,j}^{carry} - R_{ref}^{depo}\right) \tag{71-16}$$

Note that since c represents a single interest rate curve, the carry return at each key-rate point and the deposit rate return is uniform across all securities and therefore the same for the portfolio or the benchmark. In this case the curve carry management is zero by construction. Further, if we do not use a reference curve, then the global curve carry term also becomes zero and the global curve carry outperformance is simply broken down per curve and key-rate point as follows:

$$\sum_c \sum_j \left({}^b w_c^P \omega_{c,j}^P - {}^b w_c^B \omega_{c,j}^B\right) \cdot \left(R_{c,j}^{carry} - R_c^{depo}\right) \tag{71-17}$$

We now turn to the second component of the curve return, the *curve change* return. The outperformance due to curve change is decomposed similarly using

key-rate durations as allocation weights and the negative of the key-rate yield change as return, i.e., $\alpha_{k,m_k} = KRD_{c,j}$, $f_{k,m_k} = -\Delta y_{c,j}$ and $f_k^H = -\Delta y_{ref,j}$.

Under this setting the local yield-curve change allocation is

$$-\sum_c \sum_j \left({}^b w_c^P KRD_{c,j}^P - {}^b w_c^B KRD_{c,j}^B \right) \cdot \left(\Delta y_{c,j} - \Delta y_{ref,j} \right) \tag{71-18}$$

And the local yield-curve change management is

$$-\sum_c \sum_j {}^b w_c^P KRD_{c,j}^P \cdot \left(\Delta y_{c,j} - \Delta y_{c,j} \right) = 0 \tag{71-19}$$

Finally, the global duration mismatch is

$$-\sum_c \sum_j \left({}^b w_c^P KRD_{c,j}^P - {}^b w_c^B KRD_{c,j}^B \right) \cdot \Delta y_{ref,j} \tag{71-20}$$

Once again, within a specific curve interest rate changes are the same for all securities and therefore for the portfolio and the benchmark. This causes the management term to be zero. In addition, if no reference curve is specified, then the global duration mismatch becomes zero as well and the global curve change outperformance is simply broken down per curve and key-rate point as follows:

$$-\sum_c \sum_j \left({}^b w_c^P KRD_{c,j}^P - {}^b w_c^B KRD_{c,j}^B \right) \cdot \Delta y_{c,j} \tag{71–21}$$

Once outperformance from interest rate curve exposures has been accounted for, the remaining return, i.e., the return in excess of FX and curve return can be explained using a different set of local markets using the same methodology discussed above in the "Outperformance from Allocation to Local Markets" section.

Global Curve Allocation in Practice

To illustrate the concepts just developed, let's consider the following example. A U.S. dollar-denominated portfolio is managed against the Barclays Capital Global G4 Treasury Index, an index consisting of government bonds from four currencies, U.S. dollar, euro, Japanese yen and British pound. The manager is allowed to make the portfolio deviate from the index in order to express views that in her opinion will produce superior returns. In this case, the manager believes that euro will strengthen versus the U.S. dollar and at the same time U.S. rates will rise while euro rates will fall. She wants no active exposure to the yen market. Finally, to minimize sovereign risk she prefers to concentrate exposure within the euro-zone to the strongest economies in the region.

The portfolio is constructed in line with the above views as follows:

- The portfolio is long euro (against the U.S. dollar, the base currency of the portfolio).

- The portfolio uses 6-month FX forwards selling Japanese yen against the U.S. dollar to bring the portfolio yen exposure in line with that in the benchmark.
- The portfolio is net long interest-rate duration in euro-denominated securities and net short interest-rate duration in U.S. dollar–denominated securities.
- The portfolio overall interest rate duration is neutral against the benchmark.
- In the euro-zone, only bonds from AAA-rated countries are included in the portfolio.

The major portfolio exposures are summarized in Exhibit 71–1.

Exhibit 71–2 shows the breakdown of the portfolio outperformance versus the benchmark for a period of one month. The total outperformance is +10.5 bp. It is broken down by currency, with U.S. dollar being the top contributor at +15.5 bp. It is also broken down by type of exposures, where we see that FX positioning contributed +14.3 bp, allocation to local markets (including interest rate exposures) contributed +6.5 bp, while local management within each currency market had a negative contribution of –10.3 bp. As expected, most of the FX Allocation outperformance came from the exposure to the euro (+14.4 bp), indicating that the manager's view regarding a strengthening euro was correct. The breakdown also shows a small contribution from hedging effects under Japanese yen, +0.1 bp. As discussed previously, the 6-month JPY/USD FX forwards contributed to non-FX return in two ways: (1) They were exposed to the short end of the yen and U.S. dollar yield-curve movements; and (2) over the attribution period they accumulated nonzero market value and therefore created a cash balance effect.

EXHIBIT 71–1

Portfolio Major Characteristics by Currency

Currency Buckets	Market Value [%]			OAD Contribution		
	Portfolio	Benchmark	Net	Portfolio	Benchmark	Net
Total	100	100	0.0	6.46	6.47	–0.01
U.S. Dollar	24.1	28.6	–4.5	1.05	1.50	–0.45
Euro	34.4	29.8	4.6	2.33	1.88	0.45
Japanese Yen	34.5	34.5	0.0	2.45	2.46	–0.01
British Pound	7.0	7.1	–0.1	0.63	0.63	0.00

Source: Barclays Capital POINT

EXHIBIT 71–2

Total Outperformance Breakdown by Currency

	Total	U.S. Dollar	Euro	Japanese Yen	British Pound
Outperformance	10.5	15.5	–5.1	0.5	–0.4
FX Allocation & Hedging	14.3	0.0	14.4	0.0	–0.1
Hedged FX Allocation	14.6	0.0	14.8	–0.1	–0.2
FX / Local Cross Term	–0.4	0.0	–0.4	0.0	0.0
Hedging Effects	0.1			0.1	
Local Market Allocation	6.5	16.5	–9.7	–0.3	0.0
Local Yield-Curve	3.1	14.9	–12.0	0.2	0.0
Local Market Allocation Over Curve	3.4	1.6	2.3	–0.5	0.0
Local Management	–10.3	–1.0	–9.8	0.8	–0.3
Asset Allocation	0.6	–1.1	1.3	0.4	0.0
Security Selection	–10.9	0.1	–11.1	0.4	–0.3

Source: Barclays Capital POINT

Both effects are captured in the non-zero hedging effects outperformance. The yield-curve allocation outperformance is +3.1 bp, with U.S. and the euro-zone contributing +14.9 bp and –12.0 bp, respectively. From this perspective and for this period, the views the manager had regarding the movements on the yield-curve played well for him regarding the U.S. dollar, but against him regarding the euro. The local market allocation in excess of the yield-curve totals +3.4 bp. Finally, local management pulled back the overall outperformance. Security selection in the euro-zone, in particular, contributed –11.1 bp to total outperformance.

Let us first look into the FX allocation outperformance in detail (Exhibit 71–3). In line with the fund manager's view, the euro strengthened, producing +306.1 bp of FX plus cash deposit return in excess of the base currency (U.S. dollar) cash deposit return. Since the euro had an average overweight of 4.6% during this period, it contributed +14.8 bp of FX outperformance. This number can be approximated as the product of the average overweight times the excess return of the currency, i.e., $4.6\% \times 306.1 = +14.1$ bp. The number does not tie out exactly with the +14.8 bp outperformance reported in Exhibit 71–3 because in the attribution system it is calculated daily and then compounded taking account of any fluctuations in the exposure. In Exhibit 71–3 one can also observe that FX hedging of the yen exposure cost +8.5 bp of outperformance since the yen also appreciated during this period. However, the reverse could be true should the yen weaken against the U.S. dollar. The return coming from the hedged FX Allocation

EXHIBIT 71–3

FX Allocation Outperformance Breakdown by Currency[3]

Currency Market	FX Rate Begin	FX Rate End	Excess over Base Depo	Average Market Value (%)			Un-hedged FX Allocation	Hedged FX Allocation	FX / Local Cross Term
				Portf	Bmark	Over-weight			
U.S. Dollar	1.0000	1.0000	0.0	24.1	28.6	–4.5	0.0	0.0	0.0
Euro	1.3018	1.3416	306.1	34.4	29.8	4.6	14.8	14.8	–0.4
Japanese Yen	0.0119	0.0123	327.4	34.5	34.5	0.0	8.4	–0.1	0.0
British Pound	1.5574	1.5657	56.3	7.0	7.1	–0.1	–0.1	–0.1	0.0
Total				**100**	**100**		**23.1**	**14.6**	**–0.4**

[3]The hedging effects category is not included here as it has been discussed in the Exhibit 71–2.

Source: Barclays Capital POINT

outperformance for the Japanese yen is close to zero. This shows that the manager was able to implement into the portfolio one of his goals: reduce significantly any volatility related to exposure to the yen.

Next, we look more carefully into the global yield-curve outperformance (see Exhibit 71–4). The portfolio curve carry outperformance is almost flat at –0.1 bp. Most of the outperformance comes from portfolio duration positioning. During the period, yields rose for all G4 curves. However, on a relative basis, euro yields rose less than U.S. dollar yields. Without changing the portfolio overall interest rate duration, the portfolio picked up +3.2 bp of outperformance. This was achieved by going short the interest-rate duration in the U.S. (+16.3 bp) while long duration in the euro-zone (–13.1 bp). Overall, the duration decisions played in favor of the manager. Japanese yen and British pound markets contributed little as their durations have been purposely kept neutral to the benchmark.

The outperformance contributions in Exhibit 71–4 have been calculated using Eqs. (71–17) and (71–21) and taking into account the detailed key-rate exposures of the portfolio in each currency. For the purposes of this example we simplify these equations assuming that the portfolio curve exposure is distributed evenly across all key-rate points. In this case the following simplifications can be made:

$$\sum_c \sum_j \left({}^b w_c^P \omega_{c,j}^P - {}^b w_c^B \omega_{c,j}^B\right) \cdot \left(R_{c,j}^{carry} - R_c^{depo}\right) \approx \sum_c \left({}^b w_c^P - {}^b w_c^B\right) \cdot \left(\overline{R_c^{carry}} - R_c^{depo}\right), \text{ and}$$

$$-\sum_c \sum_j \left({}^b w_c^P KRD_{c,j}^P - {}^b w_c^B KRD_{c,j}^B\right) \cdot \Delta y_{c,j} \approx -\sum_c \left({}^b w_c^P OAD_c^P - {}^b w_c^B OAD_c^B\right) \cdot \overline{\Delta y_c}$$

Here $\overline{R_c^{carry}}$ and $\overline{\Delta y_c}$ represent the average curve carry return and average yield change in each curve.

For example, the average euro yield is about 3.1%, which implies a carry-over deposit return[4] of 23.4 bp over the attribution period (one month). The contribution of the euro market value overweight to curve carry outperformance can be estimated as the market value overweight times the average carry over deposit return, i.e., (34.4% – 29.8%) × 23.4 bp = +1.1 bp. The contribution of the euro duration overweight to curve change outperformance can be estimated as the product of the duration overweight times the negative of the average yield change, i.e., (2.33 – 1.88) × (–28 bp) = –12.6 bp. This is close but not equal to the reported –13.1 bp because of the simplification above as well as the compounding effects over the attribution period. A detailed key-rate level report can be used to gain more insight into the numbers. It is interesting to note that the portfolio market weights in some currencies reported here are different than the ones reported in Exhibit 71–3. In particular, the U.S. dollar weight was 24.1% in Exhibit 71–3 but

4. Euro deposit rate is about 0.3% during the period. Its monthly carry over deposit return can be estimated as (3.1% – 0.3%) / 12.

EXHIBIT 71–4

Global Yield-Curve Allocation Outperformance

Currency Market	Average Yield Level (%)	Carry Over Deposit (bp)	Curve-Matched Market Weight (%)		Average Yield Change (bp)	Duration (years)		Curve Outperformance (bp)		
			Portf	Bmark		Portf	Bmark	Carry	Change	Total
U.S. Dollar	2.7	20.4	21.6	28.6	35.0	1.05	1.50	–1.4	16.3	14.9
Euro	3.1	23.4	34.4	29.8	28.0	2.33	1.88	1.1	–13.1	–12.0
Japanese Yen	1.2	9.1	37.0	34.5	5.0	2.45	2.46	0.2	0.0	0.2
British Pound	3.6	25.0	7.0	7.1	20.0	0.63	0.63	0.0	0.0	0.0
Total			**100.0**	**100.0**		**6.46**	**6.47**	**–0.1**	**3.2**	**3.1**

Source: Barclays Capital POINT

is now reported as 21.6%; the yen weight was 34.5% but is now reported as 37.0%; the euro and British pound weights are unchanged. This is because the market value of the JPY/USD forwards has been excluded from the local analysis since such positions are considered FX hedges. The contribution of the cash balance effect is captured in the *hedging effects* category of outperformance as discussed above.

If we analyze the performance by currency as in Exhibit 71–4, we may penalize the fund manager unfairly for the large negative outperformance coming from the Euro exposure. An alternative way to analyze the global curve outperformance is to use a reference curve, as presented in Eqs. (71–14), (71–16), (71–18) and (71–20). This is done in Exhibit 71–5, using the U.S. dollar yield-curve as the reference curve. Although the total curve outperformance remains the same, the breakdown among currencies has changed.

For example, Japanese yen now contributes negatively to the curve carry outperformance. Although the yen has a positive carry over deposit return of +9.1 bp over the month, this return is lower than the U.S. dollar (reference) carry over deposit return of +20.4 bp. Therefore, an overweight in a relatively underperforming currency results in an underperformance. The global carry outperformance can be approximated with the formula

$$\left(\sum_c {}^b w_c^P - \sum_c {}^b w_c^B\right) \cdot \left(\overline{R_{ref}^{carry}} - R_{ref}^{depo}\right)$$

This approximation is always zero since the sum of the weights over all curves of an (unleveraged) portfolio or benchmark is equal to 1. However, since the actual calculation is using exposures at each key-rate point, the exact global carry outperformance may be non-zero.

The euro shows now a *positive* contribution to the curve change outperformance due to better performance relative to the U.S. curve. Its contribution to curve change outperformance is now estimated as – (2.33 – 1.88) × (28 bp – 35 bp) = +3.2 bp, close to the +3.1 bp reported. As concluded before, the manager decision regarding global curve positioning had an overall positive performance for the portfolio during this period. The U.S. curve—being the reference curve—does not contribute to outperformance. The global duration contribution can be estimated using the formula $-(OAD^P - OAD^B) \cdot \overline{\Delta y_{ref}}$, i.e., – (6.46 – 6.47) × 35 bp = +0.3 bp, close to the +0.1 bp reported.

After the yield-curve outperformance has been accounted for, the excess of yield-curve return is split into allocation and management components. Although in general a different set of markets can be used, in this example we will use the same G4 markets used for the curve decomposition. Exhibit 71–6 shows the details of this breakdown. Overall, the allocation of exposure to the four markets has contributed positively (+3.4 bp) with the exposure to the euro market contributing most of it (+2.3 bp). This number can be approximated as the overweight of the euro market times the excess return of the euro market in the benchmark

EXHIBIT 71–5

Global Yield-Curve Outperformance with U.S. as Reference Curve

Currency Market	Avg Yield Level (%)	Carry Over Deposit (bp)	Curve-Matched Market Weight (%)		Average Yield Change (bp)	Duration (years)		Curve Outperformance (bp)		
			Portf	Bmark		Portf	Bmark	Carry	Change	Total
Global Carry/ Duration			100.0	100.0		6.46	6.47	0.0	0.1	0.1
U.S. Dollar (Ref)	2.7	20.4	21.6	28.6	35.0	1.05	1.50	0.0	0.0	0.0
Euro	3.1	23.4	34.4	29.8	28.0	2.33	1.88	0.1	3.1	3.2
Japanese Yen	1.2	9.1	37.0	34.5	5.0	2.45	2.46	–0.2	0.0	–0.2
British Pound	3.6	25.0	7.0	7.1	20.0	0.63	0.63	0.0	0.0	0.0
Total			**100.0**	**100.0**		**6.46**	**6.47**	**–0.1**	**3.2**	**3.1**

Source: Barclays Capital POINT

EXHIBIT 71–6

Excess of Yield-Curve Outperformance

	Return Over Curve		Market Weight (%)			Outperformance	
Currency Market	Portf	Bmark	Portf	Bmark	Overweight	Local Market Allocation Over Curve	Local Management
U.S. Dollar	–2.0	0.5	21.6	28.6	–7.0	1.6	–1.0
Euro	40.5	67.9	34.4	29.8	4.6	2.3	–9.8
Japanese Yen	6.3	4.7	37.0	34.5	2.5	–0.5	0.8
British Pound	2.0	7.5	7.0	7.1	–0.1	0.0	–0.3
Total	**16.0**	**22.5**	**100.0**	**100.0**	**0.0**	**3.4**	**–10.3**

Source: Barclays Capital POINT

relative to the overall benchmark, i.e., 4.6% × (67.9 bp – 22.5 bp) = +2.1 bp. On the other hand, the local management of excess to curve return in the euro market has not been successful, contributing –9.8 bp to outperformance. The approximate calculation yields 34.4% × (40.5 bp – 67.9 bp) = –9.4 bp. This underperformance can be understood by looking at more detailed issuer-level reports as presented in Chapter 70. In this example, it turns out that the lower-rated EU countries experienced much bigger spread tightening during the period. The concentration in the strongest economies in the region may reduce the portfolio long-term risk, but during this particular period contributed to loss of performance.

DERIVATIVES AND LEVERAGE

Derivative instruments are widely used across asset classes as both hedges and means to express market views. Their payoffs are tied to changes in the values of underlying securities, and their market values do not generally represent the size of the actual exposure to risk factors. In this section, we discuss how a performance attribution model may handle derivative instruments in order to maintain the intuitive and meaningful nature of the results.

Returns and Basis

Returns of derivative instruments can be difficult to measure. The market value of a contract is typically small (or sometimes zero) compared with its notional exposure, and the standard definition of return—profit/loss (P&L) divided by market value—can result in extremely large (or even infinite) values. For example, the market value of instruments that are marked-to-market daily, such as Treasury futures, is guaranteed to be zero at the end of the day, resulting in a theoretically infinite return. To maintain the notion of return as a P&L per unit of investment, we seek to use a denominator that represents the size of the position in terms of its exposure. We refer to this quantity as the "return basis" or simply "basis." One should define an appropriate return basis for each derivative type of interest. Usually, the basis is set equal to the notional amount, although in many cases special rules are used to define the basis in a bond-equivalent way.

To complicate the issue of derivatives further, the standard methodology of multi-period return compounding cannot be applied. Consider the following definition of single- and multi-period returns, where PL_t and R_t are the P&L and return over the period (t–1, t). The portfolio return is given by

$$R_t = \frac{PL_t}{MV_{t-1}}$$

And the multi-period return is:

$$R = \left(\prod_{t=1}^{T} (1 + R_t) \right) - 1$$

By using market value as a basis for the return and compounding it with the above formula, we get an intuitive relationship between the market values at t = 0 and t = T, and the return over the period (0, T).[5]

$$MV_T = MV_0\,(1+R)$$

Changing the basis to a quantity that is not proportional to the market value will annul this property. This is more evident when returns are large. As an exaggerated example, consider a futures contract that is marked to market daily and therefore always has zero market value. A reasonable basis for returns for a position in this contract is the notional amount invested. Suppose the notional amount is $1,000 and that over two days, the contract produces a mark-to-market P&L of –$500 and $1,000, respectively. Using the notional amount as the basis of returns, the returns for the two days are –50% and +100%, respectively. Using the chain rule to compound returns yields zero return over the two days: $(1-50\%)\times(1+100\%)-1=0\%$. Obviously, this is not consistent with the positive P&L of $500 produced over the two days. Such effects are always present when compounding returns using a basis that is different from the market value of the position; however, their effect is much smaller when the magnitude of returns is small. To avoid such nonintuitive results, one should make appropriate adjustments to the compounding of returns of derivative securities—something out of the scope of this chapter.

Returns for Portfolios and Sectors Containing Derivatives

The return of each individual derivative contract is defined using its basis as described above. However, in typical portfolios, these contracts coexist with cash securities. When we analyze partitions of the portfolio, such as sector or rating, that contain both cash and derivative securities, it is still typical to use market value as the denominator for all returns and weights.[6] Nevertheless, the presence of the derivatives imposes some changes into the analysis.

Let's define the leverage ratio for each security, β_i, to be the basis divided by the market value of the security. Then the leveraged weight of the security is the product of the market value weight and the leverage ratio, $w_i\beta_i$. The return of the portfolio or sector can then be written as the leveraged weighted sum of the deleveraged return of each security:

$$R^P = \sum_i \frac{PL_i^P}{MV^P} = \sum_i \frac{MV_i^P}{MV^P}\frac{basis_i^P}{MV_i^P}\frac{PL_i^P}{basis_i^P} = \sum_i w_i^P \beta_i^P R_i^P$$

5. We assume that the portfolio has no significant cash flows. When such cash flows do occur, the above formula does not hold. For more details, refer to time-weighted versus money-weighted return discussion in Chapter 71.

6. Net (or gross) basis and gross market value could also be used as the denominator for the entire portfolio when analyzing highly leveraged or long-short strategy funds.

Although this transformation does not change the return, notice that the leveraged weights are no longer constrained to sum to 1 when derivatives are present in the portfolio.

$$\sum_i w_i \beta_i \neq 1$$

Therefore, when we seek to explain the contribution of each instrument to the security selection outperformance of each bucket (the last step of the top-down decomposition—see Chapter 69), derivatives give rise to an additional term of outperformance that comes from the implicit leverage they introduce. The example below illustrates this issue.

Example: Leverage from Derivatives and Security Selection Outperformance

Consider a bucket with a single credit security A experiencing excess of curve return of +10%, while the corresponding benchmark bucket has two equally weighted securities, the one in the portfolio A and another one B returning 0%. The total return for that bucket in the benchmark is therefore +5%. Let us also assume that the market value weight of this bucket in the portfolio is 20%; therefore, its contribution to security selection would typically be calculated as 20% × (10% – 5%) = 1.0%. The contribution of security A to security selection is calculated as 20% × (100% – 50%) × (10% – 5%) = 0.5%, and the one of security B is 20% × (0% – 50%) × (0% – 5%) = 0.5%.

Now assume that the portfolio also contained a short protection credit default swap on the issuer of bond A with a return basis equal to the market value of A, essentially doubling the exposure to the issuer of A. Let us assume that the default swap is at-the-money, i.e., its market value is zero, and that it also experiences a return of +10% (using notional as the return basis). Since the market value of the portfolio bucket remains the same but its P&L doubles, the return of the sector is now reported as +20%, and the security selection term becomes 20% × (20% – 5%) = 3.0%. Notice that the market value weight of the bond remains 100% and that the default swap also has a weight of 100% (return basis over market value of the bucket). Bonds A and B contribute to security selection 0.5% exactly as before. The default swap contributes 20% × (100% – 0%) × (10% – 5%) = 1.0%. The contributions of the three securities to security selection sum to 2.0%, leaving 1.0% of security selection unexplained.

This comes from the leverage introduced to the bucket. Indeed, the sum of securities weights in the portfolio is 200%, whereas in the benchmark it is 100%. This causes an outperformance of 20% × (200% – 100%) × 5% = 1.0%, completing the decomposition of security selection. This term was introduced as the "top-level exposure" for the excess return model in Chapter 70 (see Eq. (70–6)).

Typically, in the presence of derivatives, this top-level term can be reported as a separate line item for each bucket–bucket leverage, and folded into the security selection term. Alternatively, it can be reported as leverage at the portfolio level.

A General Framework for Leverage

Leverage complicates portfolio returns calculations and comparison to the benchmark. Furthermore, there are different means to achieve leverage, and the decision to employ it can occur at any level of the portfolio management decision structure. For instance, cash borrowing can be used to leverage the entire portfolio, while derivatives can be used to leverage specific sectors. The latter case can be further distinguished into a decision made by an asset allocator or by a sector manager. Below, we outline an analytical way to account for leverage in a consistent framework with the one discussed in Chapter 69.

We expand the concept of leverage ratio as introduced before and apply it to the entire portfolio. We assume that a "funded" market value—generally different from the actual market value—can be defined for the portfolio, partition buckets and individual securities, and serve as the *basis* for the calculation of unleveraged returns. The ratio of the returns basis to actual market value is the leverage ratio of the portfolio.

$$R^P_{leveraged} = \frac{basis^P}{MV^P} \cdot \frac{PL^P}{basis^P} = \beta^P R^P$$

We can also recursively break down the portfolio return into the contributions of its various sectors by appropriately defining the leverage ratio of each sector:

$$R^P_{leveraged} = \sum_s \frac{PL^P_s}{MV^P} = \sum_s \frac{MV^P_s}{MV^P} \cdot \frac{basis^P_s}{MV^P_s} \cdot \frac{PL^P_s}{basis^P_s} = \sum_s w^P_s \beta^P_s R^P_s$$

Using similar terminology for the benchmark, the total leveraged outperformance can be expressed as a function of leverage ratios and unleveraged returns as:

$$R^P_{leveraged} - R^B_{leveraged} = \beta^P R^P - \beta^B R^B = \sum_s w^P_s \beta^P_s R^P_s - \sum_s w^B_s \beta^B_s R^B_s$$

We will now consider the different ways to break down the total outperformance into contributions from asset allocators and sector managers. It is worthwhile to note that when leverage is allowed, there is no limit to how much exposure managers can allocate to sectors or securities. Consequently, it no longer makes sense to compare sector returns against a hurdle rate (as discussed in Chapter 69) to determine the contribution from asset allocation decisions.

Separate Allocation of Market Weight and Leverage of Each Sector

In this case, each sector is given a market value budget, but sector managers are free to take leverage within their sectors. Separate agents determine the market value allocation and the leverage in each sector. The simple asset allocation/sector

management equations can be readily applied in this case. The comparison of sector returns of the portfolio and the benchmark occurs on a leveraged basis. In this case, the outperformance from leverage decisions is embedded in the sector management term. Specifically, the asset allocation would come as

$$\sum_s \left(w_s^P - w_s^B\right) \cdot \beta_s^B R_s^B \tag{71-22}$$

And the sector management as

$$\sum_s w_s^P \cdot \left(\beta_s^P R_s^P - \beta_s^B R_s^B\right) \tag{71-23}$$

Allocation of Total Exposure to Sectors

Alternatively, leverage can be determined by the asset allocator instead of the sector managers. In this case, a single agent decides the total exposure[7] to the unleveraged return of each sector. Once again, the asset allocation/sector management equations can be applied, but we now need to use total exposure instead of market value as the allocation weight. In this case, the outperformance from leverage decisions is embedded in the asset allocation term. The asset allocation is

$$\sum_s \left(w_s^P \beta_s^P - w_s^B \beta_s^B\right) \cdot R_s^B \tag{71-24}$$

While the sector management comes as

$$\sum_s w_s^P \beta_s^P \cdot \left(R_s^P - R_s^B\right) \tag{71-25}$$

In general, we can assume that leverage decisions are made at both the portfolio and the sector levels. A top-level manager may determine the total portfolio leverage (relative to the benchmark), and an asset allocator may subsequently determine the total exposure to each sector. Therefore, if total leverage is determined at the portfolio level, then the allocation of total exposure to each sector is constrained by the portfolio leverage decision and must be measured relative to that. Instead of using the absolute total exposure as the allocation weight, we now need to use the relative total exposure (total exposure divided by the portfolio/benchmark leverage). We also need to use a hurdle return, as exposure at the sector level is partially constrained.

In this scenario the outperformance decomposition has some extra terms, as shown below. The asset allocation outperformance can be derived as

$$\beta^P \sum_s \left(\frac{w_s^P \beta_s^P}{\beta^P} - \frac{w_s^B \beta_s^B}{\beta^B}\right) \cdot \left(R_s^B - R^H\right) \tag{71-26}$$

7. The total exposure is defined here as market weight times leverage.

While the sector management comes as

$$\sum_s w_s^P \beta_s^P \cdot \left(R_s^P - R_s^B\right) \tag{71-27}$$

The top-level leverage is

$$\left(\beta^P - \beta^B\right) \cdot R^H \tag{71-28}$$

If we do not assume that leverage aggregates linearly, i.e., generally $\beta^P \neq \sum_s w_s^P \beta_s^P$ and $\beta^B \neq \sum_s w_s^B \beta_s^B$ in order to keep the decomposition complete we need to add an additional term, that we call "diversification."

$$\left(\sum_s w_s^P \beta_s^P - \beta^P \frac{\sum_s w_s^B \beta_s^B}{\beta^B}\right) \cdot R^H \tag{71-29}$$

If we assume no leverage in the benchmark, the diversification term becomes

$$\left(\sum_s w_s^P \beta_s^P - \beta^P\right) \cdot R^H$$

Moreover, this term is zero if the leverage is aggregated linearly; that is,

$$\beta^P = \sum_s w_s^P \beta_s^P, \quad \beta^B = \sum_s w_s^B \beta_s^B$$

However, there are situations where we may not want the leverage to aggregate linearly. As an example, suppose that betas are defined based on risk. Then, if the different sectors are not perfectly correlated, the beta of the portfolio would tend to be smaller than the sum of the individual sector betas. This is due to the well-known risk diversification effect, hence the name for this term. In this case, the leverage creates a diversification effect with positive returns for our portfolio as long as the hurdle rate return is positive.

Handling leverage is a generalization of the top-down decomposition algorithm described in Chapter 69, where unleveraged returns are the factor returns, leveraged weights are the factor loadings and we assume linear aggregation of leverage (so that the diversification term vanishes). This analysis is also similar to the one regarding the decomposition of the spread related outperformance, described in Chapter 70.

Special Handling of Certain Derivative Types

Often, derivatives are used to manage a specific type of risk exposure and are not meant to participate in the general asset allocation/security selection

portfolio management framework. We already encountered this issue earlier in this chapter, while discussing how to handle the role of currency derivatives as FX hedging instruments. A similar situation arises with interest-rate derivatives as instruments of managing interest-rate risk only. In both cases we have to account for the return that is not tied to their primary hedging function and for the implicit cash allocation that occurs when derivative instruments used as hedges acquire market value between rebalancing dates. On the other hand, credit derivatives are typically used along with cash instruments to manage exposures to sectors and issuers; therefore they do participate in asset allocation and security selection. Depending on the portfolio and level of analysis, we may want all these different effects to be captured and reported separately. Below, we discuss in more detail issues arising from the handling of common derivatives and the treatment typically adopted.

Currency Derivatives

FX forwards are typically used as FX hedging instruments. In this case, their return and outperformance contributions should not be allowed to affect the local (excess of FX) outperformance analysis. As discussed previously in this chapter the easiest way to achieve this is to remove them completely from the analysis of non-FX outperformance. However, removing FX hedges from the local analysis introduces two side-effects that have to be explicitly accounted for: (a) The non-FX return of FX hedges must be recorded. Such return can be non-negligible in periods of market crisis or whenever hedges with longer tenors are being used. (b) Since FX hedges are not being rolled daily, they accumulate market value which represents an allocation to cash, if positive, or leverage, if negative. This effect—called earlier as the "FX hedging cash balance effect"—contributes to outperformance and should be appropriately recorded.

Interest Rate Derivatives

Derivatives designed to hedge or gain exposure to interest rate factors are typically overlays onto a portfolio after the core positions are chosen. These instruments, such as government bond futures and interest rate swaps, typically affect the curve return of the portfolio but have little effect on the excess return over yield-curve. Typically, they are used in portfolios that lend themselves to attribution models that treat curve outperformance separately (e.g., the excess return model discussed in Chapter 70). In these models, interest rate derivatives should only contribute to the curve outperformance, which is a common factor, and they should be removed entirely from the decomposition of the allocated factors. Two portfolios identical except for the use of interest rate derivatives should have the same asset allocation and security selection returns.

Similar to currency hedges, the removal of interest rate derivatives from the asset allocation/security selection outperformance analysis introduces a cash-balance effect if the market value of such derivatives is non-zero. Indeed, a positive market value indicates an implicit allocation to cash, whereas a negative

market value indicates implicit borrowing and, therefore, leverage. Further, exchange-traded derivative instruments may incur return that cannot be explained by their curve exposures. For example, Treasury futures frequently trade at a spread to their theoretical fair value. Changes in this spread result in return that cannot be explained by interest rate movements. However, this return should be accounted for and reported as a side-effect of interest rate hedging.

Credit Derivatives

In contrast to currency and interest rate derivatives, credit default swaps (CDS), credit index default swaps (CDX or iTraxx), and total return swaps (TRS) are primarily used to manipulate exposure to excess (over curve) return factors. Typically, these instruments are included in the regular asset allocation/security selection decomposition. Single issuer credit default swap instruments have small interest-rate exposure which does contribute to the yield-curve outperformance, but their primary exposure is to the credit factor of the underlying issuer. The performance of credit default swap indices should be explained by exploding them into their single-issuer constituents. The constituents are then included in the asset allocation/security selection decomposition, ensuring that the correct weights and returns are used to reflect the actual exposure to each partition bucket. The basis of returns for credit derivatives is not their market value. As a result, they generate bucket leverage, as discussed previously.

FROM THEORY TO PRACTICE

In order to be of any practical use, a performance attribution system must deal with a significant number of special situations that arise in day-to-day portfolio management. Such issues include missing security prices or analytics, bad prices or analytics, intra-period transactions, settlement conventions, pricing discrepancies between the portfolio and its benchmark, and so on. Below, we discuss some of these issues.

Return and Outperformance Compounding[8]

Multi-period arithmetic total return is compounded by taking the product of the single-period total returns:

$$R = \left(\prod_{t=1}^{T} (1 + R_t) \right) - 1$$

As discussed in Chapter 69, a general framework of performance attribution begins with the splitting of a single-period total return into the contributions

8. For an introduction to multi-period attribution and compounding see Chapter 69.

of various factors, $R_t = \sum_k \alpha_{k,t} f_{k,t}$. This leads to the question of how the return splits should be compounded so that the sum of the compounded return splits remains equal to the compounded total return. This is necessary to satisfy the additivity and completeness requirements of attribution.

One way to accomplish this is the following: Let us designate with $\hat{R}_k$ the multi-period compounded factor return. Setting $\hat{R}_k$ equal to the single-period factor return, $f_{k,t}$, scaled by the compounded portfolio value at the beginning of the period, i.e.,

$$\hat{R}_k = \sum_{t=1}^{T} \alpha_{k,t} f_{k,t} \prod_{s=1}^{t-1} (1 + R_s), \qquad \text{where} \qquad \prod_{s=1}^{0} (1 + R_s) \equiv 1 \tag{71-30}$$

guarantees the additive decomposition of total multi-period return, i.e., $R = \sum_k \hat{R}_k$. This decomposition algorithm is fairly straightforward and has the properties of additivity and completeness, but what about fairness?

Consider a simple example with two factors and two periods. Let us assume that both factors contribute 20% return, but factor A does so in the first period and has zero return in the second period, while factor B has zero return in the first period and 20% return in the second period. The total portfolio return is therefore (1 + 20%) × (1 + 20%) – 1 = 44%. According to the algorithm above, the contribution of the first factor is not scaled because it occurs in the first period and remains at 20%; the contribution of the second factor is scaled by the portfolio value at the end of the first period (1.20) so it becomes 24%. Although one could argue that the decomposition is unfair—as it favors the second factor which contributed returns after the first factor—the notion that later returns and contributions can be affected by the earlier performance of the portfolio as a whole is generally accepted as a fair practice.

In addition to the total return and return splits compounding, any multi-period attribution algorithm also needs to address the compounding of outperformance. In the context of simple factor-based performance attribution models the above algorithm can be readily applied:

$$R^P - R^B = \sum_k \left(\hat{R}_k^P - \hat{R}_k^B \right)$$

However, in the context of a general attribution model where the categories to which outperformance is decomposed to may depend both on the portfolio and the benchmark (e.g., asset allocation or security selection), such simple decomposition is not possible and more complex algorithms must be used.

Since single-period performance attribution provides a complete, additive and fair decomposition of single-period outperformance, most compounding algorithms seek to define scaling coefficients for each period, such that the sum

of the scaled single-period outperformance is equal to the total multi-period outperformance.[9]

$$R^P - R^B = \sum_t \beta_t \left(R_t^P - R_t^B\right)$$

Once β_t is determined, it can be used to scale every outperformance component (e.g., yield-curve, asset allocation, security selection, etc.) because of the additivity and completeness properties of single-period performance attribution.

One commonly used approach in practice is the optimized linking coefficient approach.[10] The basic idea behind this approach is to seek coefficients which avoid extreme values under most scenarios. Indeed, if not carefully defined, such coefficients can become zero or attain very high values distorting the outperformance decomposition and making it unfair. The value of β_t in the optimized-linked method is determined as follows:

$$A = \frac{\left(R^P - R^B\right)/T}{\left(1+R^P\right)^{1/T} - \left(1+R^B\right)^{1/T}}$$

$$C = \frac{R^P - R^B - A\sum_{t=1}^{T}\left(R_t^P - R_t^B\right)}{\sum_{t=1}^{T}\left(R_t^P - R_t^B\right)^2}$$

$$\beta_t = A + C\left(R_t^P - R_t^B\right)$$

Transactions

Return and outperformance calculations require special treatment of transactions. Security transactions which usually settle on a forward basis create "intra-period" returns as well as "unsettled" positions. It is important to recognize intra-period return separately because it does not participate in the decompositions previously discussed. It is also important to make the distinction between settled and unsettled positions because only the settled positions earn carry.

Intra-Day Return

Daily attribution models compound returns and outperformance using end-of-day market-closing prices. However, the models should allow users to enter transactions that occur during the day at the actual transaction prices, which can be quite

9. The exact nature of the algorithm that should be used to link the results of a multi-period attribution has been the subject of intense debate in the performance attribution literature. The entire Fall 2002 issue of the *Journal of Performance Measurement* was devoted to this topic.
10. Jose Menchero, "An Optimized Approach to Linking Attribution Effects over Time," *Journal of Performance Measurement* (Fall 2000), pp. 36–42.

different from the closing prices of the traded security used to calculate daily returns. This flexibility guarantees that the returns of the portfolio, including trading activities, are captured accurately. The difference between the trade price and the closing price should be captured and reported separately as "Trading" return. Further, the return contribution from intra-day trading activities, which is not captured by the end-of-day portfolio snapshots, must also be accounted for and reported as "Intra-Day Trading" outperformance.

Unsettled Positions

Most security transactions settle on a forward basis; i.e., both cash and the security are exchanged some days in the future. For example, corporate securities transactions settle after three business days (T+3), while most government securities settle after one day (T+1). Certain mortgage-backed securities (TBAs) have special settlement rules as they settle on a specific day each month. A comprehensive attribution model should allow transactions to settle on any forward date.

While buyers of a security are exposed to its clean price fluctuations (market risk) immediately after the transaction, they do not begin earning the coupon return of the security (more accurately, the yield or time return of the security r^{carry}) until after the settlement date. Instead, they keep earning the yield on the cash (r^{cash}) that they have promised to pay on the settlement date. Therefore, an unsettled position in a portfolio is earning a return equal to $r^{cash} + r^{price}$, while the same security in an index, always settled, is earning $r^{yield} + r^{price}$. The return $(r^{cash} - r^{yield}) \cdot \Delta t$, where Δt is the time to settlement, constitutes real outperformance (usually negative) that must be accounted for. Conversely, when the portfolio sells the position, it is earning the security yield (instead of cash) until the sell settlement date, making back any yield lost when the security was bought. These effects should be captured by the outperformance algorithm and reported for each model as carry outperformance.

Handling Inconsistent or Missing Data

Security prices used to compute returns of benchmark indices may be different from what portfolio managers use to mark their positions.[11] For any outperformance decomposition to be meaningful, it is important for the price and, hence, the return of the same security to be consistent in both universes. In most cases, managers would want to use their own prices to compute their portfolio returns. In general, we should use the security returns from the portfolio by default. However, since the total return of the benchmark index typically needs to be consistent with the published number, the algorithm should allow for the pricing difference effect to be reported as a separate source of outperformance.

11. This is not uncommon for less liquid securities.

When there are missing prices during the attribution period, the system can either exclude the securities from the analysis entirely or imply prices if that is deemed reasonable. During the period with missing prices, one can use last available analytics and market changes to imply prices so that daily outperformance can be computed. This approach is particularly useful if prices for the beginning and end of the period are available so that the correct return over the attribution period is known.

KEY POINTS

- Multi-currency portfolios add an additional layer of complexity to the portfolio management structure. An attribution algorithm normally needs to decompose the global total outperformance into FX and local market allocations, as well as local management.
- Being able to accurately separate the performance due to active foreign-exchange (FX) positions from that due to the hedging effects is a complex but particularly important task in any multi-currency attribution system.
- Factor-based local market allocation, such as duration-based global curve allocation, quantifies better the risk and return in a particular market than the market-value weighted local markets allocation.
- Derivatives change the nature of the basis used to define returns. They often require special treatment in order to obtain intuitive and meaningful attribution results.
- Return and outperformance compounding is an important task in order to ensure the additivity and completeness properties for any multi-period attribution.
- A complete attribution system should be able to handle intra-day transactions, unsettled positions as well as missing and inconsistent prices.

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METHODOLOGY FOR CALCULATING CURRENCY EXPOSURES IN BOND PORTFOLIOS AND INDEXES

CURT HOLLINGSWORTH
Portfolio Manager
Fidelity Investments

In an unhedged global bond portfolio, currency exposures are responsible for most of the return volatility. As a result, it is worth taking the time to calculate currency exposures accurately. This Appendix provides a methodology for calculating the currency exposures in a bond portfolio as of the close of the most recent portfolio pricing date. This methodology can also be used to calculate the currency exposures in Citigroup indexes and Barclays Capital indices.

It is assumed that each currency exposure will be calculated as part of an automated overnight batch process. When calculating currency exposures, there are a number of approaches that can be used. As a result, it may be helpful to define a few guiding principles at the outset:

1. If a portfolio is structured so that it exactly replicates its index, then the portfolio and the index should have the same currency exposures. In other words, each currency exposure that one calculates for the portfolio should exactly match the corresponding currency exposure that one calculates for the index.
2. If a security is held by both the portfolio and the index, then one should use the same price for the portfolio and the index.
3. For each actual price in the bond market, there is an associated settlement date. The price and the settlement date go together; they are joined at the hip. When calculating accrued interest or analytics, one should use the settlement date that goes with the price.
4. For the portfolio, identify the most reliable source for the net assets as of the close of the most recent portfolio pricing date. Use these net assets when calculating currency exposures.

5. Intra-month, for the index, use the cash positions from the index provider. Do not calculate these cash positions for the index. (Doing so is difficult for government/credit indices, and almost impossible for aggregate bond indices.)

These five guiding principles seem reasonable enough. However, except for very simple portfolios and indexes, it is impossible to adhere to all five of them at once. As a result, when calculating currency exposures, one needs to make a few tradeoffs and arbitrary decisions, and there will likely be a few inconsistencies in the end result. The methodology described in this Appendix was designed to adhere as closely as possible to these five guiding principles, minimize operational risk, and produce extremely accurate results.

A brief word on scope: In order to provide a fully defined methodology in a reasonable number of pages, it is assumed that the portfolios:

1. Invest only in the types of securities that are constituents of investment-grade global bond indexes, such as the Citigroup World Government Bond Index (WGBI) and the Barclays Capital Global Aggregate Bond Index.
2. Execute standard FX trades.
3. Maintain cash balances in foreign currencies.

Thus, derivatives, TBAs, and many other instruments are out of scope. In addition, FX forward outrights with more than one year from the most recent portfolio pricing date to the value date are out of scope. Finally, no adjustments for "bad days" are made in the discussion below. A bad day occurs when a security is scheduled to make a principal or interest payment on a weekend or holiday.

MAIN FORMULA FOR BOND PORTFOLIOS

The following formula can be used to calculate a bond portfolio's exposure to a single currency:

Currency Exposure (A) =

Market Value of Securities (B)
+ Cash Balance (C)
+ Unsettled Sells of Securities (D)
– Unsettled Buys of Securities (E)
+ Unsettled Buys of Currency (F)
– Unsettled Sells of Currency (G)
+ Coupon Payments for Gilt Holdings (H)
+ Coupon Payments for Unsettled Sells of Gilts (I)
– Coupon Payments for Unsettled Buys of Gilts (J)

+ Coupon Payments for Unsettled Sells of Non-Gilts (K)
– Coupon Payments for Unsettled Buys of Non-Gilts (L)
+ Interest Payments for Agency MBS Holdings (M)
+ Principal Payments for Agency MBS Holdings (N)
+ Interest Payments for Unsettled Sells of Agency MBS (O)
+ Principal Payments for Unsettled Sells of Agency MBS (P)
– Interest Payments for Unsettled Buys of Agency MBS (Q)
– Principal Payments for Unsettled Buys of Agency MBS (R)

Currency Exposure (A) is the portfolio's exposure to a single currency as of the close of the most recent portfolio pricing date. This currency exposure is expressed in the local currency. It has not been converted to the base currency of the portfolio. This main formula for bond portfolios can also be used to calculate a portfolio's exposure to the base currency of the portfolio.

There are 17 inputs that are needed in order to calculate this currency exposure. All of the 17 inputs should be expressed in the local currency. In other words, they should not be converted into the base currency of the portfolio.

For the Unsettled Buys of Currency (F) and the Unsettled Sells of Currency (G), one needs to calculate their present values before using them as inputs to the main formula for bond portfolios.

The inputs are defined below and other definitions are provided in Exhibit A–1.

EXHIBIT A–1

Defined Terms for Bond Portfolios

Accrued Interest: For non-factoring securities:

Accrued Interest = Par Amount × (Accrued Interest Factor/100)

For factoring securities:

Accrued Interest = Current Face × (Accrued Interest Factor/100)

Accrued Interest Factor: The accrued interest factor is used to calculate the accrued interest and the market value for each of the securities held by the portfolio.

- For a U.S. Treasury bond, the accrued interest factor for a specific settlement date is the accrued interest for a hypothetical trade that was executed with a par amount of USD 100.00.
- For a gilt, the accrued interest factor for a specific settlement date is the accrued interest for a hypothetical trade that was executed with a par amount of GBP 100.00.

For each of the securities held by the portfolio, use the following hierarchy in order to determine the accrued interest factor:

- In-house quantitative models
- Bloomberg

(*Continued*)

EXHIBIT A–1

Defined Terms for Bond Portfolios (*Continued*)

Adjusted Net Assets: Two minor adjustments to net assets should be made:

$$\text{Adjusted Net Assets} = \text{Net Assets} + \text{Shareholder Activity} + \text{Dividend Payable}$$

Analytics: Metrics such as yield to worst, modified duration, option adjusted spread, option adjusted duration, option adjusted convexity, and key rate durations are all examples of analytics.

Base Currency of the Portfolio: For a mutual fund, this is the currency in which the net asset value is denominated.

Bond Trades: Bond trades are trades involving the types of instruments that are included in the securities held by the portfolio when calculating Market Value of Securities (B) for a portfolio. (See the definition of "Securities Held by the Portfolio.")

Books and Records: The official record of the portfolio's holdings and net assets. For most mutual funds, the same entity that is responsible for maintaining the books and records is also responsible for calculating the fund's net asset value on each day that the fund is open.

Compounding Frequency: All analytics (including yield to worst) should be calculated assuming semiannual compounding.

Cross-Currency FX Trades: An FX trade where the base currency of the portfolio is not one of the currencies in the currency pair.

Currency Exposure: This is a portfolio's exposure to a single currency. The currency exposure, by definition, is always calculated and expressed in the local currency. (Later on in the overnight batch process, the currency exposure can be converted to the base currency of the portfolio and called something else.)

Dividend Payable: For those mutual funds that declare daily dividends and pay them monthly, this is the month-to-date sum of these daily dividends.

Exchange Rates—Closing Spot Rates: The following hierarchy should be used in order to determine the closing spot rates for the portfolio:

- Books and records
- Index provider (for the index that is used as the benchmark for *this* portfolio)
- WM/Reuters
- Bloomberg

Exchange Rates—Closing Forward Rates: The following hierarchy should be used in order to determine the closing forward rates for the portfolio:

- Books and records
- Index provider (for the index that is used as the benchmark for *this* portfolio)
- WM/Reuters
- Bloomberg

Ex-Coupon Date: Gilts go *ex*-coupon (or ex-dividend) seven business days before each coupon payment date. This means that if the settlement date of a trade involving a gilt falls after the seventh business day before a coupon payment date, the seller will receive the entire coupon payment. As a result,

EXHIBIT A–1

Defined Terms for Bond Portfolios (*Continued*)

if the settlement date of a trade involving a gilt falls after the seventh business day before a coupon payment date and falls before this coupon payment date, then the trade will settle with a negative accrued interest. This negative accrued interest will be subtracted from the bond's clean price. (The one exception is the 3.5% War Loan, which is a perpetual and goes *ex*-coupon 10 business days before its coupon payment dates on June 1 and December 1. This gilt is not in the WGBI.)

Factoring Securities: These securities include:

- Asset-backed securities (ABS)
- U.S. agency mortgage-backed passthrough securities
- Commercial mortgage-backed securities (CMBS)
- Enhanced equipment trust certificates (EETC)

Foreign Currencies: Any currency that is not the base currency of the portfolio.

Index Pricing Date: The date on which the index was priced by the index provider. The index pricing date should be the same as the most recent portfolio pricing date.

Local Currency: The currency in which a security or a cash balance is denominated.

Market Value: Throughout this Appendix, this value is always assumed to include accrued interest. In order to calculate the market value for each of the securities held by the portfolio, use the following formulas:

$$\text{Market Value} = \text{Principal} + \text{Accrued Interest}$$

$$\text{Principal} = \text{Par Amount} \times (\text{Price}/100)$$

$$\text{Accrued Interest} = \text{Par Amount} \times (\text{Accrued Interest Factor}/100)$$

Most Recent Portfolio Pricing Date: For a mutual fund, this is the most recent day on which a net asset value was calculated.

Net Assets: The market value of the portfolio as of the close on the most recent portfolio pricing date. In other words, if the entire portfolio were liquidated, this is the amount of money that would be returned to the shareholders and clients. For a mutual fund,

$$\text{Net Assets} = \text{Number of Shares Outstanding} \times \text{Net Asset Value per Share}$$

Non-Factoring Securities: These securities include the following types of bonds:

- Treasury
- Government-related
- Corporate

Par Amount: For non-factoring securities, use the par amount from the books and records for the portfolio. For factoring securities, use the current face from the books and records for the portfolio.

Present Value: Calculated for each unsettled FX trade where there are more than four business days between the most recent portfolio pricing date and the value date for the unsettled FX trade. For each unsettled FX trade, take both

(*Continued*)

EXHIBIT A–1

Defined Terms for Bond Portfolios (*Continued*)

currencies in the currency pair into account and calculate the present value of the currency amount for each one separately. In order to calculate the present value of the currency amount, use the following formula:

$$PV = C/(1 + R/100 \times N/B)$$

PV = Present value of the currency amount

C = Currency amount on the value date

R = Interest rate expressed as a percentage per annum

N = Actual number of days from the most recent portfolio pricing date to the value date

B = Day count basis (usually either 360 or 365, depending on the currency)

- Using four business days as the cutoff is admittedly arbitrary. For most trades involving securities, regular settlement is T + 4 business days or shorter. As a result, using four business days as the cutoff will allow one to avoid calculating present values for unsettled FX trades that were executed to fund the settlement of these securities trades. This in turn will simplify things and reduce operational risk, while having a *de minimus* impact on the calculated currency exposures.
- For most currencies, for the interest rate, one should use the Eurodeposit rate for funds deposited in that currency. These Eurodeposit rates are provided by Citigroup. In addition, these Eurodeposit rates can be obtained from market data services such as Bloomberg and Reuters. See *Citigroup Global Fixed-Income Index Catalog, 2011 Edition* (February 8, 2011); the Reuters Instrument Codes (RICs) used to obtain monthly yields (bid) for Eurodeposits are provided for 18 currencies on page 61.

Price: Price is expressed as a percentage of the par amount (or current face). For each of the securities held by the portfolio, use the following hierarchy in order to determine the price:

- Books and records
- Index provider (for the index that is used as the benchmark for *this* portfolio)
- Bloomberg

For each of the securities held by the portfolio, the same price that is used to calculate the principal and the market value should also be used to calculate *all* of the analytics.

Principal: For non-factoring securities:

$$\text{Principal} = \text{Par Amount} \times (\text{Price}/100)$$

For factoring securities:

$$\text{Principal} = \text{Current Face} \times (\text{Price}/100)$$

Securities Held by the Portfolio: These are all of the portfolio positions that should be included when calculating the Market Value of Securities (B) for all of the currency exposures in the portfolio. These portfolio positions should be based on the trade date holdings (not the "settlement date holdings") as of the close on the most recent portfolio pricing date. These portfolio positions should include:

- Factoring securities
- Non-factoring securities

EXHIBIT A–1

Defined Terms for Bond Portfolios (*Continued*)

These portfolio positions should exclude the following:

- Items "C" through "R" in the main formula for bond portfolios

Settlement Date: For each of the securities held by the portfolio, calculate two accrued interest factors:

- Calculate the first accrued interest factor using the most recent portfolio pricing date as the settlement date. Use this accrued interest factor (and the resulting market value including accrued interest) when calculating Market Value of Securities (B).
- Calculate the second accrued interest factor, and *all* analytics, using the settlement date convention of the index for this portfolio. Use this accrued interest factor (and the resulting market value including accrued interest) when calculating metrics such as the average duration of the portfolio.

Settlement Date Holdings: If a portfolio buys a security on trade date "T" for settlement in T + 3 business days, then this position is not included among the settlement date holdings for this portfolio as of the close on portfolio pricing date "T." This position is not included among the settlement date holdings for this portfolio until the close on the portfolio pricing date that corresponds to T + 3 business days.

Standard FX Trades: These include the following trades:

1. **Spot FX Trade:** Trade where the value date is zero to two business days after the trade date and the base currency of the portfolio (for example, USD) is one of the two currencies in the currency pair.
2. **Cross-Currency Spot FX Trade:** Trade where the value date is zero to two business days after the trade date and the base currency of the portfolio (for example, USD) is *not* one of the two currencies in the currency pair.
3. **FX Forward Outright:** Trade where the value date is more than two business days after the trade date and the base currency of the portfolio (for example, USD) is one of the two currencies in the currency pair.
4. **Cross-Currency FX Forward Outright:** Trade where the value date is more than two business days after the trade date and the base currency of the portfolio (for example, USD) is *not* one of the two currencies in the currency pair.
5. **FX Swap:** Trade where a trader negotiates and simultaneously executes a spot FX trade and an FX forward outright with the same dealer and the base currency of the portfolio (for example, USD) is one of the two currencies in the currency pair. (This swap never involves more than two currencies. The non–base currency in the short leg is always the same as the non-base currency in the long leg.)
6. **Cross-Currency FX Swap:** Trade where a trader negotiates and simultaneously executes a spot FX trade and an FX forward outright with the same dealer and the base currency of the portfolio (for example, USD) is *not* one of the two currencies in the currency pair. (This swap never involves more than two currencies. The currency pair in the short leg is always the same as the currency pair in the long leg. Whichever currency is bought in the short leg is always sold in the long leg. Similarly, whichever currency is sold in the short leg is always bought in the long leg.)

As of March 31, 2011, there were 14 currencies in the WGBI. Spot settlement for the Canadian dollar (CAD) is T + 1 business day. Spot settlement for the remaining 13 currencies is T + 2 business days.

(*Continued*)

EXHIBIT A–1

Defined Terms for Bond Portfolios (*Continued*)

Trade Date Holdings: If a portfolio buys a security on Trade Date "T" for settlement in T + 3 business days, then this position is included among the trade date holdings for this portfolio as of the close on portfolio pricing date "T."

Unsettled Bond Trades: These trades include all unsettled trades involving the types of instruments that are included in the securities held by the portfolio when calculating Market Value of Securities (B) for a portfolio.

Unsettled FX Trades: These trades include all of the unsettled standard FX trades.

Unsettled Trades: These trades include:

- Unsettled bond trades
- Unsettled FX trades

Inputs to the Main Formula for Bond Portfolios

Market Value of Securities (B)

In order to calculate this input, first calculate the market value (including accrued interest) for each of the securities held by the portfolio that is denominated in the single currency for which one is calculating the Currency Exposure (A). Then sum the resulting market values. The sum is the Market Value of Securities (B).

Cash Balance (C)

This is the cash balance in the single currency for which one is calculating the Currency Exposure (A). If the cash balance is not denominated in the base currency of the portfolio, then use the following formula:

Cash Balance = Contractual End of Day Cash Balance
on the Most Recent Portfolio Pricing Date

This cash balance should include all of the principal and interest payments that were scheduled to be received by the portfolio on or before the portfolio pricing date (whether or not they were actually received by the portfolio's custodial bank and credited to the portfolio). As a general rule, when the accrued interest included in the Market Value of Securities (B) drops to reflect a coupon payment (and the duration extends), then that coupon payment should be included in the Cash Balance (C) at the same point in time. (One exception is bonds that go *ex*-coupon.)

This cash balance should also reflect all of the bond trades and FX trades that were scheduled to settle on or before the portfolio pricing date (whether or not the bond trades and FX trades actually settled).

If the cash balance is denominated in the base currency of the portfolio, then use the following formula:

Cash Balance in the Base Currency = Adjusted Net Assets
– (first calculate the Currency Exposure (A) for each

non-base currency, then convert the resulting local
currency amount to the base currency of the portfolio,
and then sum the resulting base-currency amounts) – (Market Value
of Securities (B) for the base currency of the portfolio)
– (the sum of "D" through "R" for the base currency of the portfolio)

Thus, the cash balance in the base currency is a "plug" that can be calculated only after all of the other inputs have been calculated. This plug is useful for a number of reasons. For example, it causes the Currency Exposures (A), when converted to the base currency of the portfolio and then summed, to equal the net assets of the portfolio. In addition, the portfolio's exposure to each currency expressed as a percentage of net assets (i.e., as a percentage of the portfolio's overall market value) can be calculated. Summing the percentage of the market value for all of the currencies, they will sum to 100%. As a result, the currency exposures have the "portfolio property." (Contribution to duration is another example of a risk measure that has the portfolio property: Summing the contribution to duration made by each holding in a portfolio, the sum equals the average option adjusted duration for the overall portfolio.)

Unsettled Sells of Securities (D)

Identify all of the unsettled sells of securities that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then sum the total proceeds for all of these trades. The resulting sum will be the Unsettled Sells of Securities (D). These unsettled sells of securities should include all bond trades (as opposed to FX trades) where the *scheduled* settlement date is after the portfolio pricing date. (If a trade was supposed to settle on or before the portfolio pricing date, but it "failed" to settle, then do not include that trade when summing the total proceeds.)

Unsettled Buys of Securities (E)

Identify all of the unsettled buys of securities that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then sum the total proceeds for all of these trades. The resulting sum will be the Unsettled Buys of Securities (E). These unsettled buys of securities should include all bond trades (as opposed to FX trades) where the *scheduled* settlement date is after the portfolio pricing date. (If a trade was supposed to settle on or before the portfolio pricing date, but it "failed" to settle, then do not include that trade when summing the total proceeds.)

Unsettled Buys of Currency (F)

Identify all of the unsettled buys of currency that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then calculate the present value of the currency amount on the value date for each FX trade. Then sum the present values for all of these trades. The resulting sum will be the

Unsettled Buys of Currency (F). These unsettled buys of currency should include all of the FX trades (including spot FX trades, FX forward outrights, and FX swaps) where the *scheduled* value date is after the portfolio pricing date. (If a trade was supposed to settle on or before the portfolio pricing date, but it "failed" to settle, then do not include that trade when summing the present values.)

When calculating the present value, use the currency amount on the value date for each FX trade, which is the currency amount that the portfolio will receive from the counterparty when the FX trade settles. In order to calculate the present value of the currency amount on the value date, see the definition for present value in Exhibit A–1.

Unsettled Sells of Currency (G)

Identify all of the unsettled sells of currency that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then calculate the present value of the currency amount on the value date for each FX trade. Then sum the present values for all of these trades. The resulting sum will be the Unsettled Sells of Currency (G). These unsettled sells of currency should include all of the FX trades (including spot FX trades, FX forward outrights, and FX swaps) where the *scheduled* value date is after the portfolio pricing date. (If a trade was supposed to settle on or before the portfolio pricing date, but it "failed" to settle, then do not include that trade when summing the present values.)

When calculating the present value, use the currency amount on the value date for each FX trade, which is the currency amount that the portfolio will pay to the counterparty when the FX trade settles. In order to calculate the present value of the currency amount on the value date, see the definition for present value in Exhibit A–1.

Coupon Payments for Gilt Holdings (H)

Review the securities held by the portfolio and identify all of the interest-bearing gilt positions (and positions in other securities that go *ex*-coupon and thus can settle with a negative accrued interest). Then, among these positions, identify the positions that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these positions, identify the positions where the most recent portfolio pricing date falls after the *ex*-coupon date and before that coupon payment date. Calculate the payment amount (in the local currency) for each of these coupon payments. Sum these coupon payment amounts. The resulting sum will be the Coupon Payments for Gilt Holdings (H). (The sovereign debt securities of the United Kingdom are called "gilts." In this Appendix the term "gilts" is a short-hand way of referring to *all* securities that go *ex*-coupon and trade with a negative accrued interest.)

Coupon Payments for Unsettled Sells of Gilts (I)

Review the unsettled bond trades and identify all of the sells of interest-bearing gilts (and sells of other securities that go *ex*-coupon and thus can settle with a

negative accrued interest). Then, among these sells, identify the sells that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these sells, identify the sells where the most recent portfolio pricing date falls before a coupon payment date and the sell has a settlement date that falls after the *ex*-coupon date for that coupon payment date. Calculate the payment amount (in the local currency) for each of these coupon payments. Sum these coupon payment amounts. The resulting sum will be the Coupon Payments for Unsettled Sells of Gilts (I).

Coupon Payments for Unsettled Buys of Gilts (J)

Review the unsettled bond trades and identify all of the buys of interest-bearing gilts (and buys of other securities that go *ex*-coupon and thus can settle with a negative accrued interest). Then, among these buys, identify the buys that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these buys, identify the buys where the most recent portfolio pricing date falls before a coupon payment date and the buy has a settlement date that falls after the *ex*-coupon date for that coupon payment date. Calculate the payment amount (in the local currency) for each of these coupon payments. Sum these coupon payment amounts. The resulting sum will be the Coupon Payments for Unsettled Buys of Gilts (J).

Coupon Payments for Unsettled Sells of Non-Gilts (K)

Review the unsettled bond trades and identify all of the sells of interest-bearing securities that are not gilts (and that are not other securities that go *ex*-coupon and thus can settle with a negative accrued interest) and that are not Agency MBS (and that are not other securities that make delayed principal or interest payments). Then, among these sells, identify the sells that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these sells, identify the sells where the most recent portfolio pricing date falls before a coupon payment date and the sell has a settlement date that falls on or after that coupon payment date. Calculate the payment amount (in the local currency) for each of these coupon payments (and the accompanying principal payment, if there is one). Sum these payment amounts. The resulting sum will be the Coupon Payments for Unsettled Sells of Non-Gilts (K).

Coupon Payments for Unsettled Buys of Non-Gilts (L)

Review the unsettled bond trades and identify all of the buys of interest-bearing securities that are not gilts (and that are not other securities that go *ex*-coupon and thus can settle with a negative accrued interest) and that are not Agency MBS (and that are not other securities that make delayed principal or interest payments). Then, among these buys, identify the buys that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these buys, identify the buys where the most recent portfolio pricing date falls before a coupon payment date and the buy has a settlement date that falls

on or after that coupon payment date. Calculate the payment amount (in the local currency) for each of these coupon payments (and the accompanying principal payment, if there is one). Sum these payment amounts. The resulting sum will be the Coupon Payments for Unsettled Buys of Non-Gilts (L).

Interest Payments for Agency MBS Holdings (M)
Review the securities held by the portfolio and identify all of the U.S. agency mortgage-backed passthrough securities ("Agency MBS"). These are pools issued by Ginnie Mae, Fannie Mae, and Freddie Mac. Then, among these positions, identify the positions that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these positions, identify the positions where the most recent portfolio pricing date falls after an *ex*-coupon date (which is the last calendar day of a month) and before the corresponding interest payment date. Calculate the payment amount (in the local currency) for each of these interest payments. Sum these interest payment amounts. The resulting sum will be the Interest Payments for Agency MBS Holdings (M). (Use a similar approach for other securities that make delayed interest payments.)

Principal Payments for Agency MBS Holdings (N)
Review the securities held by the portfolio and identify all of the Agency MBS. Then, among these positions, identify the positions that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these positions, identify the positions where the most recent portfolio pricing date falls on or after the day on which factors and paydowns are processed for the portfolio and before the corresponding principal payment date. Calculate the payment amount (in the local currency) for each of these principal payments. Sum these principal payment amounts. The resulting sum will be the Principal Payments for Agency MBS Holdings (N). (Use a similar approach for other securities that make delayed principal payments.)

Interest Payments for Unsettled Sells of Agency MBS (O)
Review the unsettled bond trades and identify all of the sells of Agency MBS. Then, among these sells, identify the sells that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these sells, identify the sells where the most recent portfolio pricing date falls before an interest payment date and the sell has a settlement date that falls after the *ex*-coupon date for that interest payment date. Calculate the payment amount (in the local currency) for each of these interest payments. Sum these interest payment amounts. The resulting sum will be the Interest Payments for Unsettled Sells of Agency MBS (O). (Use a similar approach for other securities that make delayed interest payments.)

Principal Payments for Unsettled Sells of Agency MBS (P)
Review the unsettled bond trades and identify all of the sells of Agency MBS. Then, among these sells, identify the sells that are denominated in the single

currency for which one is calculating the Currency Exposure (A). Then, among these sells, identify the sells where the most recent portfolio pricing date falls on or after the day on which factors and paydowns are processed for the portfolio and before the corresponding principal payment date. Calculate the payment amount (in the local currency) for each of these principal payments. Sum these principal payment amounts. The resulting sum will be the Principal Payments for Unsettled Sells of Agency MBS (P). (Use a similar approach for other securities that make delayed principal payments.)

Interest Payments for Unsettled Buys of Agency MBS (Q)
Review the unsettled bond trades and identify all of the buys of Agency MBS. Then, among these buys, identify the buys that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these buys, identify the buys where the most recent portfolio pricing date falls before an interest payment date and the buy has a settlement date that falls after the *ex*-coupon date for that interest payment date. Calculate the payment amount (in the local currency) for each of these interest payments. Sum these interest payment amounts. The resulting sum will be the Interest Payments for Unsettled Buys of Agency MBS (Q). (Use a similar approach for other securities that make delayed interest payments.)

Principal Payments for Unsettled Buys of Agency MBS (R)
Review the unsettled bond trades and identify all of the buys of Agency MBS. Then, among these buys, identify the buys that are denominated in the single currency for which one is calculating the Currency Exposure (A). Then, among these buys, identify the buys where the most recent portfolio pricing date falls on or after the day on which factors and paydowns are processed for the portfolio and before the corresponding principal payment date. Calculate the payment amount (in the local currency) for each of these principal payments. Sum these principal payment amounts. The resulting sum will be the Principal Payments for Unsettled Buys of Agency MBS (R). (Use a similar approach for other securities that make delayed principal payments.)

MAIN FORMULA FOR CITIGROUP INDEXES

The following formula can be used to calculate the exposure to a single currency in a Citigroup multi-currency bond index:

Currency Exposure (A) =

Market Value of Securities (B)
+ Cash Balance (C)
– FX Forward Outright Sell (D)
+ FX Forward Outright Buy (E)

Currency Exposure (A)

This is the exposure that a Citigroup index has to a single currency as of the close on the index pricing date. This currency exposure is expressed in the local currency. It has not been converted to the base currency of the index. This main formula for Citigroup indexes can also be used to calculate the exposure to the base currency of the index.

There are four inputs that are needed in order to calculate this currency exposure. All of the four inputs should be expressed in the local currency. In other words, they should not be converted into the base currency of the index.

For the last two of these four inputs, one needs to calculate their present values before using them as inputs to the main formula for Citigroup indexes.

Inputs to the Main Formula for Citigroup Indexes

Market Value of Securities (B)

In general, one should use the same approach for indexes that one uses for portfolios. However, a few things will be different. For example, the securities in the index will be the securities that are in the current returns universe for the index. This data set should come directly from Citigroup. It should be updated each evening, in order to capture intra-month principal and interest payments that have been made by index constituents. Principal and interest payments will increase the cash balances in the current returns universe. Principal payments will lower the par amounts (or current faces) of the securities in the current returns universe.

In order to calculate this input, first calculate the market value (including accrued interest) for each of the securities in the index that is denominated in the single currency for which one is calculating the Currency Exposure (A). Then sum the resulting market values. The sum is the Market Value of Securities (B).

Cash Balance (C)

Citigroup will provide the cash balances for each currency. The Cash Balance (C) will be the cash balance in the single currency for which one is calculating the Currency Exposure (A); it will be the sum of the principal and interest payments received by the index on or after the *first* calendar day of the month and on or before the index settlement date used by Citigroup.

These cash balances should come directly from Citigroup. They should be updated each evening, in order to capture intra-month principal and interest payments that have been made by index constituents. Principal and interest payments will increase the cash balances in the current returns universe. Principal payments will lower the par amounts (or current faces) of the securities in the current returns universe. Note that as of the close on the last business day of a month, there is no cash in the returns universe for the coming month.

FX Forward Outright Sell (D)

Unhedged indexes do not contain any FX forward outright sells. As a result, for an unhedged index, set FX Forward Outright Sell (D) equal to zero, and move on.

The returns universe for a hedged version of a Citigroup index contains one FX forward outright sell for each foreign currency in the index. For each of these FX forward outright sells, Citigroup calculates the currency amount on the value date. Citigroup does this once a month at the beginning of the month, and provides this information to their clients via automated downloads. Citigroup has published two documents that together do a nice job of describing the hedging methodology used for the hedged versions of the Citigroup indexes; the first one is entitled *SSB Fixed Income Indices: Currency Hedging Methodology* (March 6, 2003) and the second one is entitled *Change in Spot Settlement Convention in the Currency Hedging Methodology* (January 6, 2011). Using the currency amount on the value date that Citigroup provides, one needs to calculate the present value of the currency amount. In order to do this, see the definition for present value in Exhibit A–2.

EXHIBIT A–2

Defined Terms for Citigroup Indexes

Accrued Interest: Always use the accrued interest provided by Citigroup.

Compounding Frequency: All analytics (including yield to worst) should be calculated assuming semiannual compounding. As of December 31, 2010, 75.3% of the securities in the WGBI (based on market value) paid coupons semiannually.

Exchange Rates—Closing Spot Rates: Use the following hierarchy in order to determine the closing spot rates for the Citigroup indexes:

- Books and records
- Citigroup
- WM/Reuters
- Bloomberg

Exchange Rates—Closing Forward Rates: Use the following hierarchy in order to determine the closing forward rates for the Citigroup indexes:

- Citigroup
- WM/Reuters
- Bloomberg

Ex-Coupon: When a security in a Citigroup index goes *ex*-coupon and starts trading with a negative accrued interest, Citigroup adds the coupon payment to the Cash Balance (C). However, there is no reinvestment return until the coupon payment is actually made on the coupon payment date. There were 23 countries in the WGBI as of March 1, 2011. Of these, the sovereign debt securities of the following six countries go *ex*-coupon and then trade with a negative accrued interest:

1. Australia
2. Norway
3. Poland
4. Singapore
5. Sweden
6. United Kingdom

(*Continued*)

EXHIBIT A–2

Defined Terms for Citigroup Indexes (*Continued*)

When these securities go *ex*-coupon, Bloomberg displays a negative accrued interest on BXT. There is one exception: when Poland's sovereign debt securities go *ex*-coupon, Bloomberg displays a zero accrued interest on BXT. However, Bloomberg takes the *ex*-coupon date into account when calculating price given yield.

Index Pricing Date: In general, one should always use the most recent index pricing date, because the most recent index pricing date will usually be the same date as the most recent portfolio pricing date. However, if the most recent index pricing date is a different date than the most recent portfolio pricing date, then there are two possibilities:

1. The most recent index pricing date is more recent than the most recent portfolio pricing date. In this case, if there is a previous index pricing date that falls on the same date as the most recent portfolio pricing date, then use that previous index pricing date. If not, then use the most recent index pricing date and remove books and records from the hierarchies used to determine the prices and exchange rates for the index.
2. The most recent index pricing date is older than the most recent portfolio pricing date. In this case, use the most recent index pricing date and remove books and records from the hierarchies used to determine the prices and exchange rates for the index.

Index Settlement Date: Use the following index settlement dates for the Citigroup indexes:

For all of the securities in the index, the index settlement date is T + 0 (except for the last business day of the month, when the index settlement date is the last calendar day of that month).

Note that T + 0 is always the index pricing date.

For each of the securities in a Citigroup index, use the index settlement date to calculate *all* of the analytics.

Market Value: In order to calculate the market value for each of the securities in the index, use the following formulas:

$$\text{Market Value} = \text{Principal} + \text{Accrued Interest}$$

$$\text{Principal} = \text{Par Amount} \times (\text{Price}/100)$$

Par Amount: For non-factoring securities, always use the par amount provided by Citigroup. For factoring securities, always use the current face provided by Citigroup.

Present Value: Calculate the present value for each unsettled FX trade where there are more than four business days between the index pricing date and the value date for the unsettled FX trade. For each unsettled FX trade, take both currencies in the currency pair into account and calculate the present value of the currency amount for each one separately. In order to calculate the present value of the currency amount, use the following formula:

$$PV = C/(1 + R/100 \times N/B)$$

PV = Present value of the currency amount

C = Currency amount on the value date

R = Interest rate expressed as a percentage per annum

N = Actual number of days from the index pricing date to the value date

B = Day count basis (usually either 360 or 365, depending on the currency)

EXHIBIT A–2

Defined Terms for Citigroup Indexes (*Continued*)

For most currencies, for the interest rate, one should use the Eurodeposit rate for funds deposited in that currency. These Eurodeposit rates are provided by Citigroup. In addition, these Eurodeposit rates can be obtained from market data services such as Bloomberg and Reuters. See *Citigroup Global Fixed-Income Index Catalog, 2011 Edition* (February 8, 2011); the Reuters Instrument Codes (RICs) used to obtain monthly yields (bid) for Eurodeposits are provided for 18 currencies on page 61.

Price: For each of the securities in the index (except U.S. agency mortgage-backed passthrough securities), use the following hierarchy in order to determine the price:

- Books and records
- Citigroup
- Bloomberg

For each of the securities in the index, the same price that is used to calculate the principal and market value should also be used to calculate *all* of the analytics. For the U.S. agency mortgage-backed passthrough securities in the index, use the price provided by Citigroup.

Securities in the Index: These are the securities that are in the current returns universe for the index. This data set should come directly from Citigroup. It should be updated each evening, in order to capture intra-month principal and interest payments that have been made by index constituents. Principal and interest payments will increase the cash balances in the current returns universe. Principal payments will lower the par amounts (or current faces) of the securities in the current returns universe.

FX Forward Outright Buy (E)

Unhedged indexes do not contain any FX forward outright buys. As a result, for an unhedged index, set FX Forward Outright Buy (E) equal to zero, and move on.

The returns universe for a hedged version of a Citigroup index will contain one FX forward outright buy for the base currency of the index (for example, USD). Citigroup will provide this information. Using the currency amount on the value date that Citigroup provides, one needs to calculate the present value of the currency amount. In order to do this, see the definition for present value in Exhibit A–2.

MAIN FORMULA FOR BARCLAYS CAPITAL INDICES

The following formula can be used to calculate the exposure to a single currency in a Barclays Capital multi-currency bond index:

Currency Exposure (A) =

Market Value of Securities (B)

+ Cash Balance (C)

– FX Forward Outright Sell (D)

+ FX Forward Outright Buy (E)

Currency Exposure (A)

This is the exposure that a Barclays Capital index has to a single currency as of the close on the index pricing date. This currency exposure is expressed in the local currency. It has not been converted to the base currency of the index. This main formula for Barclays Capital indices can also be used to calculate the exposure to the base currency of the index.

There are four inputs that are needed in order to calculate this currency exposure. All of the four inputs should be expressed in the local currency. In other words, they should not be converted into the base currency of the index.

For the last two of these four inputs, one needs to calculate their present values before using them as inputs to the main formula for Barclays Capital indices.

Inputs to the Main Formula for Barclays Capital Indices

Market Value of Securities (B)

In general, one should use the same approach for indices that one uses for portfolios. However, a few things will be different. For example, the securities in the index will be the securities that are in the current returns universe for the index. This data set should come directly from Barclays Capital. It should be updated each evening, in order to capture intra-month principal and interest payments that have been made by index constituents. Principal and interest payments will increase the cash balances in the current returns universe. Principal payments will lower the par amounts (or current faces) of the securities in the current returns universe.

In order to calculate this input, first calculate the market value (including accrued interest) for each of the securities in the index that is denominated in the single currency for which one is calculating the Currency Exposure (A). Then sum the resulting market values. The sum is the Market Value of Securities (B).

Cash Balance (C)

Barclays Capital will provide the cash balances for each currency. The Cash Balance (C) will be the cash balance in the single currency for which one is calculating the Currency Exposure (A); it will be the sum of the principal and interest payments received by the index on or after the *second* calendar day of the month and on or before the index settlement date used by Barclays Capital. There is one exception: estimated principal and interest payments generated by U.S. agency mortgage-backed passthrough securities are added to the USD cash balance at the close on the first calendar day of the month.

These cash balances should come directly from Barclays Capital. They should be updated each evening in order to capture intra-month principal and interest payments that have been made by index constituents. Principal and interest payments will increase the cash balances in the current returns universe. Principal payments will lower the par amounts (or current faces) of the securities

in the current returns universe. Note that as of the close on the last business day of a month, there is no cash in the statistics universe (which is the returns universe for the coming month).

FX Forward Outright Sell (D)

Unhedged indices do not contain any FX forward outright sells. As a result, for an unhedged index, set FX Forward Outright Sell (D) equal to zero, and move on.

Hedged indices contain one FX forward outright sell for each foreign currency in the index. Today, it is not possible to download these FX forward outright sells from Barclays Capital POINT, nor is it possible to see them on any screen, nor are they provided in any published reports. As a result, you need to calculate these amounts yourself. More specifically, you need to calculate the currency amount *on the value date* for each of the two currencies in each FX forward outright sell in each returns universe. You only have to do this once a month at the beginning of the month. A document entitled *A Guide to the Lehman Brothers Global Family of Indices* (March 2008) does a nice job of describing the hedging methodology used for the hedged versions of the Barclays Capital indices (pages 121–127). However, in order to exactly replicate the FX forward outright sells in each returns universe, one should ask the index group at Barclays Capital for specific guidance, as there are a number of nuances. Once you have calculated the currency amount on the value date for each of the two currencies in an FX forward outright sell, you need to calculate the present value of the currency amount for each of these two currencies. In order to do this, see the definition for present value in Exhibit A–3.

EXHIBIT A–3

Defined Terms for Barclays Capital Indices

Accrued Interest: Always use the accrued interest provided by Barclays Capital.

Compounding Frequency: All analytics (including yield to worst) should be calculated assuming semiannual compounding.

Exchange Rates—Closing Spot Rates: Use the following hierarchy in order to determine the closing spot rates for the Barclays Capital indices:

- Books and records
- Barclays Capital
- WM/Reuters
- Bloomberg

Exchange Rates—Closing Forward Rates: Use the following hierarchy in order to determine the closing forward rates for the Barclays Capital indices:

- Barclays Capital
- WM/Reuters
- Bloomberg

(*Continued*)

EXHIBIT A–3

Defined Terms for Barclays Capital Indices (*Continued*)

Ex-Coupon: When a security in a Barclays Capital index goes *ex*-coupon and starts trading with a negative accrued interest, Barclays Capital adds the coupon payment to the Cash Balance (C). The coupon payment is not reinvested until month end.

Index Pricing Date: In general, one should always use the most recent index pricing date, because the most recent index pricing date will usually be the same date as the most recent portfolio pricing date. However, if the most recent index pricing date is a different date than the most recent portfolio pricing date, then there are two possibilities:

1. The most recent index pricing date is more recent than the most recent portfolio pricing date. In this case, if there is a previous index pricing date that falls on the same date as the most recent portfolio pricing date, then use that previous index pricing date. If not, then use the most recent index pricing date and remove books and records from the hierarchies used to determine the prices and exchange rates for the index.
2. The most recent index pricing date is older than the most recent portfolio pricing date. In this case, use the most recent index pricing date and remove books and records from the hierarchies used to determine the prices and exchange rates for the index.

Index Settlement Date: Use the following index settlement dates for the Barclays Capital indices:

- For U.S. agency mortgage-backed passthrough securities, the index settlement date is T + 0 (except for the last business day of the month, when the index settlement date is the last calendar day of that month).
- For all securities other than U.S. agency mortgage-backed passthrough securities, the index settlement date is T + 1 calendar day (except for the last business day of the month, when the index settlement date is the first calendar day of the next month).

Note that T + 0 is always the index pricing date.

For each of the securities in the index, use the index settlement date to calculate *all* of the analytics.

Market Value: In order to calculate the market value for each of the securities in the index, use the following formulas:

$$\text{Market Value} = \text{Principal} + \text{Accrued Interest}$$

$$\text{Principal} = \text{Par Amount} \times (\text{Price}/100)$$

Par Amount: For non-factoring securities, always use the par amount provided by Barclays Capital. For factoring securities, always use the current face provided by Barclays Capital.

Present Value: Calculate the present value for each unsettled FX trade where there are more than four business days between the index pricing date and the value date for the unsettled FX trade. For each unsettled FX trade, take both currencies in the currency pair into account and calculate the present value of the currency amount for each one separately. In order to calculate the present value of the currency amount, use the following formula:

EXHIBIT A–3

Defined Terms for Barclays Capital Indices (*Continued*)

$PV = C/(1 + R/100 \times N/B)$

PV = Present value of the currency amount

C = Currency amount on the value date

R = Interest rate expressed as a percentage per annum

N = Actual number of days from the index pricing date to the value date

B = Day count basis (usually either 360 or 365, depending on the currency)

For most currencies, for the interest rate, one should use the Eurodeposit rate for funds deposited in that currency. These Eurodeposit rates are provided by Citigroup. In addition, these Eurodeposit rates can be obtained from market data services such as Bloomberg and Reuters. See *Citigroup Global Fixed-Income Index Catalog, 2011 Edition* (February 8, 2011); the Reuters Instrument Codes (RICs) used to obtain monthly yields (bid) for Eurodeposits are provided for 18 currencies on page 61.

Price: For each of the securities in the index (except U.S. agency mortgage-backed passthrough securities), use the following hierarchy in order to determine the price:

- Books and records
- Barclays Capital
- Bloomberg

For each of the securities in the index, the same price that is used to calculate the principal and market value should also be used to calculate *all* of the analytics. For the U.S. agency mortgage-backed passthrough securities in the index, use the price provided by Barclays Capital.

Securities in the Index: These are the securities that are in the current returns universe for the index. This data set should come directly from Barclays Capital. It should be updated each evening, in order to capture intra-month principal and interest payments that have been made by index constituents. Principal and interest payments will increase the cash balances in the current returns universe. Principal payments will lower the par amounts (or current faces) of the securities in the current returns universe.

FX Forward Outright Buy (E)

Unhedged indices do not contain any FX forward outright buys. As a result, for an unhedged index, set FX Forward Outright Buy (E) equal to zero, and move on.

Hedged indices contain one FX forward outright sell for each foreign currency in the index. The second currency in each of these FX forward outright sells is the base currency of the index, which the index is always buying one month forward. In order to calculate the FX Forward Outright Buy (E), first calculate the currency amount on the value date for each of the foreign currencies in the index (see FX Forward Outright Sell (D) above). Then use one-month forward exchange rates (POINT displays these) to calculate the currency amount on the value date for the base currency of the index. Then sum these currency amounts on the value date for the base currency of the index. Finally, calculate the present value of this summed currency amount. In order to do this, see the definition for present value in Exhibit A–3.

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ABOUT THE EDITORS

Frank J. Fabozzi is professor of finance at EDHEC Business School and a member of the EDHEC Risk Institute. Fabozzi has authored and edited a number of books on investment management, is editor of the *Journal of Portfolio Management*, and serves on the board of directors of the BlackRock complex of closed-end funds. Fabozzi is the 2007 recipient of the C. Stewart Sheppard Award given by the CFA Institute. He lives in Buckingham, PA.

Steven V. Mann is professor of finance at the Darla Moore School of Business, University of South Carolina. He has coauthored several books, including *Floating-Rate Securities, Introduction to Fixed Income Analytics*, and *Global Money Markets*. Mann lives in Columbia, SC.