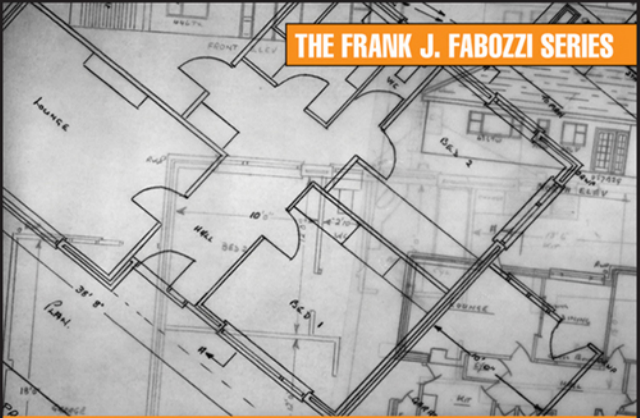

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MORTGAGE-BACKED SECURITIES

SECOND EDITION

Products, Structuring, and Analytical Techniques

FRANK J. FABOZZI, ANAND K. BHATTACHARYA, WILLIAM S. BERLINER

Mortgage-Backed Securities

Second Edition

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FJF
To my wife Donna and my children
Francesco, Patricia, and Karly

AKB
To my wife Marcia and my children
Christina and Alex

WSB
To Heidi, Morgan, and Zachary

Contents

Preface

Mortgage-backed securities (MBS) continue to comprise one of the largest securities markets in the world. As of the end of 2010, the face value of all U.S.-issued MBS was greater than $6 trillion, only exceeded by the $8.8 trillion in marketable Treasury securities outstanding. The MBS market's size in turn reflects the enormity of the U.S. residential real estate market. As an example, data from the National Association of Realtors indicate that existing home sales for 2010 were estimated to total 4.9 million units; at an average price of $220,000, the dollar value of all transactions was in the area of $1 trillion dollars for the year.

Both the consumer mortgage and MBS sectors have, however, undergone significant changes since the publication of the first edition. Many of these changes resulted, directly and indirectly, from the collapse in mortgage performance which first became evident in late 2006 and led to the financial crisis of 2007–2008. A primary reason for creating a new edition of this book was to reassess the MBS sector in the context of the changes resulting from that crisis, as well as explore the insights gained in the post-crisis period. Many of these changes can be understood by reviewing some of the trends identified in the earlier edition.

- *The growth of lending to borrowers with nontraditional financial profiles.* While this helped many underserved borrowers gain access to mortgage credit, an unintended result was that numerous borrowers who received mortgages were unable or unwilling to service their debts. Both the creation of products targeted to lower-quality borrowers, as well as the widespread relaxation of underwriting standards, led to huge losses for holders and guarantors of loans and/or securities that ultimately threatened the solvency of the world's financial system.
- *A proliferation in the types of loan products offered to consumers.* The period between 2002 and mid-2007 was characterized by a fast-growing menu of loan programs, most notably "affordability" products that allowed borrowers increased flexibility in choosing interest and principal payment schemes. However, the growth in consumer choices was not accompanied by a sophisticated understanding of the technicalities associated with many products, as well as the risks being accepted

by borrowers. This resulted in a multitude of cases where borrowers overextended themselves by spending more on homes than they could realistically afford, leaving them vulnerable to the economic downturn that began in 2008. It also led to the marketing of increasingly complex products that subsequently experienced enormous levels of credit problems and defaults.
- *Rising residential home prices*. While the "housing bubble" resulted from a variety of factors, a key element was the excess of funds that flowed into housing finance, as many borrowers utilized increasingly available loans to fund home purchases. The availability of "affordability" products, which allowed home buyers to purchase homes consuming an unsustainable share of their incomes, also contributed to sharply rising home prices. The subsequent nationwide collapse in home prices, which reduced the prices of homes in vulnerable areas by 40% to 50%, had an enormous impact on consumer behavior and MBS performance. Unprecedented phenomena such as "strategic defaults," in which homeowners default on loans that they can ostensibly still afford to pay, run counter to all earlier experience and logic, and have forced investors to rethink many of the assumptions underlying MBS credit performance.

As a result of these phenomena, the mortgage and MBS markets remain in a highly unsettled state at the writing of this edition. Many factors that will determine the future structure of these markets remain uncertain, including the status of Freddie Mac and Fannie Mae and much of the regulatory framework for MBS issuance and servicing. These uncertainties, combined with the demonstrated importance of the sector to the economy and the financial system, makes a broad and sophisticated understanding of MBS markets and products essential to financial market participants. This book attempts to fulfill that need.

There are other pragmatic considerations involved in creating this updated edition. Many people that either work in or observe the financial markets, such as investment managers, reporters, and government officials, must interact with MBS products and markets. In our view, a better and more sophisticated understanding of the mortgage and MBS sectors will work to the benefit of the entire financial system. The mortgage and MBS markets also continue to employ large numbers of people in a variety of functions and roles. In particular, the MBS markets' unique place at the junction between consumer and capital markets finance makes it one of the most dynamic and challenging areas of finance. While deep expertise is ultimately gained through experience, we enjoy the opportunity to help budding professionals understand the nuances of the product and marketplace.

This book differs from the earlier edition in a number of important ways. The discussion of prepayment behavior and analysis was completely reworked to describe the current thinking on prepayment speeds and behavior, while taking account of credit- and housing-related factors. We also discuss in detail the breakdown of prepayments based on their causation, that is, voluntary prepayments (which include home sales, cash-out activity, and rate-driven refinancings) versus involuntary prepayments (which result from borrower credit problems). In addition, we devote an entirely new chapter to the evaluation of nonagency MBS. This is particularly important given the hard-earned understanding that bonds lacking government guarantees cannot automatically be assumed to be "money-good" irrespective of their credit rating; as we note repeatedly, the evaluation of all nonagency securities requires at least some credit analysis.

In more general terms, the text incorporates experience and data accumulated from the post-2006 events. In addition to numerous contextual changes outlining pre- and post-crisis developments, we attempt to use the insights gained over the past few years to impart a more complete understanding of consumer behaviors and choices and how they impact the MBS markets. In particular, the role of real estate appreciation and depreciation is reassessed in light of the downturn in home prices after 2006 and the unprecedented problems and actions that it spawned.

As with the first edition, the text is divided into four parts. Part One (Chapters 1 and 2) provides introductions to the mortgage and MBS markets. Part Two (Chapters 3 and 4) discusses prepayment and default behavior, along with the array of metrics and conventions used to quantify these activities. Part Three, consisting of Chapters 5 through 9, describes a variety of structures and tranches, along with techniques used in structuring them. Finally, Part Four, Chapters 10 through 13, outlines the metrics and methodologies necessary to evaluate the potential risks and returns associated with mortgage-backed securities.

The appendix discusses a relatively new approach to MBS analytics. Coauthored by Andrew Kalotay, Deane Yang, and Frank Fabozzi, this "option-theoretic" approach is radically different from other MBS models in that it uses the same "recursive lattice" approach commonly used for valuing options in the equity and corporate bond markets. It represents an important advance in modeling and valuing MBS, and the Coupled Lattice Efficiency Analysis (CLEAN) model utilizing the approach was awarded a patent in April 2009.

Finally, we remain grateful to William Shang, Kevin Doyle, Joe Janssen, and Brian Stack for their help in understanding the structures and structuring techniques discussed in Part Three of the book. We also acknowledge the contributions of Paul Jacob to Chapter 13 with respect to the discussion

and analysis of transition behavior. Finally, thanks to The Yield Book, Vichara Technologies, Intex Solutions, and CoreLogic for allowing the use of their analytics and data in this book.

Frank J. Fabozzi
Anand K. Bhattacharya
William S. Berliner

About the Authors

Frank J. Fabozzi is Professor of Finance at EDHEC Business School and a member of the EDHEC-Risk Institute. Prior to joining EDHEC in August 2011, he held various professorial positions in finance at Yale University's School of Management from 1994 to 2011 and from 1986 to 1992 was a visiting professor of finance and accounting at MIT's Sloan School of Management. Professor Fabozzi is the editor of the *Journal of Portfolio Management,* as well as an associate editor of the *Journal of Fixed Income,* and on the editorial boards of the *Journal of Asset Management, Journal of Structured Finance, Quantitative Finance,* and *Review of Futures Markets*. He earned a doctorate in economics from the City University of New York in 1972. In 2002 he was inducted into the Fixed Income Analysts Society's Hall of Fame and is the 2007 recipient of the C. Stewart Sheppard Award given by the CFA Institute. He earned the designation of Chartered Financial Analyst and Certified Public Accountant. He has authored and edited numerous books in finance.

Anand K. Bhattacharya is a Professor of Practice in the Department of Finance, W. P. Carey School of Business, Arizona State University (ASU) and a Fixed Income Strategist with Stifel Nicolaus and Company Inc. He has consulted with various financial institutions on issues of balance sheet restructuring and asset valuation. Prior to joining ASU in 2009, he was a Managing Director responsible for the management of fixed income research and strategy; development of trading, valuation and risk management systems; and management of technological infrastructure at Countrywide Capital Markets Inc. His prior supervisory positions include Managing Director responsible for capital markets and risk management at Imperial Credit Industries Inc. and Managing Director, Global Head of Fixed Income Research and Strategy and a member of the Taxable Fixed Income Operating Committee at Prudential Securities Inc. Earlier on in his career, Dr. Bhattacharya held positions in research and product management at Merrill Lynch Capital Markets, Franklin Savings Association, and Security Pacific Merchant Bank. He has written extensively in various facets of fixed income valuation and debt portfolio management and authored or coauthored over 65 publications in various academic, professional journals and industry handbooks.

He has also coauthored or coedited three books on mortgage-backed and asset-backed securities. Dr. Bhattacharya earned his Ph.D. in Finance from Arizona State University in 1984.

William S. Berliner is the Principal of Berliner Consulting & Research, a boutique firm specializing in mortgages and mortgage-backed securities. His primary focus is security and loan valuation and hedging, serving both institutional investors and mortgage originators. He also writes a monthly column for *Asset Securitization Report*. Prior to founding Berliner Consulting, he was Executive Vice President in charge of the Strategies group at Countrywide Securities Corporation. In this capacity, he was directly responsible for the generation of trade strategies and relative value analysis, and wrote and edited many of the firm's research reports and publications. He began his career in 1985 at Bear, Stearns and Co., and moved to Nikko Securities in 1993, where he eventually ran CMO trading. He joined Countrywide Securities as a CMO trader in 1996, and moved to the Fixed Income Research department in early 1998. Mr. Berliner has a degree in Interpersonal Communications from Rutgers College and an MBA in Finance from the Rutgers Graduate School of Business.

PART One

Introduction to Mortgage and MBS Markets

CHAPTER 1

Overview of Mortgages and the Consumer Mortgage Market

Over the past few decades, the residential mortgage market in the United States has emerged as one of the world's largest asset classes. At its peak in the first quarter of 2008, the total face value of household mortgage debt exceeded $10.6 trillion dollars. The growth of the residential mortgage market reflected the rapid growth in the aggregate value of real estate between 2001 and 2006, along with consumers' propensity to monetize their home equity through additional borrowing.

The composition and performance of the mortgage market has undergone profound shifts on several occasions, and can be divided into separate phases. The period between 2001 and early 2007 was characterized by numerous innovations in product features, pricing paradigms, and underwriting practices, which were underpinned by steady nationwide increases in home prices. The sudden and protracted decline in the credit performance of residential mortgage loans, which first became apparent in 2006, led to the recognition that many of the products and practices developed during the earlier period were fundamentally flawed, with their weaknesses masked by the strength in the residential real estate markets. This led to a retrenchment by mortgage lenders characterized by conservative lending practices and greater regulatory scrutiny. At this writing, most lending programs require high credit scores and (with the exception of some government-backed programs) relatively large down payments. Almost all programs currently require full documentation of income sources, while so-called "affordability products" (which allow obligors to borrow increasingly large amounts relative to their income) have fallen out of favor and, in some cases, been outlawed entirely.

Despite the changes and dislocations experienced by the mortgage industry, however, it remains critical to the health of the housing market. Since most home buyers need to finance at least some of the purchase price, the availability and cost of mortgage money is a key factor driving sales volumes for new and existing homes. Moreover, the events of the past few years have demonstrated that familiarity with the primary mortgage market is important in understanding a variety of trends and factors influencing the market for securitized mortgage products.

The primary purpose of this chapter is to explain mortgage products and lending practices. The chapter introduces the basic tenets of the primary mortgage market and mortgage lending, and summarizes the various product offerings in the sector. In conjunction with the following chapter on mortgage-backed securities (MBS) and the mortgage-backed securities market, this chapter also provides a framework for understanding the concepts and practices addressed in the remainder of this book.

OVERVIEW OF MORTGAGES

In general, a ***mortgage*** is a loan that is secured by underlying assets that can be repossessed in the event of default. For the purposes of this book, 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 (both the land and the structure or "improvement"). After issuance, loans must be managed (or serviced) by units that, for a fee, collect payments from borrowers and pass them on to investors. ***Servicers*** are also responsible for interfacing with borrowers if they become delinquent on their payments, and also manage the disposition of the loan and the underlying property if the loan goes into foreclosure.

Key Attributes that Define Mortgages

There are a number of key attributes that define the instruments in question, which can be characterized by the following dimensions:

- Lien status, original loan term
- Credit classification
- Interest rate type
- Amortization type
- Credit guarantees
- Loan balances
- Prepayments and prepayment penalties

We discuss each in the following subsections.

Lien Status

The ***lien status*** dictates the loan's seniority in the event of the forced liquidation of the property due to default by the obligor. A *first lien* implies that a creditor would have first call on the proceeds of the liquidation of the property if it were to be repossessed. Borrowers have often utilized *second liens* or *junior loans* as a means of liquefying the value of a home for the purpose of expenditures such as medical bills or college tuition or investments such as home improvements.

Original Loan Term

The great majority of mortgages are originated with a 30-year original term. Loans with shorter stated terms are also utilized by those borrowers seeking to amortize their loans faster and build equity in their homes more quickly. The 15-year mortgage is the most common short-amortization instrument, although there has been fairly steady issuance of loans with 20- and 10-year terms.

Credit Classification

The majority of loans originated are underwritten to high credit standards, where the borrowers have strong employment and credit histories, income sufficient to pay the loans without compromising their creditworthiness, and substantial equity in the underlying property. These loans are broadly classified as ***prime loans***, and have historically experienced relatively low incidences of delinquency and default.

Loans of lower initial credit quality, which are expected to experience significantly higher rates of default, are classified as ***subprime loans***. Subprime loan underwriting often utilized nontraditional measures to assess credit risk, as these borrowers typically had lower income levels, fewer assets, and blemished credit histories. Issuance of the product declined precipitously after 2006, when it became evident that the sector was plagued by poor underwriting, fraud, and an excessive reliance on rising home prices.

Between the prime and subprime sector is a somewhat nebulous category referenced as ***alternative-A loans*** or, more commonly, *alt-A loans*. These loans were considered to be prime loans (the "A" refers to the A grade assigned by underwriting systems), albeit with some attributes (such as limited income or asset documentation) that either increased their perceived credit riskiness or caused them to be difficult to categorize and evaluate. As with subprime, issuance of alt-A loans fell sharply with the post-2006 decline in home prices and mortgage credit performance.

Mortgage credit analysis employs a number of different metrics, including the following.

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 and creditworthiness of the borrower. There are three different credit-reporting firms that calculate credit scores: Experian (which markets the Experian/Fair Isaac Risk Model), Transunion (which supports the Emperica model), and Equifax (whose model is known as Beacon). While each firm's credit scores are based on different data sets and scoring algorithms, the scores are generically referred to as ***FICO scores***, since they are based on Fair Isaac's software and models. Underwriters typically purchase credit scores from all three credit bureaus, and apply the median figure to their analysis; in the event that only two scores are available, the lower of the two is used.

Loan-to-Value Ratios The ***loan-to-value ratio*** (LTV) is an indicator of borrower leverage at any point in time. The LTV calculation compares the face value of the desired loan to the market value of the property. By definition, the LTV of the loan in the purchase transaction is a function of both the down payment and the purchase price of the property. In a refinancing, the LTV is dependent upon the requested amount of the new loan and the market value of the property as determined by an appraisal. (Note that if the new loan is larger than the original loan, the transaction is referred to as a *cash-out refinancing*; a refinancing where the loan balance remains the same is described as a *rate-and-term* or *no-cash refinancing*.)

The 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 has not appreciated. The level of the LTV also has an impact on the expected payment performance of the obligor; a high LTV indicates a greater likelihood of default on a loan. The recognition of this phenomenon has caused mortgage analysts to distinguish between the ***original LTV*** (i.e., the LTV at the time the loan was originated) and the ***current LTV*** (CuLTV), which accounts for changes in the home's price after the loan is issued. (Data indicate that borrowers have a increased propensity to voluntarily stop servicing their loans once their CuLTV exceeds 125%, even if they can afford making monthly payments. This behavior, called *strategic default*, was not contemplated before the post-2006 decline in home prices.)

Analysis must also account for the presence of subordinated mortgage debt. A common supplemental measure is the ***combined LTV*** (CLTV), which accounts for the presence of second and third liens. As an example, 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%.

Income Ratios In order to ensure that borrower obligations are consistent with their income, lenders calculate income ratios that compare the potential monthly payment on the loan to the applicant'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 pretax monthly income. The *back ratio* is similar, but adds other debt payments (including auto loan and credit card payments) to the total payments. In order for a loan to be classified as prime, the front and back ratios should be no more than 28% and 36%, respectively. (Because consumer debt figures can be somewhat inconsistent and nebulous, the front ratio is generally considered the more reliable measure, and accorded greater weight by underwriters.)

Documentation Lenders traditionally have required potential borrowers to provide data on their financial status, and support the data with documentation. Loan officers typically required 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 involved compiling documents such as tax returns and bank statements for use in the underwriting process. Between 2001 and 2007, however, increasingly large numbers of loans were underwritten using relaxed documentation standards. While originally designed for self-employed borrowers that had difficulty documenting their income, these programs were extended to include wage earners that often were looking to borrow larger sums than could be supported by their incomes. Such programs ranged from simply not requiring pay stubs and bank statements from existing customers, to "stated-income" programs (where income levels and asset values were provided but not independently verified) to "no income–no asset" programs for which no income figures or bank balances were provided by the borrower. The devastating post-2007 decline in performance for these products forced lenders to return to requiring full documentation in almost all cases.

Characterizing Mortgage Credit

The primary attribute used to categorize mortgage credit has long been the credit score. Prime (or A-grade) loans generally had FICO scores of 660 or higher, income ratios with the previously noted maximum of 28% and 36%, and LTVs of 90% or less. Alt-A loans occupied a middle ground between prime and subprime products. The "alt-A" label was applied to a variety of products which typically combined relaxed documentation standards, nonoccupancy by the obligor (i.e., the home was either an investment property or a second home), and credit scores between 660 and 700.

The alt-A category eventually occupied a wide band in the credit spectrum, ranging from loans that were close to prime in quality to products that were virtually subprime loans in character. The subprime sector was broadly understood to represent loans well below prime products in credit quality. However, the loan programs and grades were highly lender-specific. For example, one lender might consider a loan with a 620 FICO to be a B-rated loan, while another lender would grade the loan differently, especially if the other attributes of the loan (such as the LTV) deviated from average levels.

Interest Rate Type

Fixed rate mortgages have an interest rate (or *note rate*) that is set at the closing of the loan (or, more accurately, when the rate is "locked"), and is constant for the loan's term. Based on the loan's balance, interest rate, and term, a payment schedule effective over the life of the loan is calculated to amortize the principal balance.

Adjustable rate mortgages (ARMs), as the name implies, 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 a spread over the index (the *margin*) required for the particular loan program. A number of different indexes can be used as a reference rate in determining the loan's note rate the loan "resets," including the London Interbank Offering Rate (LIBOR), one-year Constant Maturity Treasury (CMT), or the 12-month Moving Treasury Average (MTA), a rate calculated from monthly averages of the one-year CMT. The loan's note rate resets at the end of the initial period and subsequently resets periodically, subject to caps and floors that limit how much the loan's note rate can change. ARMs most frequently are structured to reset annually, although some products reset on a monthly or semiannual basis. Since the loan's rate and payment can (and often does) reset higher, the borrower can experience "payment shock" if the monthly payment increases significantly.

Traditionally, ARMs had a one-year initial period where the start rate was effective, often referred to as the "teaser" rate (since the rate was set at a relatively low rate in order to entice borrowers.) The loans reset at the end of the teaser period, and continued to reset annually for the life of the loan. One-year ARMs, however, are no longer popular products, replaced by loans that have features more appealing to borrowers.

During the period between 2001 and 2007 when ARM issuance was at its height, the market was dominated by two different types of loans. One is the ***fixed period ARM*** or ***hybrid ARM***, which have fixed initial rates that are effective for longer periods of time (3-, 5- 7-, and 10-years) after funding. At the end of the initial fixed rate period, the loans reset in a fashion very similar to that of more traditional ARM loans. Hybrid ARMs typically have three rate caps: initial cap, periodic cap, and life cap. The *initial cap* and *periodic cap* limit how much the note rate of the loans can change at the end of the fixed period and at each subsequent reset, respectively, while the *life cap* dictates the maximum level of the note rate.

At the opposite end of the spectrum was the ***payment option ARM*** or *negative amortization ARM*. Such products begin with a very low teaser rate. While the rate adjusts monthly, the minimum payment is only adjusted on an annual basis and is subject to a payment cap that limits how much the loan's payment can change at the reset. In instances where the payment made is not sufficient to cover the interest due on the loan, the loan's balance increases in a phenomenon called "negative amortization." (The mechanics of negative amortization loans are addressed in more depth later in this chapter.)

Amortization Type

Traditionally, both fixed and adjustable rate mortgages were *fully amortizing loans*, indicating that the obligor's principal and interest payments are calculated in equal increments to pay off the loan over the stated term. Fully amortizing, fixed rate loans have a payment that is constant over the life of the loan. Since the payments on ARMs adjust periodically, their payments are recalculated at each reset for the loan's remaining balance at the new effective rate in a process called *recasting the loan*.

Between 2001 and 2007, however, many loans were originated with nontraditional amortization schemes. The most straightforward of these innovations was the *interest-only* or *IO product*. These loans required only interest to be paid for a predetermined period of time. After the expiration of the interest-only or *lockout period*, the loan was recast to amortize over the remaining term of the loan. The inclusion of principal to the payments at that point, amortized over the remaining term of the loan, causes the loan's payment to rise significantly after the recast, creating payment shock analogous to that experienced when an ARM resets.

The interest-only feature was most common in the hybrid ARM market, where the terms of the interest-only and fixed rate periods were contiguous. A by-product of the interest-only ARM can be large changes in the borrower's monthly payment, the result of the combination of post-reset rate increases and the introduction of principal amortization. However, fixed rate, interest-only products have also been popular. These are loans with a 30-year maturity that have a fixed rate throughout the life of the loan, but have a fairly long interest-only period (normally 10 years, although 15-year interest-only products are also being produced). The loans subsequently amortize over their remaining terms. These products were designed to appeal to borrowers seeking the lower payments of interest-only products without the rate risk associated with adjustable rate products.

Another variation is the *noncontiguous interest-only hybrid ARM*, where the interest-only period is different from the duration of the fixed rate period. As an example, a 5/1 hybrid ARM might have an interest-only period of 10 years. When the fixed period of a hybrid ARM is concluded, the loan's rate resets in the same fashion as other ARMs. However, only interest is paid on the loan until the recast date. These products were developed to spread out the payment shock that occurs when ARM loans reset and recast simultaneously.

Credit Guarantees

The ability of mortgage banks to continually originate mortgages is heavily dependent upon the ability to create fungible assets from a disparate group of loans made to a multitude of individual obligors. These assets are then sold (in the form of loans or, more commonly, MBS) into the capital markets, with the proceeds being recycled into new lending. Therefore, mortgage loans can be further classified based upon whether a credit guaranty associated with the loan is provided by the federal government or quasi-governmental entities, or obtained through other private entities or structural means.

Loans that are guaranteed by agencies of the Federal government are referred to under the generic term of ***government loans***. As part of housing policy considerations, the Department of Housing and Urban Development (HUD) oversees two agencies, the Federal Housing Administration (FHA) and the Veterans Administration (VA), that support housing credit for qualifying borrowers. The FHA provides loan guarantees for those 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. Department of the Treasury, thus providing these loans with the "full faith and credit" backing of the U.S. government. Government loans are securitized largely through the aegis of the Government National Mortgage Association (GNMA or Ginnie Mae), an agency also overseen by HUD.

Conventional loans have no explicit guaranty from the federal government. Qualifying conventional loans can be securitized as pools guaranteed by the two ***government-sponsored enterprises*** (GSEs), namely Freddie Mac (FHLMC) and Fannie Mae (FNMA). The GSEs are shareholder-owned corporations that were created by Congress in order to support housing activity. While neither enterprise has an explicit government guaranty, market convention has always reflected the presumption that the government would provide assistance to the GSEs in the event of financial setbacks that threaten their viability. (In the summer of 2008, in fact, both GSEs were placed in conservatorship and eventually given unlimited support by the Treasury; through the second quarter of 2010, the two companies have received a total of roughly $150 billion in support from the Treasury.) As we see later in this chapter, the GSEs insure the payment of principal and interest to investors in exchange for a guaranty fee, paid either out of the loan's interest proceeds or as a lump sum at issuance.

Conventional loans that are not guaranteed by the GSEs can be securitized as private-label transactions. Traditionally, loans were securitized in private-label form because they were not eligible for GSE guarantees, although there have been times where private-label execution was superior to agency pooling for some agency-eligible loans. Beginning in late 2007, however, private-label issuance became uneconomical for a variety of factors growing out of the mortgage crisis. This meant that loans ineligible for securitization through Ginnie Mae or the GSEs are either held on the books by lenders or sold in the form of raw or "whole" loans.

Loan Balances

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 a calendar year are adjusted late in the prior year. 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 Board (or, after mid-2009, the Federal Housing Finance Agency). Since their inception, Freddie Mac and Fannie Mae pools have had identical loan limits, because the limits are dictated by the same statute. As of 2010, the single-family limit was $417,000; the loan limits are 50% higher for loans made in Alaska, Hawaii, Guam, and the U.S. Virgin Islands.

However, having a single loan limit throughout the United States caused large numbers of loans in states such as California, where housing is relatively expensive, to be ineligible for agency securitization. Legislation passed in 2008 created overrides or "ceilings" for the maximum balance of loans originated in "high-cost" areas. As of 2010, the maximum loan size for loans originated in high-cost areas was $729,750—that is, 175% of the national ***conforming balance limit*** of $417,000.

Loans larger than the conforming limits (and thus ineligible for inclusion in agency pools) are classified as ***jumbo loans*** and can only be securitized in private-label transactions. At its peak in 2006, the outstanding balance of the private-label market exceeded $1.5 trillion. However, the size of the market began to decline in 2007, as the decline in balances due to prepayments and defaults has not been offset by new issuance.

Prepayments and Prepayment Penalties

Mortgage loans can prepay for a variety of reasons. Virtually all mortgage loans have a "due on sale" clause, which means that the remaining balance of the loan must be paid when the house is sold. Existing mortgages can also be refinanced by the obligor if the prevailing level of mortgage rates declines, or if a more attractive financing vehicle is proposed to them. In addition, the homeowner can make partial prepayments on their loan, which serve to reduce the remaining balance and shorten the loan's remaining term. As we discuss later in this chapter, prepayments strongly impact the returns and performance of MBS, and investors devote significant resources to studying and modeling them.

To mitigate the effects of prepayments, some loan programs were structured with prepayment penalties. The penalties were designed to discourage refinancing activity, and required a fee to be paid to the servicer if the loan is prepaid within a certain amount of time after funding. Penalties were typically structured to allow borrowers to partially prepay up to 20% of their loan each year the penalty was in effect, and charge the borrower six months of interest for prepayments on the remaining 80% of their balance. Some penalties could be waived if the home is sold, and are described as "soft" penalties; hard penalties required the penalty to be paid even if the prepayment occurs as the sale of the underlying property.

As with many lending practices, prepayment penalties are controversial. Critics argue that the presence of penalties increases borrowers' costs of exiting what are already expensive loans, and unfairly targets vulnerable borrowers.

MORTGAGE LOAN MECHANICS

As described in the previous section, mortgage loans traditionally are structured as fully amortizing debt instruments, with the principal balance being paid off over the term of the loan. For a fixed rate product, the loan's payment is constant over the term of the loan, although the payment's breakdown into principal and interest changes each month. An amortizing fixed rate loan's monthly payment can be calculated by first computing the *mortgage payment factor* using the following formula:

$$\text{Mortgage payment factor} = \frac{\text{Interest rate}(1 + \text{Interest rate})^{\text{Loan term}}}{(1 + \text{Interest rate})^{\text{Loan term}} - 1}$$

Note that the interest rate in question is the monthly rate, that is, the annual percentage rate divided by 12. The monthly payment is then computed by multiplying the mortgage payment factor by the loan's balance (either original or, if the loan is being recast, the current balance).

As an example, consider the following loan:

Loan balance:	\$100,000
Annual rate:	6.0%
Monthly rate:	0.50% = 0.005
Loan term:	30 Years (360 Months)

The monthly payment factor is calculated as

$$\frac{0.005(1.005)^{360}}{(1.005)^{360} - 1} = 0.0059955$$

Therefore, the monthly payment on the subject loan is \$100,000 × 0.0059955, or \$599.55.

An examination of the allocation of principal and interest over time provides insights with respect to the buildup of owner equity. As an example, Exhibit 1.1 shows the total payment and the amount of principal and interest for the \$100,000 loan with a 6.0% interest rate (or *note rate*, as it is often called) for the life of the loan.

The exhibit shows that the payment is comprised mostly of interest in the early period of the loan. Since interest is calculated from a progressively declining balance, the amount of interest paid declines over time. In this calculation, since the aggregate payment is fixed, the principal component consequently increases over time. In fact, the exhibit shows that the unpaid principal balance in month 60 is \$93,054, which means that only \$6,946 of the \$35,973 in payments made by the borrower up to that point in time consisted of principal. However, as the loan seasons, 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) for this loan occurs in month 222.

Loans with shorter amortization schedules (e.g., 15-year loans) allow for buildup of equity at a much faster rate. Exhibit 1.2 shows the outstanding

EXHIBIT 1.1 Monthly Payment Breakdown for a $100,000 Fixed Rate Loan at 6.0% Rate with a 30-Year Term (fixed payment of $599.55 per month)

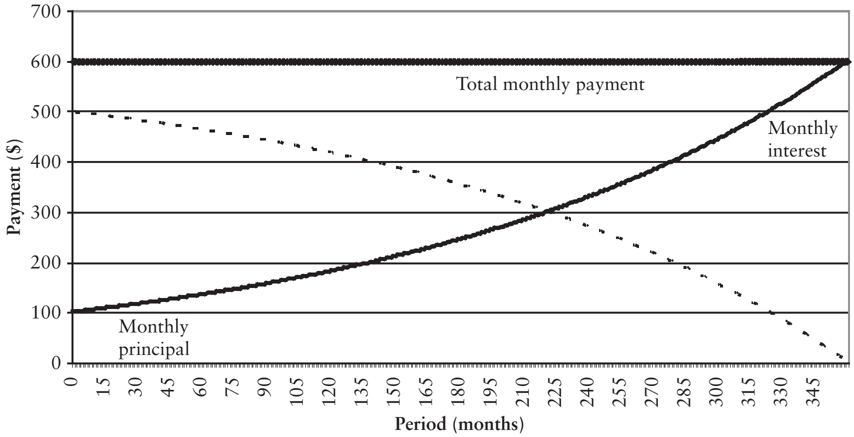
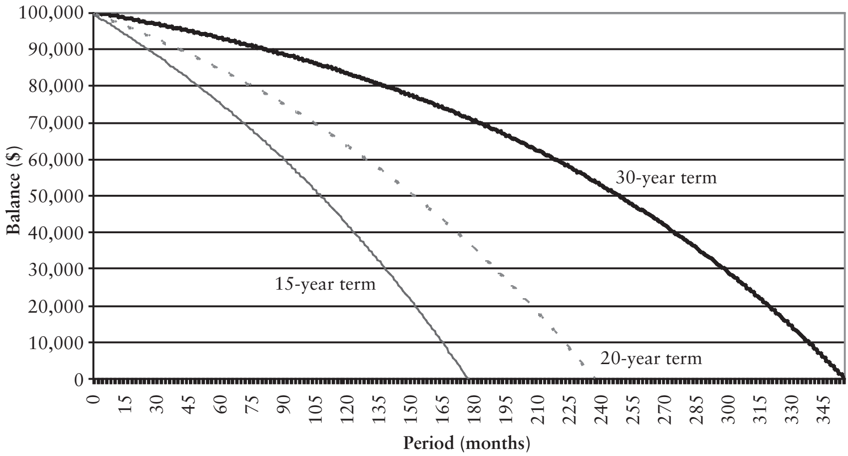
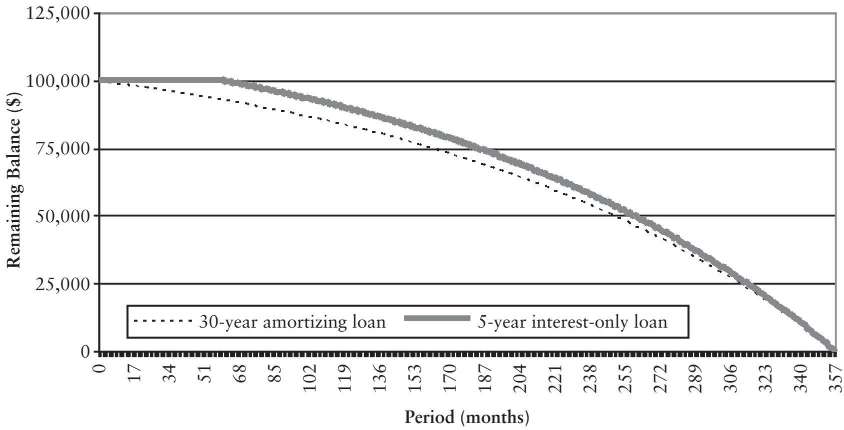


EXHIBIT 1.2 Balances for $100,000 6.0% Fixed Rate Loan over Different Original Terms



balance of a $100,000 loan with a 6.0% note rate using 30-, 20-, and 15-year amortization terms. In contrast to the $93,054 remaining balance on the 30-year loan, the remaining balances on 20- and 15-year loan in month 60 are $84,899 and $76,008, respectively. In LTV terms, if the purchase price of the home is $125,000 (creating an initial LTV of 80%), the

EXHIBIT 1.3 Remaining Principal Balance Outstanding for $100,000 6% Loan, Fully Amortizing versus Five-Year Interest-Only Loans



LTV in month 60 on the 15-year loan is 61% (versus 74% for the 30-year loan). Finally, while 50% of the 30-year loan balance is paid off in month 252, the halfway mark is reached in month 154 with a 20-year term, and month 110 for a 15-year loan.

Patterns of borrower equity accumulation due to amortization are important in understanding the attributes of interest-only loans. Exhibit 1.3 compares the remaining balances over time for the previously described fully amortizing $100,000 loan with a 6% rate, versus an interest-only loan with the same rate and term. A fully amortizing loan would have a monthly payment of $599.55, and would have reduced its principal balance by $6,946 at the end of five years. The interest-only loan, by definition, would amortize none of the principal over the same period. It would have an initial monthly payment at the 6% rate of $500, which would increase to $644 when the loan recasts in month 60. The 29% increase in the payment results from the loan's balance being amortized over the remaining term of 300 months. As Exhibit 1.3 indicates, the remaining balance of the interest-only loan amortizes faster than the fully amortizing loan because of the higher payment, although the interest-only loan's remaining balance is greater than that of the amortizing loan. The LTV of the amortizing loan (assuming a purchase price of $125,000 and an original LTV of 80%) declines to roughly 74% by month 60 and 72% in month 80. The interest-only loan has an 80% LTV through the first 60 months after issuance, but by month 80 the LTV declines to 77.5%.

For amortizing ARM loans, the initial 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, payments on a five-year hybrid ARM with a 5.5% note rate would initially be calculated as a 5.5% loan with a 360-month term. If the loan resets to a 6.5% rate after five years (based on both the underlying index and the loan's margin), the payment is calculated using a 6.5% note rate, the remaining balance in month 60, and a 300-month term. In the following year, the payment would be recalculated again using the remaining balance and prevailing rate (depending on the performance of the index referenced by the loan) and a 288-month term. In this case, the loan's initial monthly payment would be $568; in month 60, the loan's payment would change to $624, or the payment at a 6.5% rate for 300 months on a $92,460 remaining balance.

The payments on an interest-only hybrid ARM are similar to those of a fixed rate, interest-only loan. Using the rate structure described above, an interest-only 5/1 hybrid ARM would have an initial payment of $458. After the 60-month fixed rate, interest-only period, the monthly payments would reset at $675, an increase of roughly 47%. This increase represents the payment shock discussed previously. Depending on the loan's margin and the level of the reference index, borrowers seeking to avoid a sharp increase in monthly payments often attempt to refinance their loans into cheaper available products. The desire to mitigate payment shock was also largely responsible for the growth in hybrid ARMs with noncontiguous resets. Since these loans essentially separate the rate reset and payment recast, the payment increases were spread over two periods, reducing the impact of a large one-time increase in payment.

The payment structure for negative amortization ARM loans is different and highly complex. The most commonly issued form of products that allow negative amortization are so-called "payment-option loans," which are variations on traditional annual-reset ARMs. The loans have an introductory rate that is effective for a short period of time (either one or three months). After the initial period, the loan's rate changes monthly, based on changes in the reference index. The borrower's minimum or "required" payment, however, does not change until month 13. The initial or teaser payment is initially calculated to fully amortize the loan over 30 years at the introductory rate. After a year, and in one-year intervals thereafter, the loan is recast. The minimum payment is recalculated based on the loan's margin, the index level effective at that time, and the remaining balance and term on the loan. However, the increase in the loan's minimum monthly payment is subject to a 7.5% cap.[1]

[1]Note that this cap functions differently than those in the hybrid market, which are based on changes in the loan's rate rather than payment.

The minimum payment may not be sufficient to fully pay the loan's interest, based on its effective rate. This may occur if the loan's index and margin are such that the minimum payment is lower than the interest payment, or if the minimum payment is constrained by the 7.5% payment cap. In that event, the loan undergoes negative amortization, where the unpaid amount of interest is added to the principal balance. Negative amortization is typically limited to 115% of the original loan balance (or 110% in a few states). If this threshold is reached, the loan is immediately recast to amortize the current principal amount over the remaining term of the loan. Under all circumstances, the loan is automatically recast periodically, with payments calculated based on the current loan balance and the remaining term of the loan. At this point, the payment change is not subject to the 7.5% payment cap—a condition that also holds true if the loan recasts because the negative amortization cap is reached. (The first mandatory recast is generally at the beginning of either year 5 or 10; in either case, the loan will subsequently recast every five years thereafter.)

RISKS ASSOCIATED WITH MORTGAGES AND MORTGAGE PRODUCTS

Holders of fixed income investments ordinarily deal with interest rate risk, or the risk that changes in the level of market interest rates will cause fluctuations in the market value of such investments. However, mortgages and associated mortgage products have additional risks associated with them that are unique to the products and require additional analysis. We conclude this chapter with a discussion of these risks.

Prepayment Risk

In a previous section, we noted that obligors have the ability to prepay their loans before they mature. For the holder of the 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 pay off, 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 also creates uncertainty with respect to the timing of investors' cash flows. In addition, changing prepayment "speeds" due to interest rate moves cause variations in the cash flows of mortgages and securities collateralized by mortgage products, strongly influencing their relative performance and making them difficult and expensive to hedge.

While we address both the factors driving prepayment behavior and the metrics used to measure prepayment speeds later in this text, a brief introduction at this juncture will be helpful. Prepayments are phenomena resulting from decisions made by the borrower and/or the lender, and occur for the following reasons:

1. The sale of the property (due to normal mobility, as well as death and divorce).
2. The destruction of the property by fire or other disaster.
3. A default on the part of the borrower (net of losses).
4. Curtailments (i.e., partial prepayments).
5. Refinancing.

Prepayments attributable to reasons 1 and 2 are referred to under the broad rubric of "turnover." Turnover rates tend to be fairly stable over time, but are strongly influenced by the health of the housing market, specifically the levels of real estate appreciation and the volume of existing home sales. Refinancing activity can be, as noted earlier in this chapter, categorized as either "rate and term" or "cash-out" refinancings. Rate-and-term (or "no cash") transactions generally depend on a borrower's ability to obtain a new loan with either a lower rate or a smaller payment. This activity is therefore dependent on the level of interest rates, the shape of the yield curve (since short interest rates strongly influence ARM pricing) and the availability of alternative loan products. These factors also impact cash-out activity, although a primary driver of cash-out refinancings remains home price appreciation; the ability to borrow additional funds against a property is contingent on the property having appreciated in price.

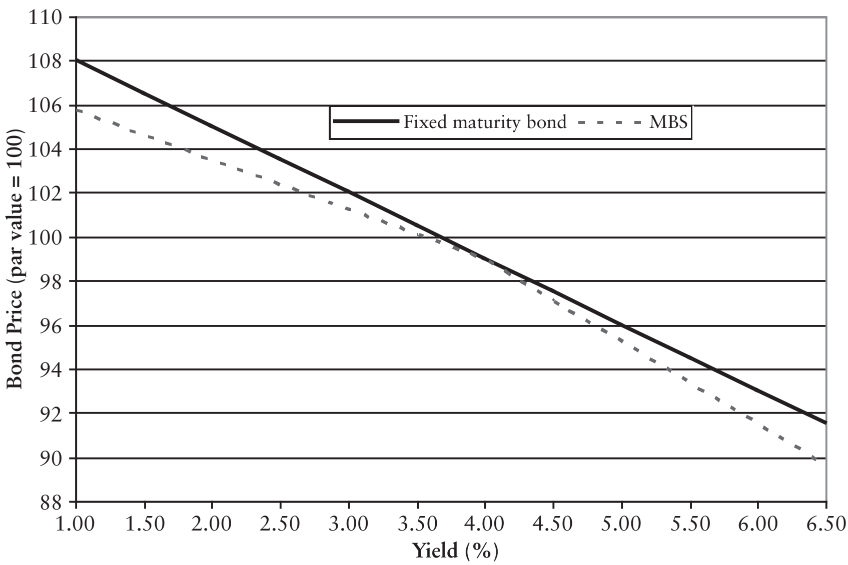
The paradigm in mortgages is thus fairly straightforward. Mortgages with low note rates (that are "out-of-the-money," to borrow a term from the option market) normally prepay fairly slowly and steadily, while loans carrying higher rates (and are "in-the-money") are prone to experience spikes in prepayments due to refinancings when rates decline. In turn, the relationship between a loan's note rate and the prevailing level of mortgage rates dictates whether the borrower has an incentive to refinance.

It is important to understand how changes in prepayment rates impact 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, constraining their price appreciation. Conversely, rising yields cause prepayments to slow and bond durations to extend, resulting in a greater drop in price than experienced by more traditional (i.e., option-free) fixed income products. As a result, the price performance of mortgages and MBS tends to lag that of comparable fixed maturity instruments (such as Treasury notes) when the prevailing level of yields increases.

This phenomenon is generically described as ***negative convexity***. The effect of changing prepayment speeds on mortgage durations, based on movements in interest rates, is precisely the opposite of what a bondholder would desire. (Fixed income portfolio managers, for example, extend durations as rates decline, and shorten them when rates rise.) The price performance of mortgages and MBS is, therefore, decidedly nonlinear in nature, and the product will underperform assets that do not exhibit negatively convex behavior as rates decline.

Exhibit 1.4 shows a graphic representation 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 involves fairly active management of MBS portfolios, and creates both higher hedging costs and the possibility of losses due to estimation and modeling error. In turn, this creates the desire on the part of some investors to limit their exposure to prepayments by investing in bonds where prepayment risk is transferred within the structure. This type of risk mitigation is central to the structured MBS market, and will be discussed in depth later in this book.

EXHIBIT 1.4 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 principal loss on a loan 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 routinely calculated, 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 utilized in the a posteriori evaluation of a mortgage pool or security.

Delinquencies

These 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; 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, many delinquent loans become current, as 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 on which the borrower goes into bankruptcy may be classified as defaulted at an earlier point in time.

The decline in mortgage credit performance after 2006 required new terminology to describe behavior that had not been previously been experienced to any significant degree. As noted previously, one new phenomenon was strategic default, which resulted from the severe decline in home prices after their 2006 peak. Another was the advent of *early-pay defaults* (EPDs). Mortgage credit analysis has traditionally assumed a significant lag between the issuance of a loan and the point in time that a borrower would default. Beginning in 2006, however, investors began to see large numbers of defaults on very new loans; in some cases, borrowers never made even their first loan payment. (The latter phenomenon came to be known as *first-pay defaults*, or FPDs.) Theses behaviors were attributed to several factors, including widespread speculation on real estate, outright fraud, and home purchases that were completely and immediately unaffordable.

Loss 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. Loss severities are heavily influenced by a loan's current LTV, which is a function of both the original LTV and any appreciation (or depreciation) in the property's value. However, in the event of a default, loans with relatively low current LTVs can also result in losses, generally for two reasons:

- The appraised value of the property may be high relative to the property's actual market value.
- There are costs and foregone income associated with the foreclosure process.

As with prepayments, the measurement of estimated and historical credit performance is discussed later in this text.

In light of these factors, the process of evaluating the credit-adjusted performance of a group of loans involves first gauging and modeling the expected delinquencies, defaults, and loss severities of the pool or security based on its credit characteristics. Subsequently, loss-adjusted yields and returns can be generated. It should be noted that investors in some segments of the MBS market do not engage in detailed credit analysis; buyers of agency pools, for example, generally rely on the guaranty of the agency in question. However, investors in private-label MBS that relied on the ratings provided by the credit rating agencies experienced capital losses when their bonds were downgraded and/or the bond's credit support proved to be inadequate. This means that even the most senior securities in private-label deals must undergo credit analysis, as their returns will be tied to the performance of the underlying loan collateral.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Mortgage
Servicers
Lien Status
Original Loan Term
Credit Classifications (Prime/Subprime/Alternative-A)
FICO (credit) Scores
Loan-to-Value Ratio (LTV)
Current LTV (CuLTV)
Combined LTV (CLTV)
Income Ratios
Documentation
Fixed Rate Mortgages
Adjustable Rate Mortgages (ARMs)
Hybrid (Fixed Period) ARMs
Payment-Option ARMs
Amortization
Government (FHA/VA) Loans
Conventional Loans
Government-Sponsored Enterprises (GSEs)
Conforming Balance Loans
Jumbo Loans
Prepayments
Negative Convexity
Delinquencies
Defaults
Loss Severity

CHAPTER 2

Overview of the Mortgage-Backed Securities Market

The growth of the real estate and primary mortgage markets led, quite naturally, to the rapid expansion of the mortgage-backed securities—or MBS—market. According to the Securities Industry and Financial Markets Association (SIFMA), there were approximately $6.5 trillion in MBS outstanding at the end of the second quarter of 2009, which would make it roughly as large as the Treasury market at that time. The size of the MBS market has forced fixed income investment managers to be cognizant of developments in the MBS markets and sensitive to factors driving MBS issuance and performance.

In the most general sense, originators securitize loans to tap the capital markets for funding and liquidity. Using a business model referenced as "loans-to-bonds," mortgage lenders accept applications, fund loans, sell them into the capital markets in the form of MBS, and then recycle the resulting proceeds into new lending. Before the development of the MBS markets, lenders made mortgage loans from deposits and typically held the loans in their portfolio. This resulted in periodic shortages of mortgage money when local financial conditions were relatively illiquid; in addition, lenders' profitability was tied to the shape of the yield curve and the ability to earn a spread over funding costs. The development of an actively traded market for mortgage products over the last quarter-century resulted in the growth of a national primary mortgage market. Mortgage lending has evolved from a fragmented industry, where rates and availability of financing were based on local liquidity conditions, to a market where sources and users of funds interact on a massive scale.

The growth and development of the mortgage-backed securities market has not, however, been an unmitigated positive. One cause of the collapse in the credit performance of the mortgage sector, which led to the credit crisis of 2007–2008, was the failure on the part of market participants to ensure the quality of the loans that backed newly issued MBS. The dearth of quality controls led to both the financial collapse of Fannie Mae and Freddie Mac in 2008, as well as large losses for holders of nonagency securities. It is also likely that the increasingly lax underwriting standards of the mid-2000s factored into the rapid and unsustainable increase in home prices prior to 2007, which led to major financial losses for homeowners and contributed to the downward spiral in mortgage performance.

This chapter introduces concepts involved in the creation and trading of MBS in the primary and secondary markets. It discusses the mechanics of issuing different forms of MBS, along with many of the market practices, conventions, and terms associated with the MBS markets. In conjunction with the previous chapter on mortgage products, it also discusses how secondary market pricing and levels drive the pricing of mortgage loans to consumers.

CREATING DIFFERENT TYPES OF MBS

The fundamental unit in the MBS market is the ***pool***. At its lowest common denominator, mortgage-backed pools are aggregations of large numbers of mortgage loans with similar (but not identical) characteristics. Loans with a commonality of attributes such as note rate (i.e., the interest rate paid by the borrower on the loan), term to maturity, credit quality, loan balance, and product type are combined using a variety of legal mechanisms to create relatively fungible investment vehicles. With the creation of MBS, mortgage loans were transformed from a heterogeneous group of disparate assets into sizeable and homogenous securities that trade in a liquid market.

The transformation of groups of mortgage loans with common attributes into tradable and liquid MBS occurs using one of two mechanisms. Loans that meet the guidelines of the agencies (i.e., Fannie Mae, Freddie Mac, and Ginnie Mae, as discussed in the prior chapter) in terms of credit quality, underwriting standards, and balance are assigned an insurance premium, called a ***guaranty fee***, by the agency in question and securitized as an agency pool. Loans that either do not qualify for agency treatment, or for which agency pooling execution is not efficient, can be securitized in nonagency or "private-label" transactions when such transactions are economically feasible. These types of securities do not have an agency guaranty, and must therefore be issued under the registration entity or "shelf" of the issuer.[1] As noted later in this chapter, the insurance (or "credit enhancement") for the loans is in the form of either a private guaranty or, more

[1]The Securities Exchange Act of 1934 requires nonexempt entities to register their offerings with the Securities and Exchange Commission (SEC) prior to issuance. Because of their quasi-government status, securities issued by the GSEs are exempt from the SEC's registration requirements. "Shelf registration" refers to SEC rule 415,

commonly, structured in the deal through so-called "subordinate classes." The senior portions of many of these deals are similar to agency pools, and are often referred to as ***private label*** or ***senior pass-throughs***.[2]

(Note that the term "private label" is a generic term that can reference many different types of transactions that lack the backing of any of the agencies. The structures utilized in such deals depend on the types of loans being securitized. For the purposes of this text, private label transactions are those backed by prime quality loans ineligible for inclusion in agency pools and are described in Chapter 8; subprime and second lien products are securitized in "mortgage-related, asset-backed securities" that are described in Chapter 9.)

Once a pool (in either agency or private-label form) is created, it can be sold to investors in the form of a pass-through, in which principal and interest is paid to investors based on their pro rata share of the pool. However, the cash flows of pools can also be carved up to meet the requirements of different types of investors. The creation of ***structured securities*** involves ***tranching*** (i.e., dividing) the underlying pools' cash flows into securities that have varying average lives and durations,[3] different degrees of prepayment protection or exposure, and (in the case of private-label deals) different degrees of credit risk. These types of securities are broadly referred to as ***collateralized mortgage obligations*** (CMOs). The flexibility inherent in tranching, along with the broad range of loan instruments, allows the MBS market to reflect a large degree of market segmentation. In turn, this allows a wide range of investor types with different investment objectives and risk tolerances to invest in the MBS market, supplying the funds that ultimately are recycled into new mortgage lending.

It will be helpful at this juncture to briefly discuss and contrast the processes of creating and structuring agency CMOs and private-label transactions. To create an agency CMO deal, the underwriter buys agency MBS pools in the primary or secondary markets and places them in a trust-like entity. The different tranches are then created from the principal and interest cash flows generated by the MBS pools (or "collateral"). In contrast, private

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which modified registration requirements by allowing issuers to register securities up to two years before they are actually issued.

[2]The term *pass-through* indicates that principal and interest is passed on to the investor pro rata with their holding. Using this definition, the senior portion of a private-label deal is technically not a pass-through, because principal is redistributed within the structure; however, the term is nonetheless utilized to describe the senior cash flows before they are restructured.

[3]The concepts of average life and duration are discussed in Chapter 11. *Duration* is a measure of the sensitivity of the price of a fixed income instrument to changes in interest rates.

label transactions are created by placing large numbers of loans directly in a securitization vehicle, from which the structured transaction is subsequently created by the issuer. (This accounts for why these transactions are sometimes referred to as "whole loan CMOs.")[4] While the agency transaction is an arbitrage of sorts, the private-label securitization serves as the process by which loans are directly distributed into the capital markets.

A different subset of the MBS sector is the market for ***mortgage strips***, or more precisely the market for principal-only and interest-only securities. Since mortgages are comprised of both principal and interest, the two components can be separated and sold independently. The holder of the ***principal-only security*** (PO) receives only principal (scheduled and unscheduled) paid on the underlying loans. The holder of the ***interest-only security*** (IO) receives the interest generated by the underlying loans. Although IOs are quoted with a principal balance, this balance is notional in nature; it is used only as a point of reference for settling the transaction and calculating monthly interest cash flows generated by the security. The most common mortgage strips are created simply by putting agency pools into a trust and splitting principal and interest cash flows into IOs and POs. (Note that IOs in this context should not be confused with interest-only loans discussed in Chapter 1; the two concepts are totally different, even though they do share some of the same nomenclature.)

The market for mortgage strips developed to allow MBS investors a means of trading directly on prepayment speeds and expectations. POs typically have long positive durations and rise in value when rates decline, while IOs generally have negative durations, increasing in price when rates rise. However, the critical driver of performance strips is prepayment expectations. POs perform well if prepayment speeds are fast, in the same way that returns would be enhanced if a zero-coupon bond were called prior to maturity at par. By contrast, IOs perform well if prepayment speeds are slow; they can be viewed as an annuity where the value increases the longer it remains outstanding.

While IOs and POs are most commonly created in trust form, both types of bonds can also be created as part of a CMO deal. Structured IOs and POs have a similar appeal to investors as strips and are evaluated in a similar fashion. They are created as part of the process of structuring certain bonds with a targeted coupon or dollar price. If an investor seeks a bond with a lower dollar price, for example, the coupon on the bond must be

[4]CMOs are also referred to as *real estate mortgage investment conduits*, or REMICs. The terminology refers to a provision in the Tax Reform Act of 1986 in order to remedy some double taxation inefficiencies inherent in earlier collateralized structures. While the term REMIC is essentially a tax election, often the terms CMO and REMIC are used interchangeably.

reduced; this can be accomplished by stripping some coupon off the tranche in question and selling it as a structured IO. We discuss this topic in more depth in Chapter 7.

Agency MBS Creation

While both agency adjustable rate pools and private-label securities have existed for many years, the agency fixed rate market remains the most widely quoted and liquid benchmark in the MBS market. Therefore, a discussion of pooling practices and the securitization process logically begins with the formation of fixed rate agency pools. In this section, we first address the basics of agency fixed rate pools, which dictate to a large extent how such pools are created. Subsequently, we discuss the creation of ARM pools, which have many similarities to fixed rate products but are pooled quite differently.

Fixed Rate Agency Pooling

Agency fixed rate MBS are traded according to their coupons, which are normally securitized in 50 basis point increments. There are liquid markets in both even coupons and half-coupons (e.g., 6.0% and 6.5%), although quarter- and eighth-coupon pools are sometimes originated. Loans, by contrast, are normally originated in increments of 12.5 basis points (or 1/8th of a percent). As part of the transformation process, certain cash flows from the loan interest stream are allocated for servicing and credit support payments. These apportionments are as follows:

- *Guaranty fees* ("g-fees") are, as described earlier, fees paid to the agencies to insure the loan. Since these fees essentially represent the price of credit risk insurance, g-fees vary across loan types. G-fees vary depending on the perceived riskiness of the individual loans (based on credit metrics such as credit score, LTV, and documentation described in Chapter 1). However, high-volume lenders have in the past been able to negotiate generally lower guaranty fees. For Ginnie Mae pools, the guaranty fee is almost always six basis points, reflecting the loan-level guarantees provided by the Federal Housing Administration and Veterans Administration.
- *Required servicing* or *base servicing* refers to a portion of the loan's note rate that must be held by the servicer of the loan. 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. (At this

writing, base servicing is 25 basis points in the fixed rate pass-through market.)

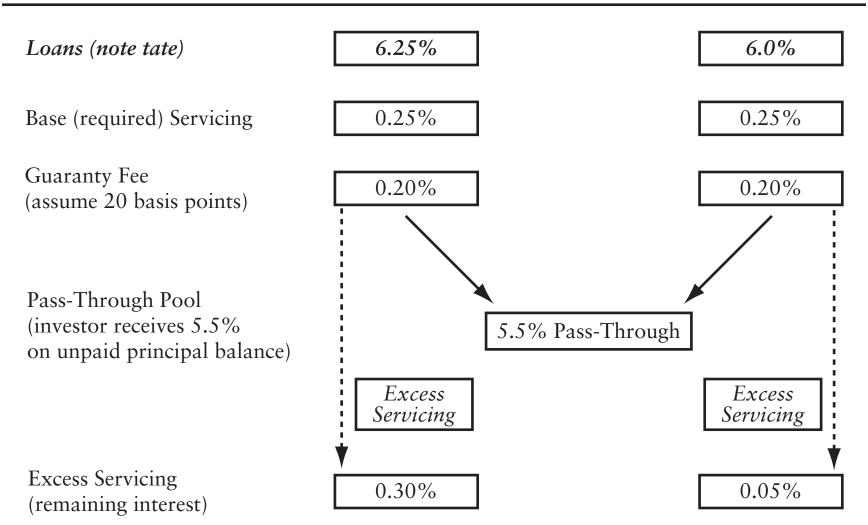
- *Excess servicing* is the amount of the loan's note rate in excess of the desired coupon remaining after the g-fees and base servicing are subtracted.

Both base and excess servicing (sometimes described as *mortgage servicing rights* or MSRs) can be capitalized and held by the servicer after the loan is funded. However, secondary markets exist for trading servicing, either in the form of raw mortgage servicing rights or interest-only securities created from excess servicing.

A simple schematic showing how two loans with different fixed note rates can be securitized into a 5.5% agency pass-through pool is shown in Exhibit 2.1. For both loans, the amount of base servicing and guaranty fee is the same, with the difference being the amount of excess servicing created by the issuer. This diagram ignores some of the complexities of pooling, however, which will be addressed later in this section.

General pooling practices in the fixed rate market mandate that the note rate of the loans must be greater than the pool's coupon. However, loans with a wide range of note rates can be securitized in pools. For example, Freddie Mac and Fannie Mae allow the note rate to be as much as 250 basis

EXHIBIT 2.1 Cash Flow Allocation for a 5.5% Agency Pass-Through Pool for Loans with Different Note Rates



points higher than the coupon rate.[5] Pooling economics normally dictate that the note rate of the loan is between 25 and 75 basis points higher than the coupon rate, since retaining large amounts of excess servicing is generally uneconomical. In addition, guaranty fees can be capitalized, or "bought down," and paid as an up-front fee to the GSE at the loan's funding. This typically occurs when the lender wishes to create pools with relatively high coupon rates (e.g., pool a 6.25% loan into a 6.0% pool) based on market conditions, a practice known as "pooling up." (Naturally enough, pooling this loan into a 5.5% pool would be called "pooling down.") Because of the base servicing requirement, however, at this writing the spread between a loan's note rate and pooling coupon cannot be less than 25 basis points.

Once large numbers of loans are funded, lenders will aggregate loans with the same coupon in order to form pools. To create a pool, the lender effectively transfers loans earmarked for a particular coupon to the agency and receives the same face value of MBS in exchange. The MBS received may consist of a pool collateralized by only its loans, or it may be part of a multi-issuer pool. After receiving the security, the lender can either sell the pool into the secondary market or (in the case of a depository) hold it in its investment portfolio.

The GSEs also buy loans for cash proceeds through what is called, appropriately enough, the *cash window*. This is often used for loan programs with unusual specifications such as certain documentation styles or loan-to-value ratios, as well as by smaller lenders that engage in piecemeal sales. Loans purchased through the cash window can either be securitized in multi-issuer pools or retained in the GSEs' portfolios.

Adjustable Rate Agency Pooling

As noted earlier in this section, pooling practices in the agency ARM market are currently somewhat different. As in the fixed rate market, a standard amount of base servicing is held on each loan, and guaranty fees are assigned and paid on the loans based on each loan's perceived riskiness. (Base servicing in the ARM market has historically been 37.5 basis points.) The lender's current production, with loans having a range of note rates, is then pooled, with the pool's coupon being an average of the net note rates in the pool weighted by the loans' balances. This is referred to as having a *weighted average coupon* or WAC coupon. Using this methodology means that:

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[5]Ginnie Mae pooling rules depend on the program used to securitize the loans. The Ginnie I program, where the majority of loans are pooled, requires that the note rate be 50 basis points over the coupon rate. The multi-issuer Ginnie II program allows the note rate to be up to 150 basis points higher than the coupon.

- No excess servicing is held in order to decrease the net note rates of the loans to a targeted level.
- G-fees are generally not bought down, since buydown pricing is not efficient in the ARM sector.
- Pools will contain loans with note rates below the coupon rate.
- The pool's coupon rate will change slightly every month, even if the pool is composed of hybrid ARMs where the initial note rate is fixed for a period of time. This occurs as some loans comprising the pool are either paid off or liquidated.

There are important implications of this different pooling methodology. ARM pools typically are originated with uneven coupons taken to three decimal places (e.g., a pool might have an initial coupon of 5.092%). In addition, coupon rates on ARM pools (and, in fact, any security with a WAC coupon) change slightly over time, as noted above. The result of these factors is that agency ARMs trade on a pool-specific basis, rather than by specific coupons as in the fixed rate universe. (There have been a number of initiatives designed to create ARM securities that can trade in forward markets more like those of the fixed rate universe, although none have yet been adopted in a broad fashion.)

Private-Label Securitization

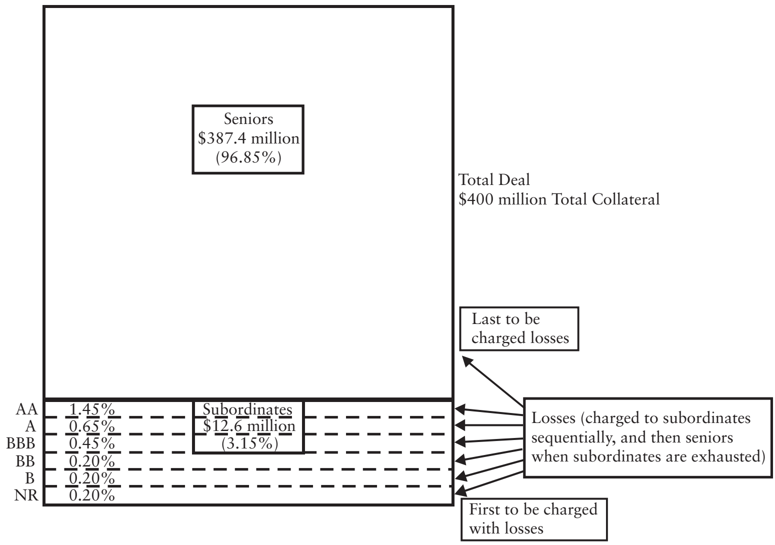
While the creation of private-label deals is conceptually similar to agency pooling practices, the lack of involvement by the agencies necessitates significant differences. Since there is no backing from either the government or the GSEs, alternative forms of credit enhancement must be utilized. As the market for private-label securitizations is, at this writing, fairly dormant, the following paragraphs describe how such deals have been structured in the fairly recent past. Given that market conditions and regulatory standards continue to evolve, the future form of such deals remains unclear. However, it is reasonable to expect that the characteristics of such deals will be fundamentally consistent with those transactions created in the recent past.

Private credit enhancement is most commonly created in the form of ***subordination***, which means that a portion of the deal is subordinate or "junior" in priority of cash flows, and is the first to absorb nonrecoverable losses in order to protect the more "senior" tranches. A common technique is to divide the subordinated part of the deal into different tranches, each with different ratings (which typically range from double-A to unrated first-loss pieces) and exposure to credit losses. (For example, the nonrated "first-loss" tranche is the first to absorb losses; if this tranche is exhausted, the losses are then allocated to the tranche second-lowest in initial priority.) The amount of subordination, as well as the size of each subordinated tranche, has historically been assigned by the rating agencies as part of the process of structuring each transaction. Subordinate tranches trade at significantly higher yields than the seniors to compensate investors for the incremental riskiness and greater likelihood of credit-related losses.

Exhibit 2.2 shows an example of a senior–subordinate deal structured in this fashion. The amount of subordination required for a deal and the relative sizes of the different subordinate tranches (often referred to as the "splits") are dictated by the rating agencies, based upon their assessment of the likelihood of losses for the subject collateral. Prior to being structured, the senior portion of the deal in the example has cash flows that are very similar (but not identical) to agency pools, as noted previously. These private-label pass-throughs are sometimes sold directly in unstructured form, although it is more common to see them restructured into tranches using the techniques we explore in Chapter 8.

Deals with subordination (also called *senior–sub deals*) typically have an additional feature designed to insure the adequacy of credit enhancement levels. All unscheduled principal payments (i.e., prepayments) are initially directed to the senior tranches, and the subordinates are locked out from prepayments (although they do receive scheduled principal payments, or amortizations). This feature causes the subordination (as a percentage of the deal) to grow over time, and increases the degree of protection for the

EXHIBIT 2.2 Diagram of a Senior–Subordinate Structure



senior sector. The subordinates eventually begin to receive some unscheduled principal payments (although the actual schedule depends on the type of collateral), and ultimately receive prepayments pro rata with their size. The technique is referred to as ***shifting interest***, and deals with this type of subordination are commonly called *shifting interest structures*. Such structures are typically backed by prime quality loans that require relatively low levels of credit support.

Other variations of the senior–subordinate structure are used in the MBS markets, especially for subprime and other loans that have a greater degree of credit risk. Some deals are structured such that there is more loan collateral than bonds in a deal, lending additional credit support to the senior bonds (in addition to some subordinate classes). This structuring technique, utilized for loans perceived to have a higher risk of default, is referred to as ***overcollateralization*** (OC) and deals structured in this fashion are referred to as *OC structures*. (We more fully address techniques of credit enhancement and subordination in Chapters 8 and 9.)

As with agency ARM pools, private-label deals typically securitize a wide range of note rates due in part to the desire of issuers to capitalize on economies of scale by issuing large deals. However, the market for fixed rate securities is generally not receptive to WAC coupons, since fixed coupons are much easier and more convenient for operations and accounting systems to manage. In order to create a fixed coupon rate in shifting interest deals, the loan collateral must be modified before the credit enhancement is structured. This technique is somewhat different from that utilized in creating agency pools. Both the range of note rates included in a deal, as well as the need to include loans with note rates below the deal's coupon (once base servicing and fees are taken into account), necessitate the creation of WAC IOs and POs, securities unique to the private-label market.

The decision with respect to which coupon is to be produced is a function of market conditions, including investor's interest rate and prepayment outlook. Once the coupon is designated, the loans are divided into "discount" and "premium" loan groups. This calculation subtracts the base servicing and fees from each loan's note rate to create the net note rate. The net note rate is then compared to the deal's designated coupon. Discount loans are those loans that have a *net note rate* lower than that of the deal's coupon; premium loans are those where the net note rate is above the deal coupon.

At this point, the two loan groups are each structured to give them the deal's coupon. The discount loans are "grossed up" to the deal's coupon rate by creating, for each note rate, a small amount of PO.[6] The amount of

[6]By creating some PO for each strata, the available interest is allocated over a smaller amount of principal, effectively raising its net note rate to that of the deal coupon.

PO created for each rate stratum is computed based on the *PO percentage*, which is calculated as follows:

PO percentage = [Deal coupon – Note rate] ÷ Deal coupon

The PO percentage for each note rate stratum is then multiplied by its face value, and the sum of the POs created for all discount note rates is the size of the WAC PO.

The loans in the premium loan group are stripped of some of the interest in order to reduce their net note rates to that of the deal coupon. The interest strip is assigned a notional value equal to the face value of the stratum. As an example, assume that $20 million face value of loans has a 6.5% note rate, and the designated deal coupon is 6.0%. Assuming 25 basis points of base servicing and no fees gives it a 6.25% net note rate. Therefore, 25 basis points of interest is stripped from these loans, creating $20 million notional value of a strip with a coupon of 0.25%. The notional value of the WAC IO is simply the combined notional value of all loans having premium net note rates, and its coupon is the average of the strip coupons weighted by their notional balances. (Note that in some cases the strip cash flows generated by the premium loans are held by the originator in the form of excess servicing, rather than securitized into a WAC IO.)

The breakdown and grouping of loans backing a hypothetical private-label deal, and the structuring of the loans into a pool with one fixed coupon rate, is shown in Exhibit 2.3. The exhibit shows the calculations for a package of loans with various note rate strata for a deal with a 5.75% coupon, assuming 25 basis points of base servicing and 0.9% trustee fee (which are both standard assumptions at this writing). All loans with note rates of 6.125% and higher are considered premium loans, since they will have a net note rate higher than the 5.75% cutoff; loans with note rates below 6.125% are classified as discount loans. Notice that changing the deal's coupon changes the sizes of the WAC IO and PO, as well as the WAC IO's coupon. In the example, lowering the deal coupon to 5.5% pushes $82 million face value of loans, with note rates of 5.75% and 5.875%, into the premium sector, increasing the WAC IOs notional face value from $333.5 million to $415.5 million. The face value of the WAC PO declines, however, from approximately $7.21 million to $2.72 million. Therefore, the "market conditions" influencing the choice of coupon include the preferences of investors for premium or discount coupons, as well as the relative demand for IOs and/or POs.

EXHIBIT 2.3 Example of Loan Stratification and Coupon Creation for a Hypothetical Private-Label Deal (assuming 25 basis points base servicing, 0.9 basis points trustee fee, and a 5.75% security coupon)

	Note Rate	Net Note Rate[a]	Balance in Cohort	Difference—Net Note Rate and Coupon	Net Contribution to WAC[b]	PO %[c]	PO % × Balance	Face Value Added to WAC IO
Discount Loans	5.000%	4.741%	500,000	–0.0101	0.0000	17.5%	87,739	0
	5.125%	4.866%	2,600,000	–0.0088	0.0000	15.4%	399,722	0
	5.250%	4.991%	5,000,000	–0.0076	0.0000	13.2%	660,000	0
	5.375%	5.116%	8,000,000	–0.0063	0.0000	11.0%	882,087	0
	5.500%	5.241%	16,400,000	–0.0051	0.0000	8.9%	1,451,757	0
	5.625%	5.366%	21,000,000	–0.0038	0.0000	6.7%	1,402,435	0
	5.750%	5.491%	31,000,000	–0.0026	0.0000	4.5%	1,396,348	0
	5.875%	5.616%	37,000,000	–0.0013	0.0000	2.3%	862,261	0
	6.000%	5.741%	45,000,000	–0.0001	0.0000	0.2%	70,435	0
Premium Loans	6.125%	5.866%	55,000,000	0.0012	0.0012	0.0%	0	55,000,000
	6.250%	5.991%	70,000,000	0.0024	0.0024	0.0%	0	70,000,000
	6.375%	6.116%	41,000,000	0.0037	0.0037	0.0%	0	41,000,000
	6.500%	6.241%	42,000,000	0.0049	0.0049	0.0%	0	42,000,000
	6.625%	6.366%	37,000,000	0.0062	0.0062	0.0%	0	37,000,000
	6.750%	6.491%	30,500,000	0.0074	0.0074	0.0%	0	30,500,000
	6.875%	6.616%	22,000,000	0.0087	0.0087	0.0%	0	22,000,000
	7.000%	6.741%	21,000,000	0.0099	0.0099	0.0%	0	21,000,000
	7.125%	6.866%	8,000,000	0.0112	0.0112	0.0%	0	8,000,000
	7.250%	6.991%	4,000,000	0.0124	0.0124	0.0%	0	4,000,000
	7.375%	7.116%	3,000,000	0.0137	0.0137	0.0%	0	3,000,000
						Total	7,212,783	333,500,000
	Total Deal Size		500,000,000					
	WAC IO Size[d]		333,500,000					
	WAC PO Size[e]		7,212,783					

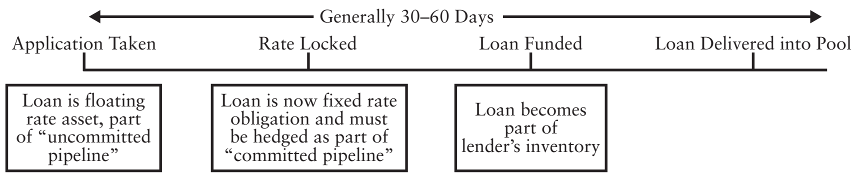
[a] Note rate less base servicing and trustee fee.
[b] For premium loans, the net contribution is defined as Net note rate – Security coupon. It is 0 for discount loans.
[c] For discount loans, the PO percentage is defined as (Security coupon – Net note rate)/Security coupon.
[d] The face value of the WAC IO is the sum of the face value of the premium loans.
[e] The face value of the WAC PO is the sum of the face value of the discount loans times the PO percentage.

MBS TRADING

The structure of the MBS markets has long reflected the practices of both originators and borrowers in the primary mortgage market. This discussion is facilitated by a brief overview of the timeline of a mortgage loan, illustrated in Exhibit 2.4. A loan begins as an application, which may either be associated with a designated rate (making the loan "locked" or "committed") or carried as a floating rate obligation (to be locked at a point prior to funding). Borrowers that lock their loan at the time of application pay slightly more for their loans (in terms of either a rate differential or slightly higher fees) to account for the cost of hedging the loan for the period between application and funding. Most importantly, there is a lag between the points in time when borrowers apply for their loans and the loans are funded that lenders must take into account in managing their book of business, or *pipeline*. This lag reflects the time necessary for lenders to underwrite the loan and process the paperwork, which includes appraisals, title searches and insurance, geological and flood surveys, and credit analysis. In addition, purchase transactions often require additional time to process and register the underlying real estate transaction.

The lag between application and funding, which varies depending on the type of loans and market conditions, allows lenders to sell their expected production for settlement in the future. However, it also forces lenders to manage and hedge their production pipeline in order to control the variability of their proceeds and maximize their profitability. While hedging a loan pipeline is similar in concept to hedging other portfolios, it requires lenders to continuously be aware of the flow of new applications (which adds to the position) as well as so-called "fallout," which occurs as some borrowers allow their loan applications to lapse. A fairly consistent amount of loans will fall out under all circumstances, reflecting transactions that fail to close for a variety of reasons. Such reasons often include an applicant's inability to qualify for the loan being sought, due to credit or other financial considerations. However, fallout of committed loans can change sharply if lending rates fluctuate. For example, a drop in rates typically causes an increase in

EXHIBIT 2.4 Timeline of Loan From Application to Agency Pooling



the number of loans that fall out, as applicants let their existing application lapse and apply for new loans. In the same fashion as negative convexity discussed in Chapter 1, changing fallout rates complicate the process of hedging by making changes in the pipeline's value nonlinear with respect to interest rates.

The need for lenders to sell their expected production for future settlement has resulted in the MBS market being structured as a so-called "forward market." In a forward market, a trade is agreed upon between two parties at a price for settlement (i.e., the exchange of the item being traded for the agreed-upon proceeds) at some future date.

MBS Market Structure

The MBS market has evolved a number of conventions unique to the needs of both mortgage originators and investors. For example, settlements occur each month according to a predetermined calendar that specifies the delivery date for a variety of products over the course of each month. (The calendar is developed by the Securities Industry and Financial Markets Association [SIFMA] and published roughly six months in advance.) Prices are typically quoted for three settlements months (e.g., a quote sheet in March would post prices for April, May, and June settlement). However, trades can be executed farther in the future, subject to accounting and counterparty risk considerations.

Transactions in fixed rate pass-through securities can be effected in one of three ways:

- *A preidentified pool or pools can be traded.* In this type of ***specified pool trade***, the pool number and "original balance" of the pool (i.e., the amount of the pool as if it were a brand-new pool, before the effects of paydowns) are identified at the time the transaction is consummated.
- *A **to-be-announced (TBA) trade**.* In this case, the security is identified (e.g., Fannie Mae 6.0s) and a price is set; but the actual pools' identities are not provided by the seller until just before settlement. (This process is referred to as *pool allocation*.) The attributes of the pools that are eligible for delivery into TBA trades is specified by the BMA in order to effect a degree of standardization.
- *A **stipulated trade**.* This is a variation on a TBA trade, but the underlying characteristics of the pool are specified more precisely than in a standard TBA trade. In some cases, the pools in a stipulated trade are not deliverable, under SIFMA rules, into TBA-eligible pools. In other instances, the pools can be delivered, but are viewed as having incremental value to investors and trade at a premium to TBAs.

The TBA market only exists, at this writing, in the fixed rate market for agency pools. As noted previously, there is currently no equivalent to the TBA in the ARM market for conventional ARMs because of the wide variety of product types and specifications in the ARM market. (There has been a TBA market in the Ginnie ARM product, but trading in that sector became fairly illiquid in the late 1990s.) ARM products trade almost entirely as either specified or stipulated (or "stipped," as it is sometimes called) pools, although they generally settle based on "good-day" delivery specified by the SIFMA calendar. Both agency CMO and private-label deals are typically settled around the end of the month; secondary trading for these products typically occurs for settlement three business days after the trade is executed, for so-called "corporate settlement."

Financing and the Dollar Roll Market

An interesting attribute of forward markets that has appeal to MBS participants is the fact that they implicitly create a built-in financing vehicle. The forward market mechanism allows trading in the same securities for settlement in different months. As noted, originators generally sell their production for forward settlement in order to monetize and hedge their pipelines. However, there is also demand for MBS pools for settlement in the early or "front" months. For example, some types of investors, such as depository institutions, generally put securities on their books rather than forward obligations, which may not receive favorable accounting treatment. In addition, dealers acquiring agency pools as collateral for agency CMO deals must take delivery of the pools before their structured transaction settles. Therefore, MBS trading involves pricing the same securities for different settlement dates. This means that dealers make active markets in TBAs for different settlements, simultaneously buying positions for one settlement month and selling the identical position for another. This type of transaction is known as a ***dollar roll*** or simply a "roll."

Simply put, valuing dollar rolls involves weighing the benefits and costs, over a holding period, of either:

1. Buying the security for the front month, and owning (and financing) it for the period ending with the latter (or "back" month) settlement date.
2. Buying the security for the back month's settlement.

In the first case, where the security is bought for the front month, the investor receives coupon payments and reinvested interest for the holding period, along with principal payments (both amortizations and prepaid principal). The investor must also finance the position, typically through the repurchase market. In theory, the back month price is such that the investor is indifferent between the two alternatives. In practice, the price difference (or "drop") between the two settlement dates is often greater than that implied by the breakeven calculation due to supply–demand imbalances. This means that the investor buying the position for back-month settlement is effectively financing the security at an implied repo rate lower than that available in the repurchase market. The trade-off is illustrated in Exhibit 2.5, which compares the total holding period proceeds garnered by buying in the front month and holding the security to the horizon vis-à-vis buying the bonds in the back months.

The factors that impact roll valuations are:

- The attributes of the security (including its coupon and, to a lesser extent, its age and WAC).
- The length of the holding period (i.e., the number of calendar days between the two settlement dates).
- The assumed prepayment speed.
- The cost of funding in the repo market.

When the drop expands beyond the implied cost of funds and the roll offers subrepo financing, it is referred to as trading "special." This condition can be caused by a number of factors, including:

- Heavy issuance by originators in the back month, pushing down the price for that settlement date.
- Demand for MBS from investors that prefer to have securities (as opposed to forward-settlement TBA transactions) on their books.
- Strong demand in the front month for deal collateral, pushing up the front month price.
- A shortage of a particular security in the market. If a dealer fails to make delivery against a sale, they must pay accrued interest to the seller on the face value of the sale, while not receiving any interest for the long position; "failing" on a trade is thus very expensive. This forces the dealer (or, in some cases, multiple dealers) to buy the security for delivery in the front month, which drives up the front month price and exacerbating the specialness of the roll. (A shortage can occur either because of unanticipated low issuance of a security, or the unwillingness of investors to roll them.)

Strictly speaking, MBS dollar rolls trade as an adjunct to the TBA market in the fixed rate sector. However, all sectors in the MBS market can be traded for a variety of settlements; an ARM pool, for example, can be priced

EXHIBIT 2.5 Example of Calculation of Dollar Rolls

Security Assumptions

Coupon	6.0%
WAC	6.50%
WAM	358
Age	2
June price	100-24/32s
July price	100-19/32s
Drop (roll)	5/32s
Front-month settlement date (June)	6/13/2006
Back-month settlement date (July)	7/13/2006
Assumed prepayment speed (in CPR)	15%
(E) Assumed funding rate	5%
Delay days	24

Roll (Buy for July Settlement)

Proceeds at July price	$1,007,500
Number of days accrued	*13*
13 days of accrued interest at 6%	$2,000
Total invested	$1,009,500
Holding period (number of days between settlement dates)	*30*
(A) Reinvestment income[a]	$4,206
(B) Total future value—Rolling	$1,013,706
(D) Dollar Advantage (B–C)	**$915**
Roll special (in 32s)	3/32

Hold (Buy for June Settlement, Sell for July Settlement)

Future value of cash flows[b]	$19,323
July principal value	$991,497
July holding period	12
Accrued interest received for sale in July	$1,971
(C) Total future value	$1,012,791
Cash Flows	
June principal payment	$14,355
June coupon interest payment (at 6.0%)	$5,000
Total June cash flow (received on July 25)	$19,355
Remaining balance on $1 million original balance in July (at 15% CPR)	$985,645

Calculating Breakeven Cost-of-Funds

Reinvestment income to breakeven to hold scenario (A–D)	*$3,291*
(F) Reinvestment rate to receive same proceeds as holding[c]	*3.912%*
Total future value at breakeven reinvestment rate	*$1,012,791*
Roll Special (in basis points) (E–F)	*108.8*

[a] The holding period is the period between 6/13/06 and 7/13/06 since the proceeds of a July purchase can be invested for that period of time.

[b] Because of delay days, cash flows for pools held on the June record date are paid on July 25; the future value calculation discounts these cash flows back to the July settlement date at the funding rate.

[c] This rate is the breakeven rate that changes the reinvestment proceeds such that the future values for both scenarios are the same.

for a number of different settlements, and originators can look to roll existing trades forward if they have difficulty funding enough loans to fill a trade. The calculation is similar to that done in the dollar roll market. Here, however, the price drop between regular and extended settlement is calculated based on the bond's coupon, expected prepayment speed, and expectations for repo rates over the horizon period.

The availability of the roll market and the potential for below-market funding often gives TBAs an intrinsic advantage over other products in the MBS sector. For example, an investor comparing a specified pool to a TBA when rolls are special must account for the opportunity cost of eschewing the below-market financing available in the TBA market in valuing the alternative security. By implication, nonrolling MBS must trade more cheaply relative to TBAs during periods when dollar roll specials offer attractive financing rates.

THE ROLE OF THE MBS MARKETS IN GENERATING CONSUMER LENDING RATES

An ancillary benefit of the growth in the MBS sector and the integration of consumer mortgage markets is the increased rationality of loan pricing to the consumer. As the mortgage market has become increasingly national in scope over the years, the influence of local supply and demand conditions has become less important in determining market-clearing rates. At the same time, the importance of capital markets in the loan funding and risk transfer process has grown. Consequently, consumer borrowing rates have become directly linked with capital market rates and flows, as well as investor demand for the associated securities. In this section, we examine some of the links between the pricing of mortgage products to the consumer and developments in the capital markets. We initially use the fixed rate agency MBS markets as an example, and subsequently describe the rate setting processes for products (such as prime jumbo loans) that cannot be securitized in agency pools.

In order to maximize their proceeds, the optimal coupon execution for different note rate strata is regularly calculated by the originator. Optimal execution is a function of the levels of pass-through prices for different coupons, as well as servicing valuations and guaranty fee buydown pricing. Exhibit 2.6 shows two possible execution scenarios for a loan with a 6.25% note rate. In the example, securitizing the loan in the 6.0% pool is the best execution option, since it provides greater proceeds to the lender than by pooling into a 5.5% coupon.

EXHIBIT 2.6 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 bps in both cases—assumes 4× multiple[a]
Excess servicing:			
Amount in basis points	0	30	
Excess servicing value	*0*	*1.2*	4× *multiple for 30 bps for 5.5s*[a]
Guarantee fee buy-up/buydown:			
G-fee buy-up/(down) in basis points[b]	(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*	

[a] 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 utilized by Freddie Mac and Fannie Mae. As a result, the choice of remittance method may also affect the optimal pooling decision.
[b] The example assumes a 20 bps g-fee. Note that the g-fee buydown is paid to the GSE and is, therefore, treated as a negative value.

Once the optimal execution is determined for each note rate strata, the associated points are then calculated. Points are up-front fees paid on the loan by the borrower, and are part of the all-in cost of any loan. (For loans with high note rates, negative points are "charged" or, in actuality, rebated to the borrower.) Points are the true expression of loan pricing by lenders, who typically quote current pricing in rate/point matrices with rates in 12.5 basis point increments. (Within reason, lenders will write loans with a wide range of note rates, but charge or rebate different points depending on the note rate.) 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 2.7 shows a hypothetical calculation of points for loans with 6.25% and 6.625% note rates, assuming that the best execution for both rate strata would be as 6.0% pools. 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. Note that in order to securitize the 6.25% loan in a 6.0% pass-through, the guaranty fee must be bought down, as described previously. In practice, points would be simultaneously calculated for many rate levels, and would subsequently be posted in a rates–point matrix used to quote rates.

The calculation of the optimal MBS coupon for loans that cannot be securitized in agency pools bears a strong resemblance to that of agency-eligible loans, although some variables differ in practice (if not in concept). Valuing the cost of credit enhancement is one major difference between the sectors. Since the loans are not pooled into any of the agency programs, there is no guaranty fee calculation. As credit enhancement generally takes the form of subordination, the weighted average price of the various subordinate classes is taken into account in calculating valuation levels.

However, the calculation for evaluating the optimal coupon for jumbo and other nonagency securitizations is conceptually similar to that used for conforming loans bound for agency pools, in that the exercise involves evaluating various components of the loan. In this case, the components would include:

- The price of the senior securities, generally quoted as a price spread behind similar coupon FNMAs (hence, the terminology of "x 32nds behind FNMAs").
- The weighted average price of the subordinate bonds.
- Proceeds realized from the sale of excess servicing, typically in the form of the WAC IO (for premium loans).
- The size and valuation of the WAC PO (for discount loans).

EXHIBIT 2.7 Sample Calculation of Points Given a Lending Rate (all levels hypothetical)

Note rate	6.25	6.625	Comments
Optimal pass-through coupon[a]	6.0	6.0	
MBS pass-through price	101	101	
Servicing values:			
Base servicing (2)	1.0	1.0	25 basis points, assuming a 4× multiple
Excess servicing (net of guaranty fee)[b]	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. 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

[a] Determined by the methodology described in Exhibit 2.6.
[b] 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.

Once levels are established for each component, the optimal coupon can be selected for a deal. Unlike in the conforming agency market, where execution is calculated for each note rate strata, the optimal coupon for a jumbo deal is determined across note rates for the period under consideration. As described previously, this allows issuers to capitalize on economies of scale and spread the fixed costs of securitizations across as large a deal as possible.

After the securitization coupon is established, points are calculated for each note rate strata. As with the optimal execution calculation, however, the variables are somewhat different, reflecting the different forms that credit enhancement takes in the jumbo market, different valuations techniques for the excess coupon generated by premium loans, and the ability to include discount loans in the pool through the creation of the WAC PO.

Note that during periods where the nonagency securitization market is dormant, lenders must use alternative means in order to price jumbo and agency-ineligible loans. Even when the nonagency market has operated efficiently, however, pricing of the various components is less transparent than that of agency-eligible loans. This is because the various private-label components are less liquid and more difficult to value. In agency securitizations, by contrast, prices for various TBA coupons are widely disseminated, and guaranty fees are dictated by Freddie Mac and Fannie Mae.

There have been some interesting historical shifts with respect to the securitization of loans with nontraditional attributes. (These loans represent the alt-A product described in the previous chapter.) This market grew fairly rapidly in the late 1990s, and loans were typically securitized in private-label structures irrespective of their balance. Around 2000, the GSEs began to offer guaranty fees on a wider variety of product attributes, and subsequently increased their market share of conforming-balance loans with alternative characteristics. By mid-2004, however, private-label conforming-balance deals became widely accepted in the capital markets. At that point, the choice of securitization vehicle for loans with alternative attributes began to be driven by best-execution considerations. The key trade-off was the relative cost of credit enhancement through either the guaranty fee charged by the GSEs or the costs of subordination (which included both the size and pricing of the subordinate tranches). These trade-offs created an additional layer of complexity for lenders attempting to price such loans for the consumer.

CASH FLOW STRUCTURING

As noted previously, the cash flows generated by agency pools and senior private-label pass-throughs are similar in nature. Both securities can be structured to take advantage of demand for a variety of bonds by different segments of the fixed income investment community. Various investor clienteles have different investment objectives and risk tolerances, and thus tend to invest in securities with different cash flow and performance attributes. Some different market segments include:

- Banks and other depository institutions, which generally seek short securities where they can earn a spread over their funding costs.
- Life insurance companies and pension funds, which typically invest in bonds with longer maturities and durations in order to immunize long-dated expected liabilities.
- Investment managers, who typically manage fixed income assets versus performance indexes.
- Hedge funds, which typically seek investment vehicles that offer the potential for very high leveraged returns.

The nature of mortgage cash flows makes mortgage loans and mortgage-backed securities ideal vehicles for creating a variety of bonds. Their long-term principal and interest cash flows allow structurers to create securities of varying average lives and durations in order to meet the needs of different classes of investors. In addition, different structures allow different risks (both prepayment and, for private-label deals, credit) to be transferred within the structure, and creates a rich environment for the wide variety of structures and structuring techniques discussed in Chapters 6 through 9.

However, mortgage structures are closed universes by nature, in that all balances and cash flows generated by the collateral within the structure must be taken into account. For example, a structure where the coupon of one bond is stripped below that of the collateral must allocate the incremental interest cash flows elsewhere in the structure. This shifting of interest cash flows can be done in a number of different forms, as we will discuss in Chapter 7. Another example might be a bond that pays principal to investors based on a schedule. This stabilizes the "scheduled" bond's average life and duration, but cash flow uncertainty is transferred to other bonds in the structure, giving their cash flows greater variability.

Therefore, the process of MBS structuring requires examining and valuing the trade-offs necessary to economically create a variety of bonds designed to meet the needs of multiple investor clienteles. To create a more desirable bond within a structure, for example, the underwriter must be able to sell the enhanced bond (or combination of bonds) at a better valuation than the original tranche, in order to offset the concession that must be given to attract investors to the bond with less-appealing attributes. Understanding the trade-offs involved in structuring therefore requires familiarity with how the different structuring techniques work, and how they impact other bonds within the structure.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Pool
Guaranty Fee
Private Label (senior pass-throughs)
Structured Securities
Tranching
Collateralized Mortgage Obligation (CMO)
Mortgage Strips (principle-only security and interest-only security)
Subordination
Shifting Interest
Overcollateralization (OC)
To-Be-Announced (TBA) Trade
Specified Pool Trades
Stipulated Trades
Dollar Roll

PART Two

Prepayment and Default Metrics and Behavior

CHAPTER 3

Measurement of Prepayments and Defaults

It is essential for participants in the residential mortgage-backed securities market to understand the general prepayment and credit performance nomenclature. The market is characterized by the usage of a variety of terms; some terms describe general phenomena, while others are specific to certain types of loan products and assets. In this chapter, the basic terms used to characterize residential mortgage-related prepayments and losses are discussed. Note that our focus is on describing the terminology and outlining the methodologies used in calculating relevant metrics, while the determinants of prepayment and default behavior will be addressed in a later chapter.

Understanding the terms used in the market to define prepayments and default experience, as well as the methodologies used to generate these metrics, is important for the following reasons:

- Efficient risk-based pricing at the origination level.
- Evaluation of relative value within the MBS sector, as well as across the fixed income universe.
- Effective hedging and management of prepayment and credit risk exposure.
- Ex post performance attribution.

The sharp deterioration in mortgage performance that emerged in late 2006 led to the realization that prepayments and defaults often had related effects on MBS performance, even though they represent very different phenomena. As a result, new terminology has emerged to clarify the different circumstances that result in early returns of principal to investors.

PREPAYMENT TERMINOLOGY

For fixed rate fully amortizing assets, such as fixed rate mortgages, *home equity loans* (HELs), and *manufactured housing loans* (MHs), the monthly scheduled payment, consisting of scheduled principal and interest payments, is constant throughout the amortization term. If the borrower pays more than the monthly scheduled payment, the extra payment will be used to pay down the outstanding balance faster than the original amortization schedule, resulting in a prepayment (or, as it is sometimes referenced, an *unscheduled principal payment*). If the outstanding balance is paid off in full, the prepayment is a *complete prepayment*; if only a portion of the outstanding balance is prepaid, the prepayment is called either a *partial prepayment* or *curtailment*. Prepayments can be the result of natural turnover, refinancings, defaults, partial paydowns, and credit-related events.

The evaluation of prepayments is further complicated by the fact that there is an interplay between defaults, which are effectively *credit-related prepayments*, and prepayments attributable specifically to declining interest rates. In an agency MBS, for example, there have at times been large numbers of seriously delinquent loans in pools for which Freddie Mac and Fannie Mae continued to pay interest and scheduled principal. In 2010, however, the GSEs changed their policies and began buying loans that were 120 days or more delinquent out of pools. These buyouts initially resulted in a surge in prepayment speeds. Moreover, the new policy meant that pools containing large numbers of lower-quality loans would tend to experience consistently faster prepayment speeds than those pools backed by better-credit loans.

In private-label securities, however, prepayments resulting from credit events must be treated differently than those attributable to refinancings. This is because a default means that the investor will probably not receive the entire amount of the defaulted principal, but only the amount recovered after the foreclosure process is completed. Moreover, the timing of payments is also at issue. There is typically a sizeable delay between the time a borrower becomes delinquent on a loan and its ultimate liquidation. This has resulted in the convention where prepayments in private-label securities are separated into ***voluntary*** and ***involuntary prepayments***. Voluntary prepayments occur as a result of a refinancing, the sale of the property, or other events (e.g., the death of the property owner) where the full principal amount is paid immediately to the bondholder. Involuntary prepayments occur as a result of a credit event, for which both the timing and net amount of the principal received is uncertain.

Prepayments and defaults can be analyzed on both the loan and pool level. Loan-level prepayment analysis, which requires detailed loan level information, is more accurate than pool-level prepayment analysis, but is also more computationally intensive. Additionally, this type of analysis allows the inclusion of specific obligor and property characteristics as determinants of prepayments and defaults. Loan-level analysis involves amortizing each loan individually, tracking defaults and prepayments on an individual loan basis and combining these amount to calculate aggregated metrics. Due to the diversity of the characteristics of the underlying loans in most deals, loan level analysis is generally more accurate and has greater predictive capabilities.

Before continuing, note that the following discussion describes the measurement of prepayments in general, without separating voluntary and involuntary speeds. Several conventions have been used to measure MBS prepayment rates: (1) Federal Housing Administration (FHA) experience; (2) the conditional prepayment rate (CPR); and (3) the Public Securities Association (PSA) prepayment convention. While the first convention is no longer used, we discuss it because of its historical significance.

In the earliest stages of the pass-through market's development, prepayments were not measured at all. Rather, cash flows were calculated assuming no prepayments for the first 12 years, at which time all the mortgages in the pool were assumed to prepay. This naive approach (referenced at the time as the "12 years and out" convention) was replaced by the "FHA prepayment experience" approach.

The prepayment experience for 30-year mortgages based on FHA tables on mortgage survival factors was once the most commonly used benchmark for prepayment rates. It called for the projection of the cash flow for a mortgage pool on the assumption that the prepayment rate would be the same as the FHA experience (referred to as "100% FHA"), or some multiple of FHA experience (faster or slower than the FHA's survival experience).

Despite the method's past popularity, prepayments based on FHA experience are not necessarily indicative of the prepayment rate for a particular pool, mainly because FHA survival factors include data for mortgages originated over all sorts of interest rate periods. As prepayment rates are tied to interest rate cycles, a survival factor (which represents an average prepayment rate for loans issued over various cycles) is not very useful in estimating prepayments. Moreover, new FHA tables are published periodically, causing confusion about which FHA table should be utilized. Finally, FHA mortgages are fundamentally different from non-FHA (or "conventional") loans. For example, FHA mortgages are often assumable, while conventional loans typically have due-on-sale provisions. This difference causes FHA statistics to systematically underestimate prepayments speeds for non-FHA loans. Because estimated prepayments using FHA experience may be misleading, the resulting cash flow is not meaningful for valuing pass-throughs.

CALCULATING PREPAYMENT SPEEDS

The first critical step in calculating prepayment speed is to define a prepayment. For the purposes of this discussion, a prepayment is defined as the early return of principal to the investor. By definition, this means that amortization (or *scheduled principal payments*) must be excluded from the calculation, leaving only unscheduled principal payments to be analyzed.

Conditional Prepayment Rate

The approach most commonly used to generate prepayment speeds is to calculate monthly prepaid principal as a percentage of the security's outstanding balance and then annualize that percentage. Most current approaches to prepayment calculations either quote this annualized periodic speed, known as the ***conditional prepayment rate*** (CPR) directly or use it as an input to generate other quotation benchmarks.[1] This methodology is useful in that it allows analysts to both calculate the historical prepayment experience of a security, as well as project prepayment speeds (and thus a security's cash flows) into the future. When used as part of a model to generate projected cashflows, the CPR calculation assumes that some fraction of the remaining principal in the pool is prepaid each month for the remaining term of the mortgage. The advantages of this approach are its simplicity and its flexibility. For example, changes in economic conditions that impact prepayment rates or changes in the historical prepayment pattern of a pool can be analyzed quickly. In addition, the CPR can be used as an input to other models and quotation mechanisms, as noted already.

The CPR is an annual rate. However, because mortgage cash flows are a monthly phenomenon, calculating the CPR requires the generation of a monthly prepayment rate, called the ***single monthly mortality rate*** (SMM). The SMM is the most fundamental measure of prepayment speeds. SMM measures the monthly prepayment amount as a percentage of the previous month's outstanding balance minus the scheduled principal payment. Mathematically, the SMM is calculated as follows:

$$\text{SMM} = \frac{\begin{matrix}\text{Total payment,} \\ \text{including prepayments}\end{matrix} - \begin{matrix}\text{Scheduled interest} \\ \text{payment}\end{matrix} - \begin{matrix}\text{Scheduled principal} \\ \text{payment}\end{matrix}}{[\text{Unpaid principal balance} - \text{Scheduled principal payment}]} \tag{3.1}$$

[1]Also called the *constant prepayment rate*.

For example, if the pool balance at month zero is $10,000,000, assuming an interest rate of 12%, the scheduled principal and interest payments are $2,861.26 and $100,000 in month one, respectively. If the actual payment received by investors in month one is $202,891.25, the SMM rate is 1%, calculated as

$$\text{SMM} = \frac{(202{,}891.25 - 100{,}000 - 2{,}861.26)}{(10{,}000{,}000 - 2{,}861.26)} = 1\%$$

Therefore, if a mortgage loan prepaid at 1% SMM in a particular month, this means that 1% of that month's scheduled balance (last month's outstanding balance minus the scheduled principal payment) has been prepaid.

Given the SMM, a CPR can be computed using the following formula:

$$\text{CPR} = 1 - (1 - \text{SMM})^{12}$$

For example, if the SMM is 1%, then the CPR is

$$\text{CPR} = 1 - (0.99)^{12} = 11.36\%$$

Conversely, CPRs can be converted into SMMs (and thus be used to generate monthly cash flows) through the following formula:

$$\text{SMM} = 1 - (1 - \text{CPR})^{1/12} \tag{3.2}$$

For example, suppose that the CPR used to estimate prepayments is 6%. The corresponding SMM is

$$\text{SMM} = 1 - (1 - 0.06)^{1/12} = 1 - 0.94^{0.08333} = 0.005143$$

PSA Prepayment Benchmark

The ***Public Securities Association (PSA) prepayment benchmark*** is expressed as a monthly series of annual prepayment rates.[2] (While the PSA has changed its name to the Securities Industry and Financial Markets Association, or SIFMA, the benchmark is still referred to as the "PSA prepayment benchmark.") The basic PSA model assumes that prepayment rates are low for newly originated mortgages and then will speed up as the mortgages age or season.

[2]This benchmark is commonly referred to as a "prepayment model," suggesting that it can be used to estimate prepayments. Characterization of this benchmark as a prepayment model is inaccurate. It is simply a market convention.

The PSA standard benchmark assumes the following prepayment rates for 30-year mortgages:

1. A CPR of 0.2% for the first month, increased by 0.2% per year per month for the next 29 months when it reaches 6% per year.
2. A 6% CPR for the remaining years.

This benchmark, referred to as "100% PSA" or simply "100 PSA," is graphically depicted in Exhibit 3.1. Mathematically, 100 PSA can be expressed as follows:

If $t \leq 30$ then CPR = 6% × (t/30)
If $t > 30$ then CPR = 6%

where t is the number of months since the mortgage was originated. Since the CPR prior to month 30 rises at a constant rate, this period is sometimes referred to as the *ramp*, and loans are considered to be "on the ramp" when they are less than 30 months old.

Slower or faster speeds are then referred to as some percentage of PSA. For example, 50 PSA means one-half the CPR of the PSA benchmark prepayment rate; 150 PSA means 1.5 times the CPR of the PSA benchmark prepayment rate; 300 PSA means three times the CPR of the benchmark prepayment rate. This is illustrated graphically in Exhibit 3.2 for 50 PSA, 100 PSA, and 150 PSA. A prepayment rate of 0 PSA means that no prepayments are assumed.

EXHIBIT 3.1 Graphical Depiction of 100 PSA

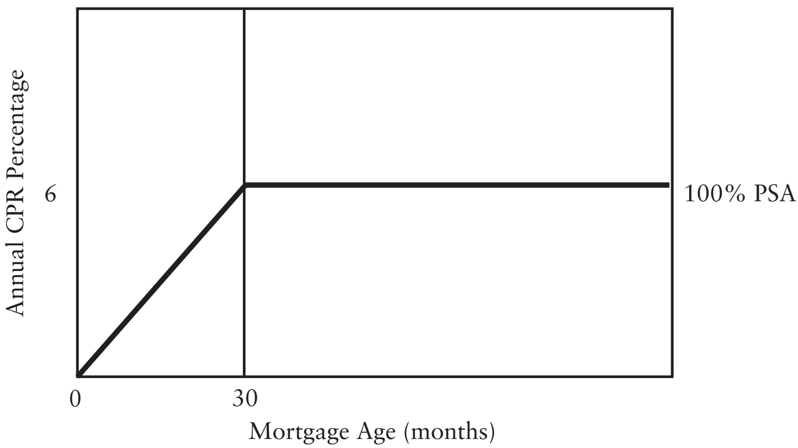
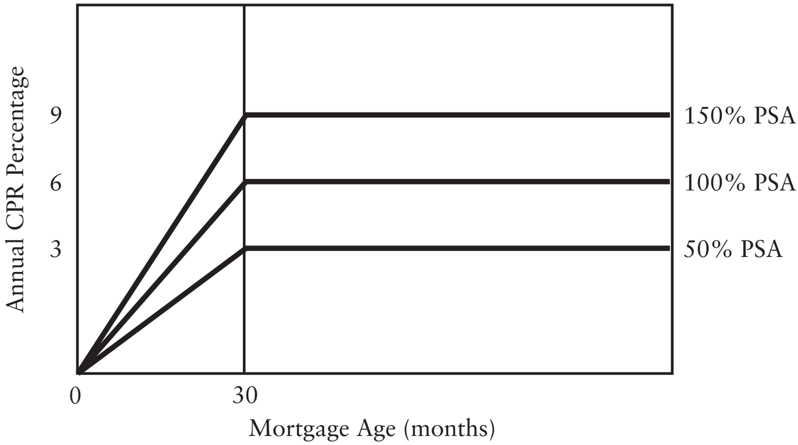


EXHIBIT 3.2 Graphical Depiction of 50 PSA, 100 PSA, and 300 PSA



It is important to note that mortgage pools will typically be comprised of loans having different origination months and, therefore, different ages. In practice, the *weighted average loan age* (WALA) of a pool or security is used as a proxy for its age. However, a large dispersion of loan ages within a pool will distort the PSA calculation.

It is helpful to outline the CPRs and SMMs assumed at different PSA assumptions for different loan ages. Using equation (3.2), the SMMs for month 5, month 20, and months 31 through 360 assuming 100 PSA are calculated as follows:

For month 5:

$$\text{CPR} = 6\%\ (5/30) = 1\% = 0.01$$
$$\text{SMM} = 1 - (1 - 0.01)^{1/12} = 1 - (0.99)^{0.083333} = 0.000837$$

For month 20:

$$\text{CPR} = 6\%\ (20/30) = 4\% = 0.04$$
$$\text{SMM} = 1 - (1 - 0.04)^{1/12} = 1 - (0.96)^{0.083333} = 0.003396$$

For months 31 through 360:

$$\text{CPR} = 6\%$$
$$\text{SMM} = 1 - (1 - 0.06)^{1/12} = 1 - (0.94)^{0.083333} = 0.005143$$

The SMMs for month 5, month 20, and months 31 through 360 assuming 165 PSA are computed as follows:

For month 5:

CPR = 6% (5/30) = 1% = 0.01
165 PSA = 1.65 (0.01) = 0.0165
SMM = $1 - (1 - 0.0165)^{1/12} = 1 - (0.9835)^{0.083333} = 0.001386$

For month 20:

CPR = 6% (20/30) = 4% = 0.04
165 PSA = 1.65 (0.04) = 0.066
SMM = $1 - (1 - 0.066)^{1/12} = 1 - (0.934)^{0.083333} = 0.005674$

For months 31 through 360:

CPR = 6%
165 PSA = 1.65 (0.06) = 0.099
SMM = $1 - (1 - 0.099)^{1/12} = 1 - (0.901)^{0.083333} = 0.007828$

Notice that the SMM assuming 165 PSA is not 1.65 times the SMM at 100 PSA. Rather, the CPR for the pool's age at 100 PSA is multiplied by 1.65 to generate the CPR representing 165 PSA at that age.

The SMMs for month 5, month 20, and months 31 through 360 assuming 50 PSA are as follows:

For month 5:

CPR = 6% (5/30) = 1% = 0.01
50 PSA = 0.5 (0.01) = 0.005
SMM = $1 - (1 - 0.005)^{1/12} = 1 - (0.995)^{0.083333} = 0.000418$

For month 20:

CPR = 6% (20/30) = 4% = 0.04
50 PSA = 0.5 (0.04) = 0.02
SMM = $1 - (1 - 0.02)^{1/12} = 1 - (0.98)^{0.083333} = 0.001682$

For months 31 through 360:

CPR = 6%

$$50 \text{ PSA} = 0.5\ (0.06) = 0.03$$
$$\text{SMM} = 1 - (1 - 0.03)^{1/12} = 1 - (0.97)^{0.083333} = 0.002535$$

Once again, notice that the SMM assuming 50 PSA is not just one-half the SMM assuming 100 PSA. It is the CPR that is a multiple (or, in this case, a fraction) of the CPR assuming 100 PSA.

Illustration of Monthly Cash Flow Construction

We now show how to construct a monthly cash flow for a hypothetical agency pass-through given a PSA assumption. For the purpose of this illustration, the underlying mortgages for this hypothetical pass-through are assumed to be fixed rate fully amortizing mortgages with a *weighted average coupon* (WAC) rate of 6.0%. It will be assumed that the pass-through rate is 5.5% with a *weighted average maturity* (WAM) of 358 months. In Chapters 6 and 7, we will use this pass-through to illustrate structuring techniques utilized in the CMO markets.

Exhibit 3.3 shows the cash flow for selected months assuming 100 PSA. The cash flow is broken down into three components: (1) interest (based on the pass-through rate), (2) the regularly scheduled principal payment, and (3) prepayments based on 100 PSA.

Let's walk through Exhibit 3.3 column by column:

Column 1. This is the month.

Column 2. This column gives the outstanding mortgage balance at the beginning of the month. It is equal to the outstanding balance at the beginning of the previous month reduced by the total principal payment in the previous month.

Column 3. This column shows the SMM for 100 PSA. Two things should be noted in this column. First, for month 1, the SMM is for a pass-through that has been seasoned three months because the WAM is 357 months. This results in a CPR of 0.8%. Second, from month 27 on, the SMM is 0.00514, which corresponds to a CPR of 6%.

Column 4. The aggregate monthly mortgage payments using a 6% note rate are shown in this column. Notice that the total monthly mortgage payment declines over time, as prepayments reduce the mortgage balance outstanding. (In the absence of prepayments, this figure would remain constant.) In essence, the payment is calculated each month as a function of the WAC, the remaining balance at the end of the prior

EXHIBIT 3.3 Monthly Cash Flow for a $400 Million Pass-Through with a 5.5% Pass-Through Rate, a WAC of 6.0%, and a WAM of 358 Months, Assuming 100% PSA

(1) Month	(2) Outstanding Balance	(3) SMM	(4) Mortgage Payment	(5) Net Interest	(6) Scheduled Prinicipal	(7) Prepayments	(8) Total Principal	(9) Cash Flow
1	400,000,000	0.00050	2,402,998	1,833,333	402,998	200,350	603,349	2,436,682
2	399,396,651	0.00067	2,401,794	1,830,568	404,810	266,975	671,785	2,502,353
3	398,724,866	0.00084	2,400,187	1,827,489	406,562	333,463	740,025	2,567,514
4	397,984,841	0.00101	2,398,177	1,824,097	408,253	399,780	808,033	2,632,130
5	397,176,808	0.00117	2,395,766	1,820,394	409,882	465,892	875,773	2,696,167
6	396,301,034	0.00134	2,392,953	1,816,380	411,447	531,764	943,211	2,759,591
7	395,357,823	0.00151	2,389,738	1,812,057	412,949	597,362	1,010,311	2,822,368
8	394,347,512	0.00168	2,386,124	1,807,426	414,386	662,652	1,077,038	2,884,464
9	393,270,474	0.00185	2,382,110	1,802,490	415,758	727,600	1,143,357	2,945,847
10	392,127,117	0.00202	2,377,698	1,797,249	417,063	792,172	1,209,235	3,006,484
11	390,917,882	0.00219	2,372,890	1,791,707	418,300	856,336	1,274,636	3,066,343
12	389,643,247	0.00236	2,367,686	1,785,865	419,470	920,057	1,339,527	3,125,391
13	388,303,720	0.00253	2,362,089	1,779,725	420,571	983,303	1,403,873	3,183,599
14	386,899,847	0.00271	2,356,101	1,773,291	421,602	1,046,041	1,467,643	3,240,934
15	385,432,204	0.00288	2,349,724	1,766,564	422,563	1,108,239	1,530,802	3,297,366
16	383,901,402	0.00305	2,342,961	1,759,548	423,454	1,169,864	1,593,318	3,352,866
17	382,308,084	0.00322	2,335,813	1,752,245	424,273	1,230,887	1,655,159	3,407,405
18	380,652,925	0.00340	2,328,284	1,744,659	425,020	1,291,274	1,716,294	3,460,953
19	378,936,632	0.00357	2,320,377	1,736,793	425,694	1,350,996	1,776,690	3,513,483
20	377,159,941	0.00374	2,312,095	1,728,650	426,296	1,410,023	1,836,319	3,564,968
21	375,323,622	0.00392	2,303,442	1,720,233	426,824	1,468,325	1,895,148	3,615,382
22	373,428,474	0.00409	2,294,420	1,711,547	427,278	1,525,872	1,953,150	3,664,697
23	371,475,324	0.00427	2,285,034	1,702,595	427,657	1,582,637	2,010,294	3,712,889
24	369,465,030	0.00444	2,275,288	1,693,381	427,962	1,638,590	2,066,553	3,759,934
25	367,398,478	0.00462	2,265,185	1,683,910	428,192	1,693,706	2,121,898	3,805,808
26	365,276,580	0.00479	2,254,730	1,674,184	428,347	1,747,956	2,176,303	3,850,488
27	363,100,276	0.00497	2,243,928	1,664,210	428,427	1,801,315	2,229,742	3,893,952
28	360,870,534	0.00514	2,232,783	1,653,990	428,430	1,853,758	2,282,189	3,936,178
29	358,588,346	0.00514	2,221,300	1,643,530	428,358	1,842,021	2,270,379	3,913,909
30	356,317,967	0.00514	2,209,875	1,633,124	428,286	1,830,345	2,258,631	3,891,755
100	223,414,587	0.00514	1,540,329	1,023,984	423,256	1,146,847	1,570,104	2,594,087
101	221,844,483	0.00514	1,532,407	1,016,787	423,185	1,138,773	1,561,958	2,578,745
102	220,282,525	0.00514	1,524,526	1,009,628	423,114	1,130,740	1,553,853	2,563,482
103	218,728,672	0.00514	1,516,686	1,002,506	423,042	1,122,749	1,545,791	2,548,297
104	217,182,881	0.00514	1,508,885	995,422	422,971	1,114,799	1,537,770	2,533,191
105	215,645,111	0.00514	1,501,125	988,373	422,900	1,106,891	1,529,790	2,518,164

EXHIBIT 3.3 (Continued)

(1) Month	(2) Outstanding Balance	(3) SMM	(4) Mortgage Payment	(5) Net Interest	(6) Scheduled Prinicipal	(7) Prepayments	(8) Total Principal	(9) Cash Flow
200	100,719,066	0.00514	919,770	461,629	416,174	515,859	932,033	1,393,662
201	99,787,032	0.00514	915,039	457,357	416,104	511,066	927,170	1,384,527
202	98,859,862	0.00514	910,333	453,108	416,034	506,298	922,332	1,375,439
203	97,937,531	0.00514	905,651	448,880	415,964	501,555	917,518	1,366,399
204	97,020,012	0.00514	900,994	444,675	415,893	496,836	912,730	1,357,405
205	96,107,283	0.00514	896,360	440,492	415,823	492,142	907,966	1,348,457
300	28,001,417	0.00514	549,218	128,340	409,211	141,907	551,118	679,457
301	27,450,299	0.00514	546,393	125,814	409,142	139,073	548,215	674,028
302	26,902,085	0.00514	543,583	123,301	409,073	136,254	545,326	668,628
303	26,356,758	0.00514	540,787	120,802	409,003	133,450	542,453	663,255
304	25,814,305	0.00514	538,006	118,316	408,934	130,660	539,595	657,910
305	25,274,710	0.00514	535,239	115,842	408,865	127,885	536,751	652,593
350	3,725,850	0.00514	424,402	17,077	405,773	17,075	422,848	439,925
351	3,303,002	0.00514	422,219	15,139	405,704	14,901	420,605	435,744
352	2,882,397	0.00514	420,048	13,211	405,636	12,738	418,374	431,585
353	2,464,023	0.00514	417,887	11,293	405,567	10,587	416,154	427,447
354	2,047,869	0.00514	415,738	9,386	405,499	8,447	413,946	423,332
355	1,633,924	0.00514	413,600	7,489	405,430	6,318	411,749	419,237
356	1,222,175	0.00514	411,473	5,602	405,362	4,201	409,563	415,164
357	812,613	0.00514	409,357	3,724	405,294	2,095	407,388	411,113
358	405,224	0.00514	407,251	1,857	405,225	0	405,225	407,082

[a] Since the WAM is 358 months, the underlying mortgage pool is seasoned an average of two months. Therefore, the CPR for month 28 is 6%.

month, and the remaining term (i.e., the original WAM minus the number of months since issuance). For example, the payment in month 10 of $2,376,474 can be generated on a calculator by inputting $391,508,422 as the balance or present value, 0.5% (6.0% divided by 12) as the rate, and 348 months as the remaining term.[3]

Column 5. The monthly interest paid to the pass-through investor is found in this column. This value is determined by multiplying the outstanding mortgage balance at the beginning of the month by the pass-through rate of 5.5% and dividing by 12.

[3]The calculation can also be presented as a series of formulas, which are available in Chapter 21 of Frank J. Fabozzi, *Fixed Income Mathematics: Analytical and Statistical Techniques* (New York: McGraw-Hill, 2006).

Column 6. This column shows the regularly scheduled principal repayment, or amortization. This is the difference between the total monthly mortgage payment [the amount shown in column (4)] and the gross coupon interest for the month. The gross coupon interest is 6.0% multiplied by the outstanding mortgage balance at the beginning of the month, then divided by 12.

Column 7. The dollar value of prepayments for the month is reported in this column. This amount is calculated by using the following equation:

$$\text{Prepayments}_t = \text{SMM}(\text{Beginning principal balance}_t - \text{Scheduled principal balance}_t) \quad (3.3)$$

So, for example, in month 100, the beginning mortgage balance is \$223,414,587, the scheduled principal payment is \$423,356, and the SMM at 100 PSA is 0.00514301 (only 0.00514 is shown in the exhibit to save space), so the prepayment is

$$0.00514301 \times (\$223{,}414{,}587 - \$423{,}356) = \$1{,}146{,}847$$

Column 8. The total principal payment, which is the sum of columns (6) and (7), is shown in this column.

Column 9. The projected monthly cash flow for this pass-through is shown in this last column. The monthly cash flow is the sum of the interest paid to the pass-through investor [column (5)] and the total principal payments for the month [column (8)].

Exhibits 3.4 and 3.5 show selected monthly cash flows for the same pass-through assuming 165 PSA and 250 PSA, respectively.

A more recent addition to MBS prepayment terminology is the *prospectus prepayment curve* (PPC). While the logic underlying the PSA convention (i.e., that loans prepay faster as they age, all other factors constant) remains in force, a PPC curve allowed its creator (typically the underwriter of a private-label deal) to specify the prepayment ramp that was used to structure the deal. Evidence suggested that loans seasoned faster than the 30 month period implied by the PSA curve, especially for some products (such as alt-A loans) that were believed to season faster than normal. Rather than use a percentage of a publicly utilized ramp, PPC curves (which are quoted in a transaction's prospectus supplement) were used for many nonagency transactions between 2004 and 2007.

EXHIBIT 3.4 Monthly Cash Flow for a $400 Million Pass-Through with a 5.5% Pass-Through Rate, a WAC of 6.0%, and a WAM of 358 Months, Assuming 165% PSA

(1) Month	(2) Outstanding Balance	(3) SMM	(4) Mortgage Payment	(5) Net Interest	(6) Scheduled Prinicipal	(7) Prepay-ments	(8) Total Principal	(9) Cash Flow
1	400,000,000	0.00083	2,402,998	1,833,333	402,998	331,173	734,171	2,567,505
2	399,265,829	0.00111	2,401,007	1,829,968	404,678	441,424	846,102	2,676,070
3	398,419,727	0.00139	2,398,350	1,826,090	406,251	551,451	957,702	2,783,793
4	397,462,024	0.00167	2,395,027	1,821,701	407,717	661,161	1,068,878	2,890,579
5	396,393,146	0.00195	2,391,039	1,816,802	409,073	770,461	1,179,534	2,996,336
6	395,213,612	0.00223	2,386,386	1,811,396	410,318	879,258	1,289,576	3,100,972
7	393,924,036	0.00251	2,381,072	1,805,485	411,452	987,459	1,398,910	3,204,395
8	392,525,126	0.00279	2,375,097	1,799,073	412,471	1,094,972	1,507,443	3,306,516
9	391,017,683	0.00308	2,368,464	1,792,164	413,376	1,201,705	1,615,081	3,407,245
10	389,402,602	0.00336	2,361,178	1,784,762	414,165	1,307,567	1,721,732	3,506,494
11	387,680,870	0.00365	2,353,241	1,776,871	414,836	1,412,469	1,827,305	3,604,176
12	385,853,565	0.00393	2,344,658	1,768,496	415,390	1,516,319	1,931,709	3,700,205
13	383,921,856	0.00422	2,335,434	1,759,642	415,825	1,619,031	2,034,855	3,794,497
14	381,887,001	0.00451	2,325,575	1,750,315	416,140	1,720,516	2,136,656	3,886,971
15	379,750,345	0.00480	2,315,086	1,740,522	416,334	1,820,689	2,237,023	3,977,545
16	377,513,322	0.00509	2,303,974	1,730,269	416,407	1,919,465	2,335,872	4,066,142
17	375,177,450	0.00538	2,292,246	1,719,563	416,359	2,016,761	2,433,120	4,152,683
18	372,744,330	0.00567	2,279,911	1,708,412	416,189	2,112,495	2,528,685	4,237,096
19	370,215,645	0.00597	2,266,975	1,696,822	415,897	2,206,589	2,622,486	4,319,308
20	367,593,159	0.00626	2,253,448	1,684,802	415,482	2,298,964	2,714,446	4,399,248
21	364,878,713	0.00656	2,239,339	1,672,361	414,945	2,389,544	2,804,490	4,476,850
22	362,074,223	0.00685	2,224,657	1,659,507	414,286	2,478,256	2,892,542	4,552,049
23	359,181,681	0.00715	2,209,413	1,646,249	413,504	2,565,029	2,978,533	4,624,783
24	356,203,147	0.00745	2,193,616	1,632,598	412,601	2,649,793	3,062,394	4,694,992
25	353,140,753	0.00775	2,177,279	1,618,562	411,575	2,732,482	3,144,057	4,762,619
26	349,996,696	0.00805	2,160,413	1,604,152	410,429	2,813,031	3,223,460	4,827,612
27	346,773,236	0.00835	2,143,028	1,589,377	409,162	2,891,380	3,300,542	4,889,919
28	343,472,694	0.00865	2,125,139	1,574,250	407,775	2,967,468	3,375,244	4,949,494
29	340,097,450	0.00865	2,106,757	1,558,780	406,269	2,938,286	3,344,555	4,903,335
30	336,752,895	0.00865	2,088,533	1,543,451	404,769	2,909,369	3,314,138	4,857,589
100	164,905,045	0.00865	1,136,936	755,815	312,411	1,423,706	1,736,116	2,491,931
101	163,168,929	0.00865	1,127,102	747,858	311,257	1,408,698	1,719,955	2,467,813
102	161,448,973	0.00865	1,117,352	739,974	310,108	1,393,831	1,703,938	2,443,913
103	159,745,035	0.00865	1,107,687	732,165	308,962	1,379,102	1,688,064	2,420,229
104	158,056,971	0.00865	1,098,106	724,428	307,821	1,364,510	1,672,332	2,396,759
105	156,384,639	0.00865	1,088,608	716,763	306,684	1,350,055	1,656,739	2,373,502

EXHIBIT 3.4 (Continued)

(1) Month	(2) Outstanding Balance	(3) SMM	(4) Mortgage Payment	(5) Net Interest	(6) Scheduled Principal	(7) Prepayment	(8) Total Principal	(9) Cash Flow
200	52,224,616	0.00865	476,917	239,363	215,794	449,870	665,664	905,026
201	51,558,952	0.00865	472,792	236,312	214,997	444,119	659,116	895,427
202	50,899,837	0.00865	468,702	233,291	214,203	438,424	652,627	885,918
203	50,247,209	0.00865	464,648	230,300	213,412	432,786	646,198	876,497
204	49,601,012	0.00865	460,629	227,338	212,624	427,203	639,827	867,165
205	48,961,185	0.00865	456,644	224,405	211,838	421,676	633,514	857,919
300	10,199,637	0.00865	200,055	46,748	149,057	86,936	235,993	282,741
301	9,963,644	0.00865	198,324	45,667	148,506	84,900	233,406	279,073
302	9,730,238	0.00865	196,609	44,597	147,958	82,886	230,843	275,440
303	9,499,394	0.00865	194,908	43,539	147,411	80,893	228,305	271,844
304	9,271,090	0.00865	193,222	42,492	146,867	78,923	225,790	268,283
305	9,045,299	0.00865	191,551	41,458	146,325	76,975	223,300	264,757
350	1,137,497	0.00865	129,569	5,214	123,882	8,768	132,650	137,863
351	1,004,848	0.00865	128,449	4,606	123,424	7,624	131,049	135,654
352	873,799	0.00865	127,338	4,005	122,969	6,495	129,463	133,468
353	744,336	0.00865	126,236	3,412	122,514	5,379	127,893	131,305
354	616,443	0.00865	125,144	2,825	122,062	4,276	126,338	129,164
355	490,104	0.00865	124,062	2,246	121,611	3,187	124,799	127,045
356	365,306	0.00865	122,989	1,674	121,162	2,112	123,274	124,948
357	242,032	0.00865	121,925	1,109	120,715	1,049	121,764	122,873
358	120,268	0.00865	120,870	551	120,269	0	120,269	120,820

[a] Since the WAM is 358 months, the underlying mortgage pool is seasoned an average of two months. Therefore, the CPR for month 28 is 1.65 × 6%.

Typically, 100% PPC is the base-case prepayment assumption used to create a particular deal. PPC curves (or ramps) are generally specified as a beginning and terminal CPR, along with the associated time period. A typical ramp might be specified as "8–20% CPR over 12 months." This translates to an assumption of 8% CPR in the first month, increasing 1.09% per month for the next 11 months, and terminating at 20% CPR in month 12. However, there is no industry standardization for the usage of this terminology, as the specification is issue-dependent. As a result, investors must confirm how "100% PPC" is defined for each particular issue before performing further analysis.

The language utilized in a deal's prospectus supplement is illuminating. For example, the document for Countrywide's CWALT 2005-J9 deal has language as follows:

EXHIBIT 3.5 Monthly Cash Flow for a $400 Million Pass-Through with a 5.5% Pass-Through Rate, a WAC of 6.0%, and a WAM of 358 Months, Assuming 250% PSA

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Month	Outstanding Balance	SMM	Mortgage Payment	Net Interest	Scheduled Principal	Prepayment	Total Principal	Cash Flow
1	400,000,000	0.00126	2,402,998	1,833,333	402,998	502,964	905,962	2,739,295
2	399,094,038	0.00168	2,399,974	1,829,181	404,504	670,653	1,075,156	2,904,337
3	398,018,882	0.00211	2,395,937	1,824,253	405,842	838,007	1,243,849	3,068,102
4	396,775,033	0.00253	2,390,887	1,818,552	407,012	1,004,812	1,411,824	3,230,376
5	395,363,209	0.00296	2,384,826	1,812,081	408,010	1,170,856	1,578,866	3,390,947
6	393,784,343	0.00340	2,377,756	1,804,845	408,834	1,335,924	1,744,759	3,549,604
7	392,039,584	0.00383	2,369,681	1,796,848	409,483	1,499,803	1,909,287	3,706,135
8	390,130,297	0.00427	2,360,606	1,788,097	409,955	1,662,281	2,072,236	3,860,333
9	388,058,061	0.00470	2,350,537	1,778,599	410,247	1,823,147	2,233,394	4,011,994
10	385,824,667	0.00514	2,339,483	1,768,363	410,359	1,982,191	2,392,550	4,160,913
11	383,432,117	0.00558	2,327,451	1,757,397	410,290	2,139,205	2,549,495	4,306,893
12	380,882,621	0.00603	2,314,452	1,745,712	410,039	2,293,986	2,704,025	4,449,737
13	378,178,597	0.00648	2,300,497	1,733,319	409,604	2,446,332	2,855,937	4,589,255
14	375,322,660	0.00692	2,285,600	1,720,229	408,986	2,596,046	3,005,032	4,725,261
15	372,317,628	0.00737	2,269,773	1,706,456	408,185	2,742,932	3,151,118	4,857,573
16	369,166,510	0.00783	2,253,033	1,692,013	407,201	2,886,803	3,294,003	4,986,017
17	365,872,507	0.00828	2,235,395	1,676,916	406,033	3,027,473	3,433,506	5,110,421
18	362,439,001	0.00874	2,216,878	1,661,179	404,683	3,164,763	3,569,446	5,230,625
19	358,869,555	0.00920	2,197,499	1,644,819	403,151	3,298,500	3,701,651	5,346,470
20	355,167,904	0.00966	2,177,278	1,627,853	401,438	3,428,516	3,829,955	5,457,808
21	351,337,949	0.01013	2,156,236	1,610,299	399,547	3,554,651	3,954,198	5,564,497
22	347,383,751	0.01060	2,134,396	1,592,176	397,477	3,676,750	4,074,227	5,666,403
23	343,309,524	0.01107	2,111,779	1,573,502	395,232	3,794,667	4,189,898	5,763,400
24	339,119,626	0.01154	2,088,411	1,554,298	392,812	3,908,261	4,301,074	5,855,372
25	334,818,552	0.01201	2,064,314	1,534,585	390,221	4,017,402	4,407,624	5,942,209
26	330,410,929	0.01249	2,039,516	1,514,383	387,462	4,121,967	4,509,428	6,023,811
27	325,901,500	0.01297	2,014,043	1,493,715	384,535	4,221,839	4,606,374	6,100,090
28	321,295,126	0.01345	1,987,921	1,472,603	381,446	4,316,914	4,698,360	6,170,962
29	316,596,767	0.01345	1,961,180	1,451,069	378,196	4,253,755	4,631,952	6,083,020
30	311,964,815	0.01345	1,934,798	1,429,839	374,974	4,191,490	4,566,464	5,996,303
100	108,745,344	0.01345	749,744	498,416	206,017	1,460,065	1,666,082	2,164,498
101	107,079,262	0.01345	739,658	490,780	204,262	1,437,677	1,641,939	2,132,719
102	105,437,324	0.01345	729,708	483,254	202,522	1,415,613	1,618,135	2,101,389
103	103,819,189	0.01345	719,892	475,838	200,796	1,393,869	1,594,665	2,070,503
104	102,224,524	0.01345	710,208	468,529	199,086	1,372,441	1,571,526	2,040,056
105	100,652,997	0.01345	700,655	461,326	197,390	1,351,324	1,548,713	2,010,039

EXHIBIT 3.5 (Continued)

(1) Month	(2) Outstanding Balance	(3) SMM	(4) Mortgage Payment	(5) Net Interest	(6) Scheduled Principal	(7) Prepayment	(8) Total Principal	(9) Cash Flow
200	21,191,894	0.01345	193,525	97,130	87,566	283,894	371,460	468,589
201	20,820,434	0.01345	190,922	95,427	86,820	278,907	365,727	461,154
202	20,454,707	0.01345	188,353	93,751	86,080	273,998	360,078	453,828
203	20,094,629	0.01345	185,820	92,100	85,347	269,164	354,510	446,611
204	19,740,119	0.01345	183,320	90,476	84,620	264,405	349,024	439,500
205	19,391,095	0.01345	180,854	88,876	83,899	259,719	343,618	432,494
300	2,546,812	0.01345	49,953	11,673	37,219	33,759	70,978	82,651
301	2,475,835	0.01345	49,281	11,348	36,902	32,808	69,710	81,058
302	2,406,124	0.01345	48,618	11,028	36,587	31,875	68,462	79,490
303	2,337,662	0.01345	47,964	10,714	36,276	30,958	67,234	77,948
304	2,270,428	0.01345	47,319	10,406	35,967	30,058	66,025	76,431
305	2,204,403	0.01345	46,682	10,104	35,660	29,174	64,834	74,938
350	222,803	0.01345	25,379	1,021	24,265	2,671	26,936	27,957
351	195,867	0.01345	25,038	898	24,058	2,311	26,369	27,267
352	169,498	0.01345	24,701	777	23,853	1,959	25,812	26,589
353	143,685	0.01345	24,369	659	23,650	1,615	25,265	25,923
354	118,420	0.01345	24,041	543	23,449	1,278	24,726	25,269
355	93,694	0.01345	23,717	429	23,249	948	24,196	24,626
356	69,498	0.01345	23,398	319	23,051	625	23,676	23,994
357	45,822	0.01345	23,084	210	22,854	309	23,163	23,373
358	22,659	0.01345	22,773	104	22,660	0	22,660	22,764

[a] Since the WAM is 358 months, the underlying mortgage pool is seasoned an average of two months. Therefore, the CPR for month 28 is 2.50 × 6%.

Prepayments of mortgage loans commonly are measured relative to a prepayment standard or model. The model used in this prospectus supplement assumes a constant prepayment rate (i.e., CPR) or an assumed rate of prepayment each month of the then—outstanding principal balance of a pool of new mortgage loans. A 100% prepayment assumption for loan group 1 (the "prepayment assumption") assumes a CPR of 8.0% per annum of the then outstanding principal balance of the applicable mortgage loans in the first month of the life of the mortgage loans and an additional approximately 1.0909090909% (precisely 12%/11) per annum in the second through 11th months. Beginning in the 12th month and in each month thereafter during the life of the mortgage loans, a 100% prepayment assumption assumes a CPR of 20.0% per annum each month.

Note that the prospectus supplement does not directly refer to a "PPC," but rather defines the prepayment ramp as "100% Prepayment Assumption."

Prepayment Conventions for Securities Backed by Home Equity and Manufactured Housing Loans

While the expression of prepayments in the MBS market is fairly standardized and comprises a combination of PSA curves and CPR calculations as previously described, a variety of descriptions are used to express the paydown behavior of securities backed by home equity and manufactured housing loans. While issuance of securities backed by these loans fell out of favor in the mid-2000s, a brief discussion of these conventions will nonetheless be helpful in understanding how prepayment conventions have been adjusted in order to represent an asset's unique behavior. Despite the diversity in terminology, most of the concepts used to indicate prepayments for these two sectors of the mortgage market use the CPR concept as the numeraire while incorporating the PSA ramping methodology.

Home Equity Prepayment Speeds

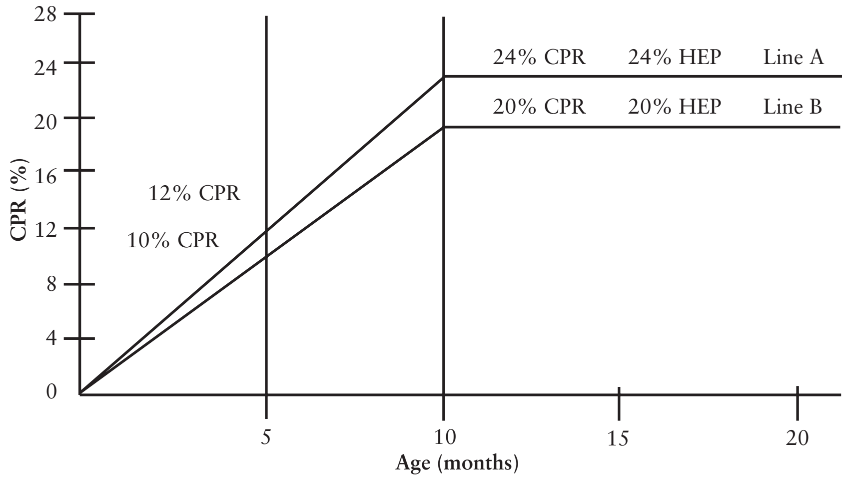
In the early stages of the development of the securitized market for home equity loans, the majority of the loans were fixed rate, closed-end loans. Over the years, the balance has slowly shifted in favor of adjustable rate loans, particularly subprime ARMs. The earliest definition of prepayment speeds in the home equity market was the ***home equity prepayment*** (HEP) ***curve***.[4] The primary motivation for using a different prepayment methodology for home equity loans was to capture the faster seasoning ramp observed for prepayments. Typically, home equity loans season faster than traditional single-family loans, making the PSA ramp an inappropriate description of the behavior of prepayments.

The HEP curve reflects the observed behavior in historic HEL data—it has a ramp of 10 months and a variable long-term CPR to reflect individual issuer speeds. A faster long-term speed means faster CPRs on the ramp because the ramp is fixed at 10 months regardless of the long-term speed. For example, a 20% HEP projection would mean a 10-month ramp going to 20% in the 10th month from 2% in the first month and a constant 20% thereafter. Exhibit 3.6 shows several HEP curves at 20% HEP and 24% HEP, where month 1 speeds of 2.4% CPR increase over 10 months to 24% CPR.

In addition to utilizing the HEP curve, a PPC ramp is also commonly used to define the base-case prepayment assumption. As with other mort-

[4]The HEP curve was developed by Prudential Securities based on the prepayment experience of $10 billion of home equity loan deals.

EXHIBIT 3.6 HEP Curves



gage products, the specification of the ramp will be dependent on the attributes of the underlying loan collateral, with respect to both the beginning and terminal speeds as well as the duration of the ramp. Occasionally, deals are also priced to a constant CPR assumption, ignoring the impact of seasoning in generating the deal's cash flows.

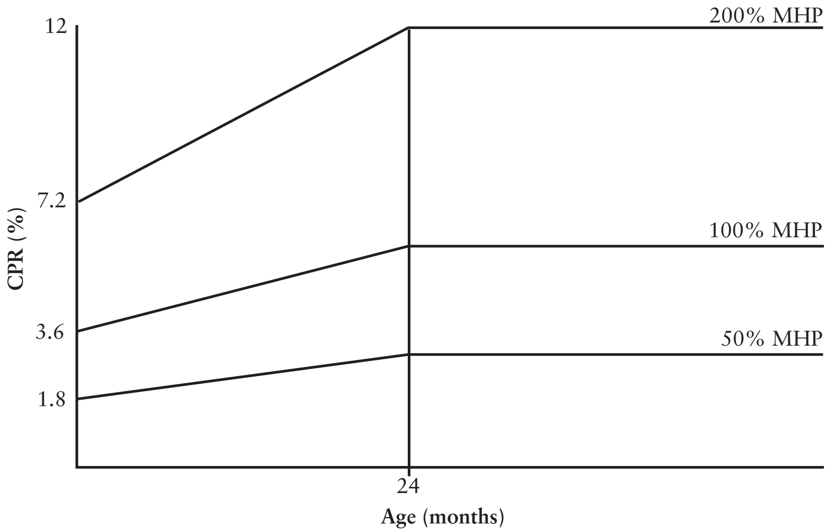
Manufactured Housing Prepayment Curve

The ***manufactured housing prepayment*** (MHP) curve is a measure of prepayment behavior for manufactured housing, based on the Green Tree Financial manufactured housing prepayment experience. MHP is similar to the PSA curve, except that the seasoning ramp is slightly different to account for the specific behavior of manufactured loans. 100% MHP is equivalent to 3.6% CPR at month zero and increases 0.1% CPR every month until month 24, when it plateaus at 6% CPR. Exhibit 3.7 shows the prepayment speeds at 50% MHP, 100% MHP, and 200% MHP.

DELINQUENCY, DEFAULT, AND LOSS TERMINOLOGY

The measurement of potential and actual cash flow impairment resulting from borrower credit problems is critically important to the analysis of nonagency MBS. Historically, the importance of these measures stemmed from their role in allowing investors in subordinate MBS tranches to assess

EXHIBIT 3.7 MHP Curves



relative value and risk. However, the mortgage crisis that began in 2007 demonstrated to investors that *all* nonagency securities have exposure to defaults and losses; put differently, it is impossible to invest in nonagency MBS without taking on some degree of credit risk. This means that any divergence in realized default and loss experience from investors' initial expectations can result in writedowns and losses on the investment.

Despite the importance of delinquencies, losses and defaults in the mortgage-related markets, the terminology is not standardized. For instance, static pool losses may be reported on a monthly or annualized basis as a percentage of either current or original balance, with the metric based upon current balance being the preferred method to ensure consistency with prepayment reporting.

Before we discuss the measurement of defaults and losses, it is instructive to briefly review the various outcomes of a loan when the obligor ceases making scheduled payments. A loan becomes delinquent when the obligor fails to make the contractual payment on the stated date. If the underlying property has appreciated from the initial purchase price, the homeowner can often sell the home and use the proceeds to settle the mortgage debt. (This generally is categorized as a voluntary prepayment and is considered part of housing turnover.) If the homeowner cannot sell the property at a high enough price and remains delinquent, the loan is declared to be in default once all collection (and modification) efforts have failed. At that point, the issuer (or the servicer) has several options. There may either be a short sale, where the borrower sells the property in a negotiated transaction subject to approval by the servicer; alternatively, the property may go into the foreclosure or repossession process and be eventually sold by the servicer. Therefore, the process chain is delinquency to default to foreclosure (or repossession) to liquidation, at which time the severity of loss can be assessed.

Delinquency Measures

As mentioned, when a borrower fails to make one or more timely payments, the loan is said to be *delinquent*. Delinquency measures are designed to gauge whether borrowers are current on their loan payment as well as stratifying unpaid loans according to the seriousness of the delinquency. The calculation method used is determined by the servicer. When the underlying pool of assets is mortgage loans, the two commonly used methods for classifying delinquencies are those recommended by the Office of Thrift Supervision (OTS) and the Mortgage Bankers Association (MBA).

The OTS method uses the following loan delinquency classifications:

- 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*

The MBA method is a somewhat more stringent classification method, classifying a loan as 30 days delinquent once payments are not received after the due date. Thus, a loan classified as "current" under the OTS method would be listed be as "30 days delinquent" under the MBA method. The two methods can report significantly different delinquencies.[5]

Default Measures

The conditions that result in classification of some loans as delinquent (such as the loss of a job or illness) may change, resulting in the resumption of timely principal and interest payments. However, some portion of the loans classified as delinquent typically end up in default. By definition, default is the point where the borrower loses title to the property in question.

[5]For example, a June 9, 2000, report by Moody's titled, "Contradictions in Terms: Variations in Terminology in the Mortgage Market," shows that the reported delinquencies can differ dramatically when the different conventions are used.

Two broadly used measures for quantifying default are the cumulative default rate and the conditional default rate. The ***cumulative default rate*** (denoted as the CDX) is the proportion of the total face value of loans in a pool that have gone into default as a percentage of the total face value of the security.

The ***conditional default rate*** (CDR) is the annualized value of the unpaid principal balance of newly defaulted loans over the course of a month as a percentage of the unpaid balance of the pool (before scheduled principal payment) at the beginning of the month. It is computed by first calculating the ***monthly default rate*** (MDR) as shown below:

$$\text{MDR for month } t = \frac{\text{Default loan balance in month } t}{\text{Beginning balance for month } t - \text{Scheduled principal payment in month } t}$$

Then this is annualized as follows to get the CDR:

$$\text{CDR}_t = 1 - (1 - \text{Default rate for month } t)^{12}$$

Note that the conversion of MDR to CDR is identical to the formula for converting SMMs to CPRs. As described in an earlier section of this chapter, the default rate is viewed as representing involuntary prepayments, and the CDR represents the involuntary prepayment speed calculated for nonagency MBS. Voluntary prepayment speeds (i.e, those resulting from refinancing activity and housing turnover) must be calculated separately.

Let's use the following as an example. Assume that a nonagency pool[6] with an 8% note rate and 300 months left to maturity has a balance at time t of $10,000,000. The pool's scheduled monthly payment is $77,181.62, comprised of $66,666.67 in interest and $10,514.96 in scheduled principal. Assume that the pool receives $20,000 of voluntary prepayments and $15,000 in involuntary prepayments.[7]

The monthly voluntary prepayment speed is calculated as follows:

$$\text{Voluntary SMM} = \frac{20{,}000}{10{,}000{,}000 - 10{,}514.96} = 0.002$$

This can then be converted to 2.37% CPR.

The MDR is calculated similarly:

[6]For clarity's sake, we assume a simple pool with no credit enhancement.

[7]These payments are reported in the monthly remittance reports compiled by a transaction's trustee.

$$\text{MDR} = \frac{15{,}000}{10{,}000{,}000 - 10{,}514.96} = 0.0015$$

which can be converted to 1.78% CDR.

In some cases, the involuntary and voluntary prepayment speeds are combined to calculate a single prepayment speed. In this case, the calculation of a "total CPR" is as follows:

$$\text{Total SMM} = \frac{35{,}000}{10{,}000{,}000 - 10{,}514.96} = 0.0035$$

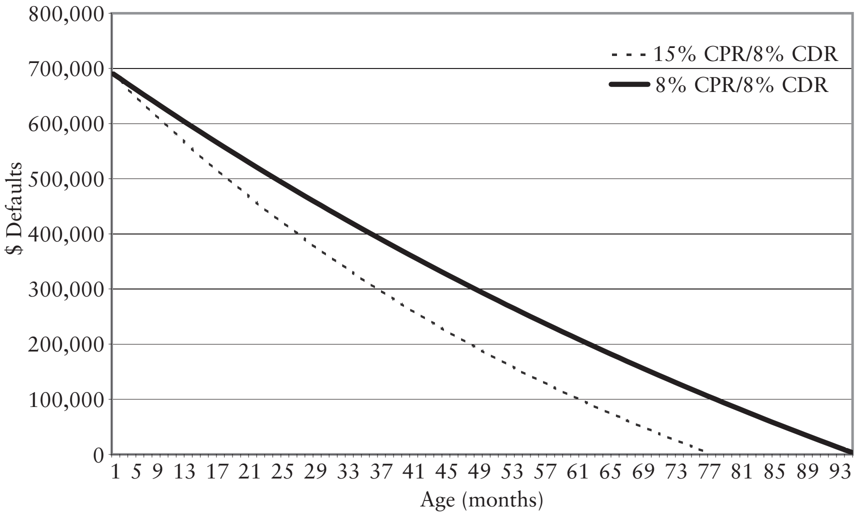
which can be converted to a total CPR of 4.12%.

There are a number of issues implied by these calculations. First, note that the voluntary SMM and MDRs equal the pool's total SMM. (It is not true, however, that CPRs and CDRs sum to equal the total pool CPR; it is only the monthly rates that are additive.) In using the output of a model, it is also important to ascertain what the vendor means when they quote a "CPR." Since many systems will show CPRs as the annualized rate of *all* prepayments (i.e., total CPRs) and show CDRs separately, the voluntary prepayment speed must be calculated separately. This can be accomplished by deannualizing the CPRs and CDRs (i.e, converting them to SMMs and MDRs), subtracting the MDR from the SMM, and annualizing the difference. In the above example, the voluntary SMM is 0.0035 less 0.0015 or 0.002, which annualizes to 2.37% CPR.

Also note that the CDR metric measures only the amount of defaults and not the amount of losses because the actual amount of losses depend upon the amounts that can be recovered on loans in default, adjusted for the costs of collection and servicer advances, if applicable. In the extreme case, if there is full recovery of the unpaid principal balance of the defaulted loans, the losses will be zero with the exception of the costs of recovery. However, depending upon the timing of the recovery of the defaulted loan balances, the cash flows to certain bondholders may be interrupted.

There is also an interesting and important relationship between the voluntary prepayment speed and the dollar amount of defaults in a pool. Every dollar of principal that is prepaid voluntarily is returned at 100 cents on the dollar and cannot subsequently go into default. Therefore, the dollar amount of a pool's principal that goes into default declines as voluntary prepayment speeds increase, even if the assumed CDR remains constant. This is illustrated in Exhibit 3.8. The exhibit shows the projected dollar amounts of defaults on a $100 million pool with an 8.5% note rate at 8% CDR for two different voluntary CPRs. At a combination of 15% CPR and 8% CDR, the pool is expected to lose a total of $21.9 million in face value;

EXHIBIT 3.8 Monthly Dollar Amounts of Defaults on a $100 Million Pool Using 8% CDR at Different Voluntary Prepayment Speeds



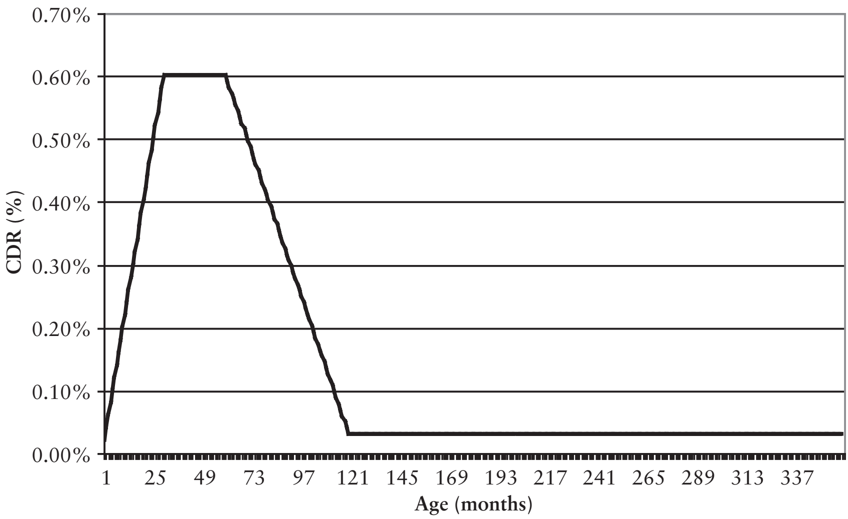
the projected amount of defaulted principal using 8% CPR and 8% CDR increases to $29.0 million.

As with prepayment analysis, there are disadvantages to using constant CDRs that tend to distort credit analysis. A constant CDR assumption is not necessarily consistent with the actual behavior of defaults, and also does not allow the analysis to take variations in the timing of defaults into account. As with prepayments, credit problems have historically tended to be very low immediately after the loans are closed, but generally increase with time as the pool in question ages.

One time-honored methodology is to utilize the *standard default assumption* (SDA) convention, which assumes that defaults (as measured in annual terms using CDRs) have a fairly consistent pattern over the life of the pool. The SDA model is similar in concept to the PSA convention used in prepayment analysis, and is specified as follows:

- 0.02% initial CDR, rising 0.02% CDR until reaching 0.6% CDR in month 30.
- A constant 0.6% CDR from months 30 to 60.
- A linear decline of 0.0095% between months 61 and 120, reaching 0.03% in month 120.
- A constant 0.03% CDR for the remaining term.

EXHIBIT 3.9 100% SDA Without Effects of Prepayments



The base SDA curve is shown in Exhibit 3.9.

In addition to the prescribed CDR curve described above, the base SDA model explicitly accounts for the effects of voluntary prepayments by assuming a prepayment speed of 150% PSA. One hundred percent SDA at 150% PSA results in cumulative defaults of around 2.80%, and vary significantly when different assumptions are used. The dollar amount of monthly defaults is calculated as the product of monthly default rates or MDRs (i.e., the deannualized CDR) and the monthly balance factor at the projected prepayment speed. Cumulative defaults are the sum of this vector. Exhibit 3.10 shows how 100% SDA would be calculated, assuming a 6.0% coupon pass-through (as in the prior examples). A depiction of monthly defaults using the base assumptions of the SDA model at 150% PSA is shown in Exhibit 3.11. Note that this example results in cumulative defaults of roughly 2.73%.

Loss Severity Measures

Where the lender has a lien on the property, a portion of the value of the loan can be recovered through the legal recovery process (i.e., through foreclosure and repossession) and subsequent sale of the asset. The difference between the proceeds received from the recovery process (after all transaction costs) and principal balance of the loan is the loss in dollars. The historical loss severity rate in any month is defined as follows:

EXHIBIT 3.10 Calculation of Monthly Defaults Using 100% SDA at 150% PSA for a Pass-Through with a 5.5% Pass-Through Rate, a WAC of 6.0%, and a WAM of 357 Months

(1)	(2)	(3)	(4)	(5)
Month	100% SDA (in CDRs)	100% SDA (in MDRs)[a]	Bond Factor (@ 150% PSA)	Factor-Adjusted MDR[b]
1	0.080%	0.007%	0.99798	0.0067%
2	0.100%	0.008%	0.99571	0.0083%
3	0.120%	0.010%	0.99318	0.0099%
4	0.140%	0.012%	0.99041	0.0116%
5	0.160%	0.013%	0.98738	0.0132%
6	0.180%	0.015%	0.98410	0.0148%
7	0.200%	0.017%	0.98057	0.0164%
8	0.220%	0.018%	0.97680	0.0179%
9	0.240%	0.020%	0.97278	0.0195%
10	0.260%	0.022%	0.96853	0.0210%
11	0.280%	0.023%	0.96403	0.0225%
12	0.300%	0.025%	0.95930	0.0240%
13	0.320%	0.027%	0.95433	0.0255%
14	0.340%	0.028%	0.94914	0.0269%
15	0.360%	0.030%	0.94372	0.0284%
16	0.380%	0.032%	0.93807	0.0298%
17	0.400%	0.033%	0.93220	0.0311%
18	0.420%	0.035%	0.92612	0.0325%
19	0.440%	0.037%	0.91982	0.0338%
20	0.460%	0.038%	0.91332	0.0351%
21	0.480%	0.040%	0.90661	0.0363%
22	0.500%	0.042%	0.89970	0.0376%
23	0.520%	0.043%	0.89260	0.0388%
24	0.540%	0.045%	0.88531	0.0399%
25	0.560%	0.047%	0.87783	0.0411%
26	0.580%	0.048%	0.87017	0.0422%
27	0.600%	0.050%	0.86233	0.0432%
28	0.600%	0.050%	0.85456	0.0428%
29	0.600%	0.050%	0.84685	0.0425%
30	0.600%	0.050%	0.83920	0.0421%

EXHIBIT 3.10 (Continued)

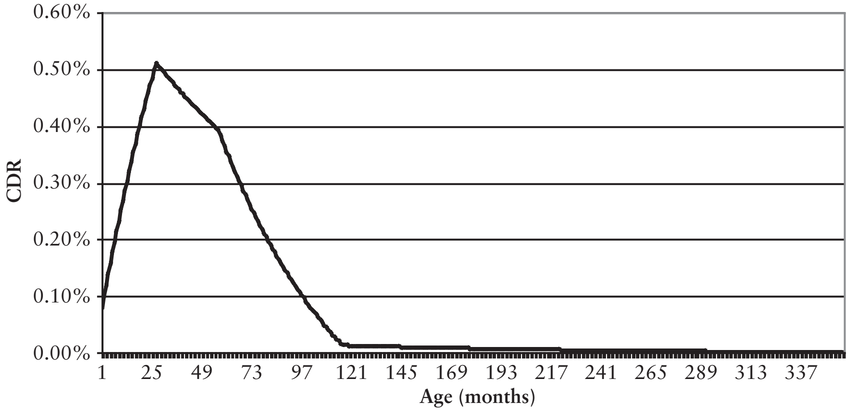
(1)	(2)	(3)	(4)	(5)
Month	100% SDA (in CDRs)	100% SDA (in MDRs)[a]	Bond Factor (@ 150% PSA)	Factor-Adjusted MDR[b]
100	0.192%	0.016%	0.43487	0.0069%
101	0.182%	0.015%	0.43064	0.0065%
102	0.173%	0.014%	0.42644	0.0061%
103	0.163%	0.014%	0.42228	0.0057%
104	0.154%	0.013%	0.41815	0.0054%
105	0.144%	0.012%	0.41406	0.0050%
200	0.030%	0.003%	0.14894	0.0004%
201	0.030%	0.003%	0.14715	0.0004%
202	0.030%	0.003%	0.14538	0.0004%
203	0.030%	0.003%	0.14363	0.0004%
204	0.030%	0.003%	0.14188	0.0004%
205	0.030%	0.003%	0.14016	0.0004%
300	0.030%	0.003%	0.03093	0.0001%
301	0.030%	0.003%	0.03022	0.0001%
302	0.030%	0.003%	0.02952	0.0001%
303	0.030%	0.003%	0.02882	0.0001%
304	0.030%	0.003%	0.02814	0.0001%
305	0.030%	0.003%	0.02745	0.0001%
350	0.030%	0.003%	0.00289	0.0000%
351	0.030%	0.003%	0.00247	0.0000%
352	0.030%	0.003%	0.00204	0.0000%
353	0.030%	0.003%	0.00163	0.0000%
354	0.030%	0.003%	0.00121	0.0000%
355	0.030%	0.003%	0.00080	0.0000%
356	0.030%	0.003%	0.00040	0.0000%
357	0.030%	0.003%	0.00000	0.0000%
		Cumulative Defaults		2.75%

[a] CDRs are converted to MDRs by using the following formula:

$$MDR = 1 - (1 - CDR)^{1/12}$$

[b] Column (3) × (4)

EXHIBIT 3.11 Monthly CDRs for 100% SDA Using 150% PSA



$$\text{Loss severity rate} = 1 - \frac{\text{Liquidation Proceeds}}{\text{Liquidation Balance}_t}$$

The loss severity rate ranges from 0 to 1 (or 0% to 100%). If the loss severity rate is zero, then liquidation proceeds are equal to the liquidated loan balance. A loss severity rate of 1 (or 100%) means that there are no liquidation proceeds. The *loss rate* is equal to the annual default rate multiplied by the loss assumption severity. In projecting future cashflows and losses, investors will often use a constant loss severity assumption based on a combination of loan attributes, projected changes in home prices, and the length of time until liquidation. The percentage of loss severity is then applied to the monthly default amount (generated by using the applicable MDR) in order to calculate monthly losses.

Default and loss severity assumptions (which translate into expected losses) are critical metrics for holders of mortgages and MBS that have exposure to mortgage credit performance. From the viewpoint of issuers, the assumptions used to value and capitalize investments in retained tranches are critical for assessing firm value, as any deterioration in the performance of retained tranches can negatively impact overall corporate valuations. Investors in whole-loan mortgages and subordinate MBS routinely use the credit metrics discussed above to analyze the relative value of different alternatives by generating default- and loss-adjusted returns and valuations.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Voluntary Prepayments
Involuntary Prepayments
Conditional Prepayment Rate (CPR)
Single Monthly Mortality Rate (SMM)
Public Securities Association (PSA) Prepayment Benchmark
Home Equity Prepayment (HEP) Curve
Manufactured Housing Prepayment (MHP) Curve
Conditional Default Rate (CDR)
Monthly Default Rate (MDR)

CHAPTER 4

Prepayments and Factors Influencing the Return of Principal

Prepayments and their impact on principal cash flows are critical components of the valuation, trading, and risk management of mortgage-backed securities. Because of this, substantial resources are expended by investors and dealers in understanding and modeling prepayment "speeds." However, prepayment behavior is not static, and has evolved repeatedly since the first prepayment waves in the early 1990s. Moreover, the very definition of "prepayments" has evolved from one focused primarily on borrowers' refinancing options to one encompassing a plethora of actions and decisions.

While not intended as a comprehensive study of prepayment behavior, this chapter discusses the underlying factors impacting principal repayment rates. We also draw distinctions between the traditional view of prepayments and a broader one that puts credit-related factors into context.

PREPAYMENT FUNDAMENTALS

As noted in the introduction, traditional prepayment analysis has focused on borrowers' option to retire their loans prior to maturity. Virtually all mortgage loans allow for the early repayment of principal. Prepayment behavior can be divided into several categories. The first of these is referred to as ***turnover***, which occurs when the underlying properties are sold and the associated loan is retired. Turnover can occur for a number of reasons:

- The homeowner moves or trades up to a larger house.
- The obligor relocates as part of changes in their job or employment.
- The property is sold subsequent to the death of the homeowner or as part of a divorce settlement.
- The property is destroyed by a fire or other natural disaster.

In all these cases, the resulting proceeds (from either the property's sale or an insurance settlement) are passed on as prepaid principal to the holder of the mortgage. In the event of the sale of the property, the loan is paid off from the proceeds of the sale; in fact, most loans contain a "due-on-sale" clause insuring that the loan is retired once the property is sold. Properties are also sold in the event that the obligors encounter financial difficulties. While we discuss credit-related factors at several points in this chapter, it is important to note that prepayments resulting from credit events are sometimes taken into account under the broad umbrella of "turnover."

A second form of prepayment can be broadly ascribed to *refinancing*. This behavior can take a number of forms. A ***rate-and-term refinancing*** is undertaken to reduce the borrower's month payment, most commonly due to a decline in the level of consumer mortgage rates. Such a change puts the market rate for new mortgages below the rate of existing loans, creating an incentive to refinance. A related activity takes place when borrowers refinance in order to liquefy their home's equity by increasing the balance on their new loan. Such transactions, referred to as ***cash-out refinancings***, often are taken as an alternative to second lien loans. Cash-out activity is strongly correlated with rates of home price appreciation which, logically enough, creates the borrower equity extracted through the transaction. Such activity can also be relatively insensitive to traditional refinancing incentives, and has at times boosted prepayment speeds for lower-coupon MBS.

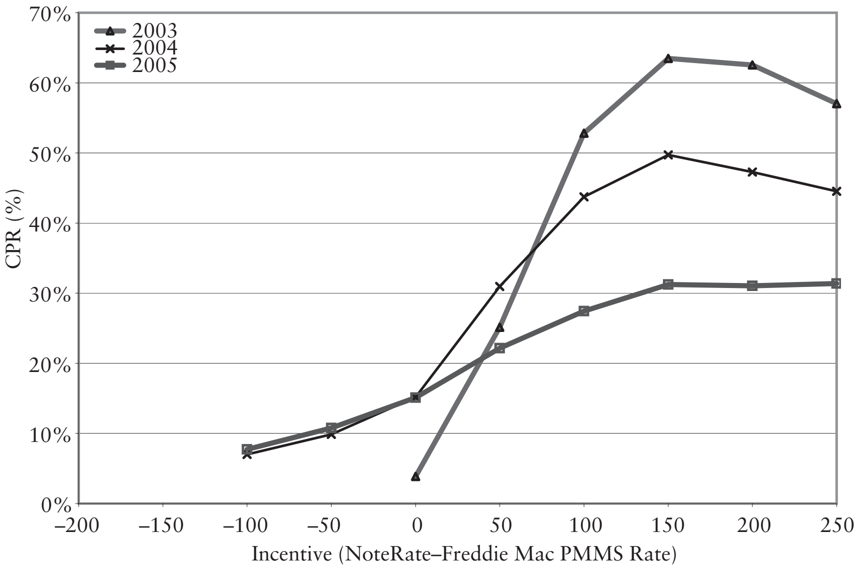
At various points in time, borrowers have also been inclined to refinance from one product into a different one that offers a payment savings. A simple form of *product transition* is to refinance from a fixed rate loan into an ARM that offers a lower rate. Borrowers have also transitioned into products with alternative amortization schemes, such as interest-only and negative amortization loans, in order to reduce their monthly payment burdens. Such transitions are contingent on the availability and popularity of alternative products, as well as borrowers' ability (either through lower rates or other nontraditional means) to achieve payment reductions.

Another critical factor in prepayments is based on the borrower's financial situation. However, the impact of borrower credit on prepayments is quite complex. Prepayments often result directly from changes to homeowners' financial situation. At its simplest, principal is returned to investors when borrowers default on their loans, although the amount and timing of principal cash flows is subject to many variables. However, credit-related factors also exert more subtle effects on prepayment behavior. For example, borrowers with weak credit, or who don't have significant equity in their home, may not be able to take advantage of declining interest rates by obtaining new loans.

Taken together, these factors and activities result in prepayment speeds that vary across the MBS market. The most common way to assess prepayment speeds within a product group is by a simple view of CPRs at various levels of refinancing incentive. Prepayment ***S-curves*** show prepayment speeds for different levels of mortgage rates and/or refinancing incentives. S-curves can be created using a number of different methodologies and data sources. Either projected or historical prepayment speeds can be shown; additionally, the level of prepayments can be compared to either the absolute level of rates or the relative degree of refinancing incentive.

An example of S-curves for different periods of time is shown in Exhibit 4.1. The chart shows historical prepayment speeds for 30-year conventional fixed rate pools exhibited by refinancing incentive (defined as the cohort's WAC less the Freddie Mac 30-year fixed survey rate for that period). The different shapes of the S-curves are indicative of different consumer behaviors. For example, the curve for 2003 was quite steep, indicating that borrowers were extremely sensitive to refinancing opportunities; borrowers that had an incentive to refinance (or, to borrow a term from the option market, were "in-the-money") did so in large numbers. At the same time, prepayments on "out-of-the-money" pools (i.e., those lower WACs and no apparent refinancing

EXHIBIT 4.1 Prepayment S-Curves for Different Years for 30-year Fixed Rate Conventional Loans



Data Source: eMBS.

incentive) were relatively slow, reflecting relatively slow housing turnover and limited cash-out activity. By contrast, the S-curves for 2004 and 2005 were increasingly flat. This reflected faster housing turnover, brisk levels of cash-out activity, and growing product transition activity for loans with minimal or negative incentives, while in-the-money loans were less responsive to apparent refinancing opportunities.

The following subsections discuss the primary drivers of prepayment speeds in more detail.

Turnover

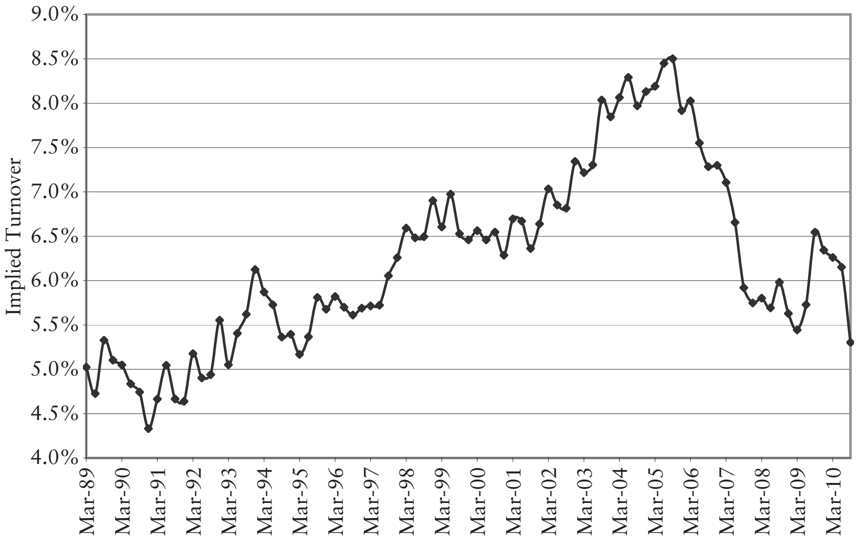
As previously described, *turnover* refers to activity in which the underlying property is sold or liquidated, with the proceeds of the sale subsequently passed through to the holder of the mortgage as a prepayment. There are a number of ways to observe the level of turnover. A simple way to assess turnover is to look at the prepayment speeds of out-of-the-money MBS pools, such as, for example, prepayment speeds on Fannie 4.0s when mortgage rates are 5% or higher.

However, prepayment speeds for lower-coupon MBS can also be influenced by factors other than turnover. For example, high levels of cash-out refinancings (when borrowers refinance primarily to monetize the equity in their homes) will also increase prepayment speeds on out-of-the-money coupons. Product transition activity, which was widespread from 2004 through early 2007, can also distort the normal calculation of "in-the-moneyness." As discussed later in this chapter, transitions typically are associated with the widespread availability and popularity of products that allow borrowers to reduce their monthly payment obligations through either lower loan rates or alternative amortization schemes.

A truer estimate of housing turnover can be obtained by calculating existing home sales for single-family homes as a percentage of the number of such homes owned. Existing home sales data are published monthly by the National Association of Realtors, while the number of single-family homes outstanding is reported by the Census Bureau on a quarterly basis, subject to periodic adjustments. Exhibit 4.2 shows housing turnover over time, calculated by dividing existing home sales into the total number of single-family homes. As the chart indicates, this estimate of turnover has varied over time, primarily reflecting changes in the level of home sales.

It is tempting to associate elevated housing turnover with robust growth in home prices. Purely speaking, however, housing turnover is not directly associated with real estate price appreciation, but rather with the level of home sales activity and the number of completed transactions. While home

EXHIBIT 4.2 Implied Turnover Rate: Quarterly Single-Family Existing Home Sales/Total Single Family Homes



Data Sources: National Association of Realtors, U.S. Census Bureau.

prices and sales are highly correlated, it is conceivable that home prices could stagnate while sales activity remains firm, and vice versa.

Refinancing

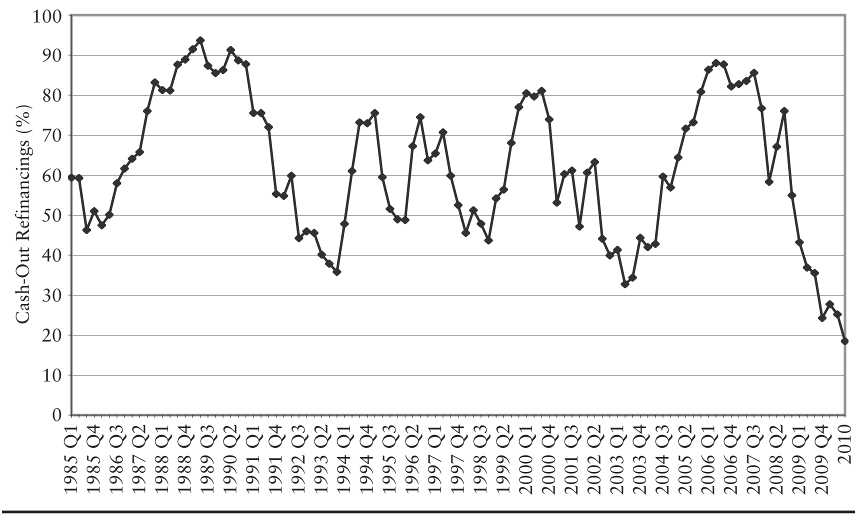
Refinancing ("refi") activity can be broadly defined as transactions where borrowers replace their existing mortgage with a new loan, using the proceeds from the new loans to pay off their preexisting mortgage obligations. While it encompasses a number of different activities, it most commonly occurs when the prevailing level of interest rates declines to the point where borrowers can take out new loans and reduce their monthly payments (after accounting for transaction costs and potential penalties).

As noted already, refinancing activity can be broadly categorized as rate-and-term refinancings, where borrowers act solely to reduce their mortgage payments, and cash-out refinancings for which the new loan is larger than the one being retired. Rate-and-term refis are easily conceptualized as a form of option exercise. In a fashion similar to a corporation calling a debt issue, homeowners can reduce their required debt service obligations by calling their current loans carrying above-market rates and issuing new debt.

However, the nature of mortgage lending complicates borrowers' refinancing decisions. Homeowners refinancing their loans are subject to a variety of costs and fees, many of which are fixed. The expected monthly savings, by contrast, is a function of the size of the loan in question. This implies that refinancing incentives are strongly impacted by loan size, as smaller loans typically require a greater refinancing incentive in order to trigger refinancing activity. Take, for example, two loans with 5% note rates and balances of $200,000 and $400,000, respectively. A 50 basis point rate savings reduces the payment on the $200,000 loan by $60 per month, while the same rate savings reduces the larger loan's monthly payment by roughly $120. If both loans are subject to $1,000 in refinancing costs, the borrower with the $400,000 loan will recoup the initial outlay in month 8; the borrower with the smaller loan needs more than double the time to break even. This makes loan size a critical variable in modeling and projecting future prepayment speeds.

Cash-out refinancings are commonly viewed as a subset of overall refinancing activity. For example, Freddie Mac defines cash-out refis as transactions where the new loan is at least 5% larger than the original one, and reports cash-outs as a percentage of overall prepayment activity. Using this measure, the level of cash-out activity has varied significantly over time. Exhibit 4.3, for example, shows Freddie Mac's reported percentage of cash-out

EXHIBIT 4.3 Quarterly Percentage of Freddie Mac Refinancings with 5% Greater Loan Balance



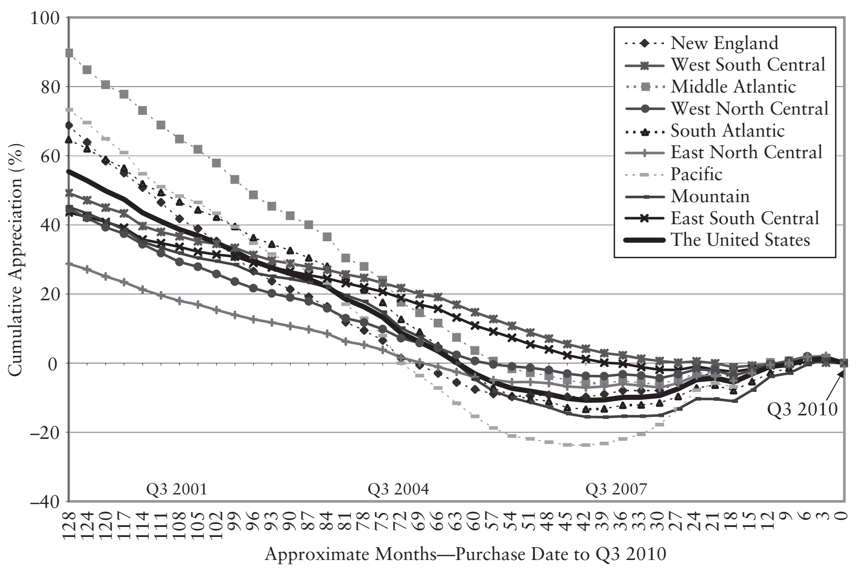
Data Source: Freddie Mac.

refinancings to prepayments since 1985. The chart indicates that the relative level of cash-out activity was extremely high in the late 1980s and 1990s, as well as in the period between 2003 and 2007.

The primary driver of cash-out activity at any point in time is the amount of equity borrowers have in their homes. In turn, equity is a function of both the original equity in the home (i.e., the inverse of a loan's LTV) and the rate of home price appreciation since the home was purchased. Exhibit 4.4 indicates how aggregate home price appreciation and depreciation rates have varied, depending on both a property's location and the time at which it was purchased. Using the Freddie Mac Home Price Index reported for the third quarter of 2010, it indicates how much average home prices would have changed for borrowers in various regions of the United States, depending on when they purchased their homes (or last removed equity from their property). Many borrowers that bought their homes prior to 2005 still have significant appreciation in their homes; by contrast, borrowers in most regions that bought homes in 2006 or later would be "underwater" and, in some regions, deeply so.

Aggregate refinancing incentives can be observed by examining the distribution of note rates within the MBS universe at various points in time.

EXHIBIT 4.4 Cumulative Home Price Percentage Change From Time of Purchase to Q3 2010, by Region



Data Source: Freddie Mac.

Keep in mind that the outstanding mortgage population is always changing, as new loans are issued and older loans are retired. The distribution of note rates for the population of outstanding loans is strongly impacted by refinancing activity, which can be thought of as recycling older high-rate loans into new mortgages with lower rates.

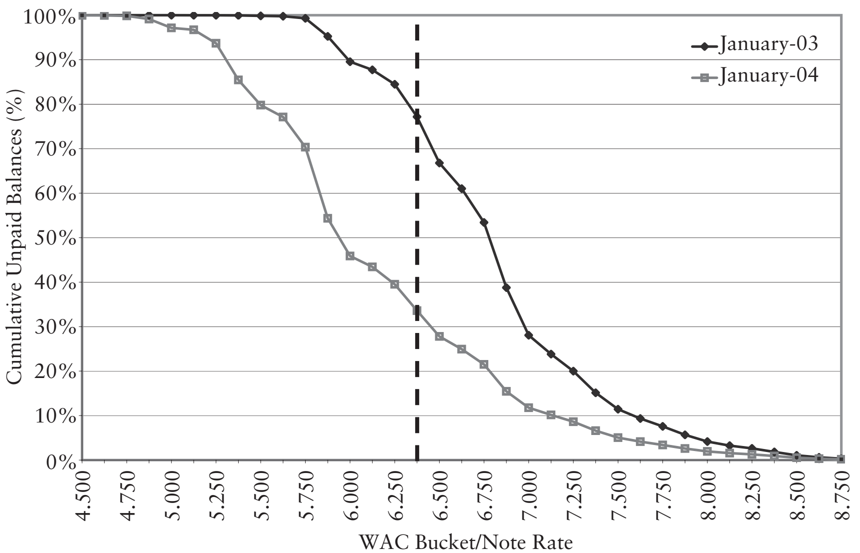
A useful technique is to compare the outstanding balances and the cumulative percentages of note rates for MBS products at different points in time. The cumulative balance percentages are calculated as follows:

- Divide the outstanding market balances into discrete segments or "buckets" by WAC. (The following analysis uses 12.5 basis point WAC buckets.)
- For each WAC bucket, calculate the percentage of the remaining balances with note rates equal to and below that bucket.

For example, if the lowest WAC bucket is 5.0% to 5.124% and it represents 2% of the remaining balance, its cumulative percentage is 2%. If the next WAC bucket (5.125% to 5.249%) comprises 6% of the unpaid balance of the market, its cumulative balance is therefore 8%. This process is completed for all WAC buckets.

Exhibit 4.5 shows, for the conventional fixed rate MBS market, the cumulative proportion of outstanding balances by note rate outstanding at

EXHIBIT 4.5 Cumulative Percentage of Conventional MBS Market by Note Rate



Data Source: eMBS.

two different points in time. Note that the cumulative balances shifted dramatically during 2003, a period characterized by extremely fast overall prepayment speeds. The change in the market profile resulted largely from the large-scale recycling of high-rate loans into new loans with lower note rates.

This technique is particularly useful in assessing the "refinanceability" of the market at particular points in time. Using a rate of 6.375% as a threshold (indicated by the vertical line), the chart indicates that almost 80% of the fixed rate market had a rate higher than the threshold rate at the beginning of 2003; by contrast, less than 35% would have had a refinancing incentive at that rate by the beginning of 2004. This simple example illustrates an important reason why refinancing activity and prepayment speeds vary significantly over time, as discussed in the next section.

FACTORS INFLUENCING PREPAYMENT SPEEDS

In understanding and evaluating prepayment behavior, the level of consumer mortgage rates is the single factor upon which most attention is paid. However, there is no single "market" rate that analysts can observe. There are always differences in the rate offerings of different lenders; since loans are the "product" they offer, it's not surprising that there are pricing discrepancies. Individual lenders also have a variety of offerings, with different combinations of interest rates and up-front fees (or "points," which vary inversely with the rate offered). While these options give borrowers choices between up-front costs and monthly payments, the relationship between rates and points is highly lender-specific and a function of their pricing algorithms. Finally, lenders seek to price in the risk of loans to various borrowers in a serious of activities broadly classified under "risk-based pricing."[1]

However, a variety of outside factors that influence prepayment speeds and refinancing behavior can be outlined. These include exogenous factors, mortgage industry economics, and consumer behaviors and preferences.

Borrower Inefficiencies

Rational borrowers will always seek to lower their borrowing costs by refinancing their debts. Refinancing opportunities present themselves to both institutional and individual borrowers. Unlike corporations and municipalities, however, residential borrowers are relatively inefficient in capitalizing on refinancing opportunities. (If mortgagors were efficient, for example, few

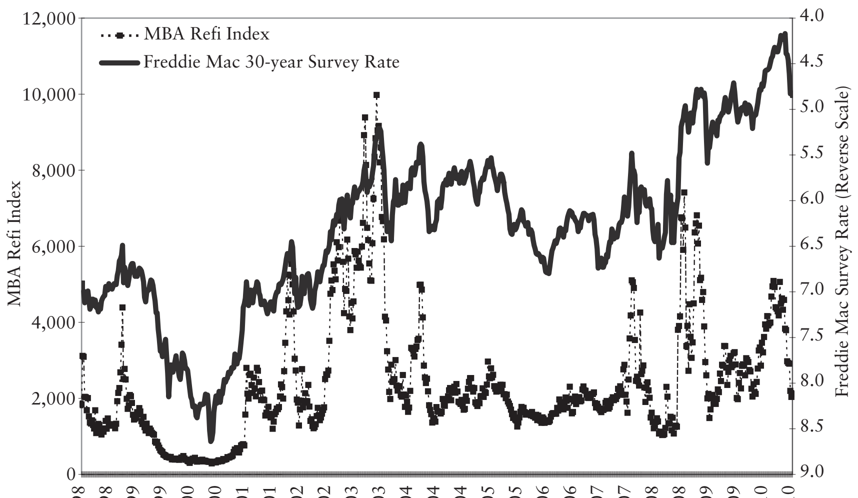
[1]For a discussion of pricing methodologies, see A. K. Bhattacharya, W. S. Berliner, and F. J. Fabozzi, "The Interaction of MBS Markets and primary Mortgage Rates," *Journal of Structured Finance*, 14, no. 3 (2008): 16–36.

if any premium pools would be outstanding; however, there were approximately \$110 billion of 30-year Fannies with coupons of 6.5% and higher at the end of 2010.)

Borrower inefficiencies exist for a number of reasons. Homeowners have varying degrees of awareness of financial market rates and conditions, and as a result are not always cognizant of refinancing opportunities. Borrowers often hear about declines in rates from their friends and coworkers; they also may read about it in the financial press or see it discussed on news programs. These are collectively referred to as *media effects*. While the growth of the financial press (with information available from print, television, and the Internet) has improved refinancing efficiency over time, it often takes a significant and noteworthy drop in rates to generate conversation and media "buzz." This explains the tendency for refinancings to occur in waves, as illustrated in Exhibit 4.6. The chart shows mortgage rates (again using Freddie Mac's 30-year survey rate as a proxy, shown on a reverse scale) versus refinancing activity, using the Mortgage Bankers Association's refinancing applications index. The chart indicates that refinancing activity often remains tepid for long periods of time, but spikes when mortgage rates decline beyond some indeterminate threshold.

In addition, the costs associated with refinancing alter the refinancing economics for borrowers. The need to overcome cost hurdles serves to

EXHIBIT 4.6 MBA Refi Index versus Freddie Mac 30-year Survey Rate



Data Sources: Mortgage Bankers Association and Freddie Mac.

inhibit refinancing activity and complicates refinancing decisions. As noted previously, this is particularly relevant for borrowers with smaller loan balances, who typically require a greater refinancing incentive before engaging in rate-and-term refinancings.

Refinancing efficiency has also been impacted by the structure of the mortgage industry. Beginning in the mid-1990s, lenders became increasingly adept at marketing their products and generating refinancing activity. Some of these activities involve directly contacting existing customers, while others involve mass marketing through television commercials, print advertisements, and direct mail and phone solicitations. Also contributing to the marketing effort was a cadre of mortgage brokers and other "third-party originators" who acted as agents linking lenders and borrowers. These developments contributed to improved refinancing efficiency.

The events that culminated in the financial crisis in 2008, however, led to sharp contraction in "wholesale" lending activities. Brokers were blamed for poor loan quality and sloppy paperwork; since they did not make loans directly, they arguably had no incentive to insure the quality of their loans. As a result, many smaller originators that were dependent on the wholesale channel failed, while a number of large originators curtailed or severely limited their interaction with third-party lenders. This developments in turn served to impair borrowers' ability and/or willingness to capitalize on refinancing opportunities.

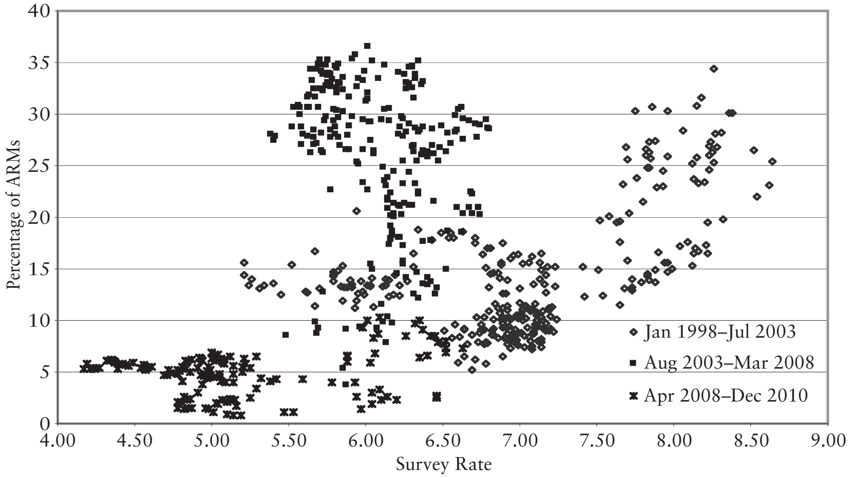
Finally, additional factors impact refinancing activities. After 2007, for example, a combination of significantly tighter lending standards, fewer product offerings, and declining borrower equity due to falling home prices acted to further depress refinancing activity. Referring back to Exhibit 4.6, the inability of the MBA's refi index to reach and maintain high levels reflected the fact that the pool of borrowers with the ability to refinance was quickly exhausted when mortgage rates plummeted beginning in early 2009.

Product Choices and Transitions

Both rate-and-term and cash-out refinancing activity is at times influenced by ***product transitions***. This means that borrowers can lower their monthly payment by refinancing from one product into another. This type of activity has varied over time, depending on the availability, popularity, and pricing of alternative products.When the yield curve has been relatively steep, for example, large numbers of borrowers have sometimes refinanced out of fixed rate loans into adjustable rate products.

Transition activity has varied substantially over time, however, driven by both lender offerings and consumer preferences. Prior to mid-2003, for example, ARMs were a niche product targeted primarily to first-time home

EXHIBIT 4.7 Freddie Mac 30-Year Survey Rate versus MBA's ARM Percentage



Data Sources: Mortgage Bankers Association and Freddie Mac.

buyers. In the summer of 2003, however, ARM volumes rose fairly dramatically, as consumers refinanced out of fixed rate products into newly popular hybrid ARMs. This reflected both consumers' increased comfort with the adjustable rate loans as well as marketing efforts by mortgage lenders designed to maintain issuance volumes. By mid-2007, borrowers once again eschewed ARMs, in part due to bad publicity emphasizing their riskiness.

These abrupt changes in behavior are illustrated in Exhibit 4.7. The exhibit contains a scatterchart showing the Freddie Mac 30-year fixed survey rate on the horizontal axis, and the percentage of loans taken as ARMs on the vertical axis. The chart demonstrates the existence of three distinct regimes. ARMs were relatively unpopular in the years prior to mid-2003, and only reflected a large share of activity when mortgage rates were relatively high. From mid-2003 through early 2008, by contrast, the percentage of ARMs was relatively high irrespective of the level of mortgage rates and, by implication, refi activity. After the beginning of 2008, ARMs again fell out of favor; by 2010 they comprised less than 10% of new loan applications.

The varying popularity of fixed-to-ARM refinancings has several implications. Because of the generally upward slope of the yield curves, ARM rates are typically lower than fixed rates. This means that borrowers willing to utilize adjustable rate products will be presented with an apparent refinancing incentive more often than those borrowers that eschew ARMs and will only consider fixed rate products. (Of course, this savings is only guaranteed for an ARM's fixed rate or "teaser" period.) Returning to the framework of Exhibit 4.5, taking available ARM rates into account serves to push the available mortgage rate to the left, meaning that more borrowers can reduce their mortgage rates by refinancing. (If ARM rates are low enough, virtually the entire fixed rate coupon stack can be considered in-the-money.) As a result, regimes where ARMs are a popular product choice (due to consumer preferences and/or a steep yield curve) are characterized by steady levels of refinancing activity and relatively flat S-curves.

Alternatively, when short rates rise and push ARM rates higher, fixed-to-ARM refinancing incentives are reduced. In fact, regimes associated with flat yield curves are often characterized by ARM-to-fixed transitions, as borrowers seek to lock in lower long-term rates. Taken together, these phenomena indicate that refinancing behavior is not simply dictated by the level of intermediate and long interest rates. The levels of *all* interest rates, as well as the shape of the yield curve, are important drivers of refinancing incentives and prepayment activity.

Large-scale transitions also have been observed as borrowers utilized loan products with alternative amortization schedules and payment schemes. As a simple example, a borrower with a $200,000 loan balance and a 30-year loan with a fixed 5% note rate would have monthly P&I payments of $1,074. If they refinanced into an interest-only loan with the same term and note rate, their new monthly payment would be $833, an initial savings of $240. However, the savings would only be available for the period that the borrower was allowed to make interest-only payments; at that point, the loan is "recast" (i.e., the payments are recalculated) over the remaining term. If the borrower chooses a new loan with an interest-only period of 10 years, the post-recast monthly payment would be $1,320, significantly higher than the payment on the original loan.

The borrower's decision thus trades off early savings for a payment spike (or *payment shock*) at the recast. While such decisions were popular during the period of widespread product transitions, the mortgage crisis of 2007 led to the realization that these types of transitions exposed both borrowers and lenders to serious embedded risks. As a result, transitions into alternative payment products became fairly rare by 2008.

Changes in Homeowner Equity and Credit

As noted in the introduction to this chapter, the experience of the post-2007 period has highlighted the interrelationship between prepayments and home prices and, by extension, borrower credit. In a previous section, we highlighted the importance of cash-out refinancings and the critical role that home price appreciation plays in this activity. In addition, deteriorating borrower credit (of which homeowner equity is a crucial element) often directly results in prepayments, as we discuss next.

However, changing home prices and borrower credit have other subtle affects on prepayments. For example, borrowers often are presented with an enhanced refinancing incentive when their credit improves. If they took loans with relatively high rates because of risk-based pricing, they can capitalize on their improved situation by refinancing. Such "credit curing" can be related to economic factors such as improving labor markets and consumer credit conditions, particularly when observing local or regional activity. A similar phenomenon is associated with rapid increases of home prices. Borrowers with high LTVs who were saddled with higher risk-based mortgage rates and/or mortgage insurance premiums can lower their payments once their homes appreciate in value, even if the overall level of mortgage rates remained unchanged.

Alternatively, borrower credit can also act to slow prepayment speeds. Borrowers with deteriorating credit may not be able to capitalize on declining interest rates if they cannot obtain new loans because of tighter credit standards. Declining real estate values can also prevent homeowners from refinancing existing loans by reducing or eliminating equity. If homeowners' equity disappears or becomes negative (a situation often referenced as "being underwater"), they may lose the ability to obtain new loans. Moreover, significant declines in home values ultimately serve to constrain homeowners from selling their properties, as they would be forced to realize large losses on their homes. These developments are collectively called *prepayment lock-in*, and serve to slow both refinancing- and turnover-related prepayments.

Time

Prepayment rates vary with the passage of time. In addition to purely random variations, fairly predictable changes occur to prepayment speeds due to factors that are independent of interest rates. The behavior of borrowers undergo a variety of secular and cyclical changes as time elapses; in addition, the composition of closed loan populations (i.e., loans collateralizing a pool) change as the pool ages and loans drop out for any number of reasons.

Time-related factors mean that evaluating any MBS at a single constant speed is unrealistic. This realization was first incorporated into the PSA model discussed in Chapter 3, which recognized the fact that loans are more likely to prepay as they age (or *season*). Borrowers are disinclined to prepay their loans immediately after issuance, but become increasingly open to the possibility as time elapses. This is due to a variety of factors:

- Borrowers' typically are reluctant to undertake the effort and expense of refinancing until their loans are at least a few months old.
- Borrowers are unlikely to sell their properties and move immediately after purchasing a home. This is true even for homeowners that relocate frequently; evidence suggests that they tend to stay in their homes for at least a year.
- It takes some time for borrowers to build equity in their property (assuming, of course, a regime of rising home prices).

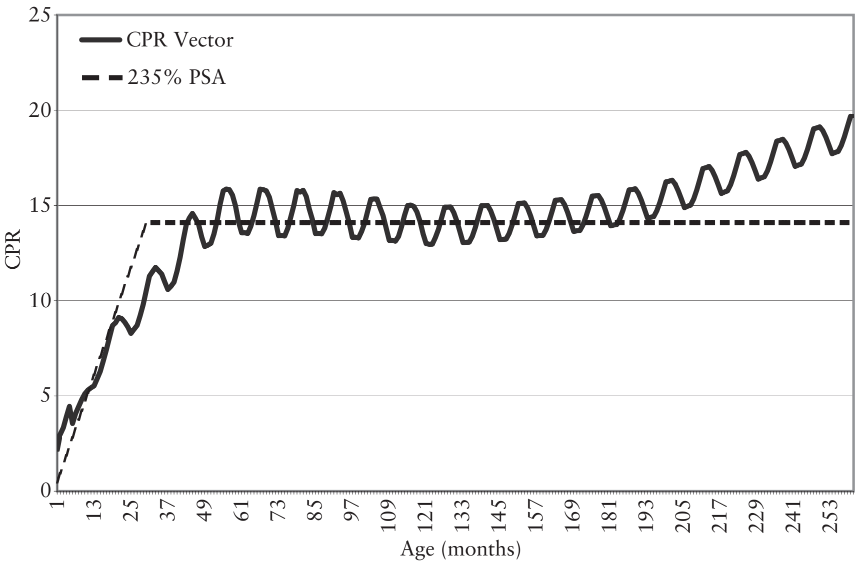
The key insight introduced by the PSA model is the concept that prepayment speeds are not constant over time, especially early in loans' lives. It is, however, simplistic in its assumption of a constant speed after 30 months, and does not account for other time-related behaviors. One such factor is *seasonality*, which suggests that prepayments typically increase during spring and summer months. Another behavior, *burnout*, accounts for the observation that loans remaining in a population are less likely to refinance after a certain point in time. The underlying logic is that borrowers that have not availed themselves of refinancing opportunities lack the ability and the inclination to do so.

The combination of these behavior means that a time series of CPRs generated by a prepayment model (as well as the realized prepayment speeds for any security)—the ***CPR vector***—will look very different than the equivalent speeds quoted as percentages of the PSA model. This is illustrated by the chart in Exhibit 4.8, which shows the vector of projected CPRs from the YieldBook analytical system compared to the equivalent PSA generated by the model.[2] Market practices have evolved to the point where the PSA convention (or any single prepayment metric) is used primarily as a quotation mechanism (e.g., "the bond is priced *x* basis points over the curve at 250 PSA") rather than as an analytical framework.

Time-related changes to prepayment speeds are even more profound for mortgage products that do not require fixed monthly payments over their life. For example, ARMs typically experience a spike in prepayment speeds as the loans approach their first reset date. (For example, the monthly payments on 5/1 hybrid ARMs change when the loans reset at month 60.) Interest-only loans exhibit comparable behavior, as their required monthly payments increase once the IO period expires. All such products exhibit prepayment patterns reflecting variations in the loans' monthly payments and, by implication, refinancing incentives.

[2]The *model-equivalent PSA* is the single PSA speed that would generate the same weighted average life for a security as the vector of CPRs projected by the prepayment model.

EXHIBIT 4.8 CPR Vector versus Equivalent PSA for a Hypothetical Fixed Rate Pool



Data Source: YieldBook.

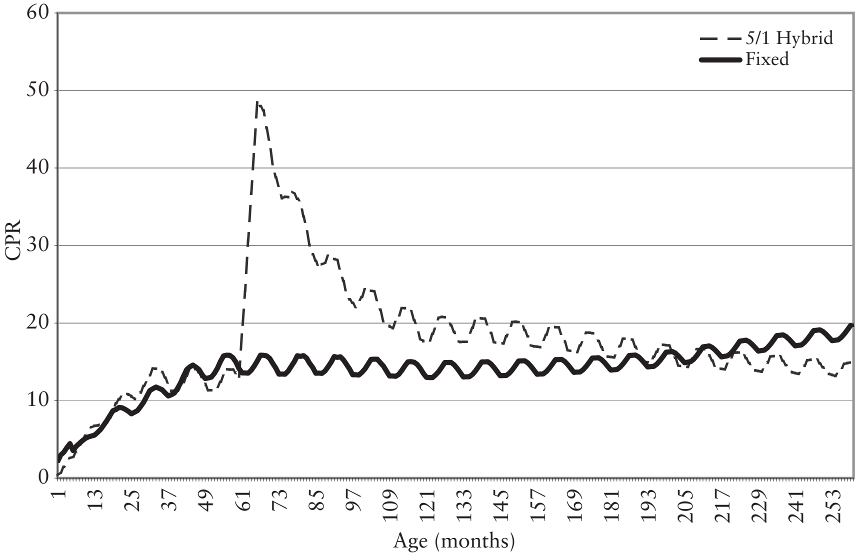
The spike in ARM speeds at their reset results from a variety of factors. Unlike homeowners in Europe, U.S. borrowers have traditionally been somewhat averse to adjustable rate loans. This means that borrowers often prepay hybrid ARMs simply to avoid being exposed to changing interest rates and variable payments. It also is a function of the level of the benchmark rate at the reset; in regimes where the yield curve is flat or inverted, the new loan rates are often higher than the teaser rate. The resulting payment shock creates a refinancing incentive for borrowers during periods when the new rate is higher than that for either a new ARM or a fixed rate loan.

Exhibit 4.9 shows projected CPR vectors from YieldBook for hypothetical fixed rate and 5/1 hybrid ARM pools. The exhibit shows the sharp increase in CPRs at the reset; in addition, the model also projects a cyclical increase in speed every 12 months thereafter, corresponding with the annual rate resets for the loans as well as normal seasonal patterns.

DEFAULTS AND "INVOLUNTARY" PREPAYMENTS

The mortgage crisis that erupted in early 2007 underscored the critical role of credit performance in all sectors of the mortgage and MBS markets. In the

EXHIBIT 4.9 Prepayment Vectors for Hypothetical Fixed Rate and 5/1 Hybrid ARMs



Data Source: YieldBook.

past, investors assumed that senior nonagency MBS were "money-good" by virtue of their triple-A ratings. The collapse of mortgage performance both reinforced the importance of sound credit analysis of private-label securities, while also giving investors a painful and expensive lesson on the factors influencing residential mortgage credit performance.

Factors Influencing Default Frequency and Credit Performance

At this point, a brief discussion of borrower delinquency and default will be useful. The general thinking has long been that borrower equity simply provides a cushion for the lender in cases when the home must be repossessed. However, a critical lesson learned from the post-2006 experience is that borrower credit performance and home prices are strongly interrelated at a number of levels, and that high-LTV loans have, all else being equal, an increased likelihood of default.

At its most basic, appreciating home prices give borrowers the ability to monetize their home's equity in order to meet their financial obligations and mitigate cash flow problems. In addition, steady or rising home prices also impact the resolution of troubled loans. Delinquent borrowers that have equity in their homes can sell their properties and, using the net proceeds, pay off their loans instead of going into foreclosure. In theory, borrowers should never default if their homes' values are great enough to extinguish the loan and pay the associated costs. Borrowers whose homes have declined to the point where their LTVs are greater than 100% (i.e., where their loans are greater than the value of their homes) do not have this option. This accounts for why some loan vintages (such as the year 2000) have experienced relatively high levels of delinquency but limited defaults and losses; borrowers in financial difficulty were able to sell their homes and emerge "whole." (In these cases, the transaction is recorded as a home sale and captured under "turnover.")

The decline in home prices that began in 2007 resulted in unexpectedly large increases in defaults. The loss of home equity induced numerous borrowers to exercise the option embedded in any collateralized loan that allows the collateral to revert back to the lender. It is axiomatic in corporate credit theory that borrowers are expected to default on loans once the value of the loans' collateral declines below the value of the loans themselves. However, the mortgage sector has long operated under the assumption that obligors rarely walk away from the properties because of the importance of dwellings to families' well-being. This behavior was untested until 2007, in large part because home prices have never before experienced significant and widespread declines. However, the new phenomenon of the "strategic default" emerged during the mortgage crisis, where large numbers of homeowners with income and assets sufficient to service their loans nevertheless ceased making monthly mortgage payments.

The emergence of this activity has a number of implications. The most important realization is that home prices and mortgage credit performance are closely linked. In this light, the strong credit performance exhibited by the mortgage market since the 1950s was arguably skewed higher by decades of steady home price appreciation. This assertion implicitly argues that residential mortgage loans are riskier assets than previously assumed. In addition, mortgage underwriters have placed undue faith in metrics such as credit scores which, while valuable, cannot serve as reliable proxies for borrowers' willingness to service their loans during times of financial distress.

Voluntary and Involuntary Prepayments

Once borrowers cease making regular payments, the loans eventually go into default, meaning that the borrowers lose title to the underlying properties. The properties are subsequently liquidated, typically by being placed in foreclosure; this means that the servicer eventually takes possession of the property and sells it. The proceeds of the sale, less associated costs, are categorized as *recovered principal* or ***recoveries***. Since recoveries are typically less than the amount of the loan, some entity must absorb a principal loss.

Losses for agency MBS are absorbed by the entity or agency that guaranteed them. At some point, seriously delinquent loans in agency pools are classified as "nonperforming" and subsequently bought out of the pools, either by the GSEs or (in the case of FHA and VA loans) the servicer. Because of the principal guaranty, the full face value of principal is quickly returned to investors. This means that all unscheduled principal payments can be captured in a single "prepayment speed" reported for the security in question. This measure is calculated based on the total principal repaid on the pool and the breakdown (either reported or estimated) between amortizations and prepayments (i.e., between scheduled and unscheduled principal payments). As a result, many agency securities exhibited increased prepayment speeds during periods of poor credit performance and widespread delinquencies, particularly when the agencies change their buyout policies.[3] (This also blurs the line between credit-related prepayments and normal housing "turnover.")

By contrast, traditional and credit-related prepayments must be calculated and reported separately for nonagency securities. This is because of the fact that credit support for these securities is internal; as discussed in Chapter 8, deals are structured such that senior bonds in a transaction have priority over other bonds in receiving principal and interest. Since the transaction itself will absorb incurred losses, traditional prepayments (which return all of principal to the security holder) and credit-related prepayments (which result in shortfalls that must be allocated within structures), must be segregated. As a result, private-label securities report both ***voluntary prepayments***, which encompass tradition prepayment activity, and credit-related ***involuntary prepayments***. The latter result from defaults or other events specifically related to credit events (such as short sales of homes), while also accounting for the likelihood that less than the full amount of principal will be returned to the transaction (or, more accurately, the trust holding the deal's collateral).

These factors complicate the projection and calculation of prepayment speeds for private-label securities. Voluntary prepayments are typically quoted as *VPRs,* which stands for *voluntary prepayment rate*. They are calculated similarly to a CPR, in which a monthly percentage of prepaid principal (sometimes called a *VMM*) is annualized. Involuntary prepayment

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[3]In early 2010, Fannie Mae and Freddie Mac instituted policies in which loans that were 120 days or more delinquent were automatically bought out of pools. Prior to that, buyouts had been left to the discretion of the GSEs. The process of buying out large numbers of seriously delinquent loans led to sharp short-term spikes in prepayment speeds, as well as huge writedowns for the GSEs.

speeds are quoted as CDRs (which are calculated by annualizing the MDRs, as described in Chapter 3). Note that the sum of the monthly VMMs and MDRs equals the total deal SMM for any particular month.

Involuntary prepayments require additional metrics to be reported. In addition to the rate of default, an estimate must be made of the *loss severity* (which indicates how much of the defaulted principal amount is returned to investors) as well as the *lag* between the time when loans go into default (i.e., when the borrowers lose title to the properties) and when the trusts receive the recovered principal.

Interactions Between Prepayments and Defaults

There are some interesting interactions between voluntary and involuntary prepayment speeds that impact the analysis of private-label securities. All things equal, fast prepayments enhance the performance of these securities; faster return of principal means that there is less principal outstanding to go into default. At the same assumed CDR, faster voluntary prepayment speeds (i.e., a higher VPR assumption) will typically result in higher projected yields and returns.

This assertion is somewhat simplistic, however, since it doesn't take the changing composition of the pool into account. For example, it is unlikely that the CDR would remain constant under the different VPR assumptions, as the profile of any closed population of mortgages changes over time. In addition to home prices and economic conditions, the composition of the collateral pool backing a transaction evolves as the result of attrition. Loans pay off over time as a result of both voluntary and involuntary factors. Voluntary prepayments negatively impact the composition of a pool because "better" borrowers (i.e., those with stronger credit and/or more equity in their homes) are able to take advantage of refinancing opportunities; since weaker borrowers are locked into their existing loans, the credit profile of the remaining population deteriorates. This is known as ***adverse selection***, and suggests that the credit quality of a pool typically declines over time, all things equal.

The high level of defaults experienced during the mortgage crisis also created a new and unanticipated phenomenon. High levels of defaults means that *weaker* borrowers are dropping out of the collateral pools. In turn, the remaining borrowers generally have stronger credit, meaning that the population's credit profile improves over time. This is especially noteworthy during periods of declining home prices. Borrowers with poor credit (i.e., both those unable or unwilling to service their loans) go into default in large numbers, while stronger borrowers who are nonetheless "locked in" by a lack of equity nonetheless continue to service their loans and remain in the pool. This process is sometimes called ***favorable selection***, and was most prominently observed in subprime and alt-A pools which experienced very high levels of defaults.

Neither the processes of adverse or favorable selection take place in a vacuum. For example, the performance of a cohort assumed to be adversely selected (i.e., having experienced relatively high levels of voluntary prepayments) will improve in the face of home price appreciation. Alternatively, a population of subprime loans may experience a renewed surge in defaults if money-market rates increase sharply. Since many subprime loans have adjustable note rates with very high loan margins, rising rates create widespread payment shock that challenges the ability of borrowers to service their loans.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Turnover
Rate-and-Term Refinancing
Cash-Out Refinancing
Product Transitions
S-Curves
CPR Vector
Default Frequency
Recoveries
Voluntary and Involuntary Prepayments
Adverse and Favorable Selection

PART Three

Structuring

CHAPTER 5

Introduction to MBS Structuring Techniques

Structuring techniques in the mortgage-backed securities market evolved steadily over the multidecade period that ended in 2007. Structuring expanded from its simplest form (a pass-through security, which "passes through" principal and interest to investors) to include techniques allowing investors to meet maturity and duration targets while choosing from different risk–reward trade-offs. Arguably, the ability to carve up and redirect mortgage cash flows to meet the needs of different investor clienteles contributed strongly to the growth of the MBS market which, at one point, was the largest securities market in the world.

Many types of securitized and nonsecuritized assets can be used as the "collateral" (i.e., the assets providing the principal and interest cash flows) for structured deals. However, mortgages and MBS are the most interesting asset group around which to frame a discussion of structuring ideas and techniques. This is attributable to a number of factors:

- Mortgages are typically amortizing assets that generate principal cash flows throughout much of the loan's term.
- The product has varying degrees of credit risk, depending on the characteristics of the obligors.
- Mortgages have the unique dimension of prepayment risk, impacting returns in ways often difficult to foresee.

The interplay of these factors, and the varying appetites for each of the associated risk parameters, has resulted in a large variety of structuring variations. While this book is dedicated to discussing mortgage products and MBS structures, the techniques addressed in the remainder of the text are applicable to a growing number of asset classes, including consumer and commercial debt.

Before proceeding, it is important to put discussions of structured MBS in context. A wide variety of private-label transactions were created during the period between 2001 and 2007, utilizing mortgages with a variety of credit attributes. Private-label issuance grew exponentially over that period before collapsing due to poor performance and industry excesses. It is nonetheless important to understand the concepts and techniques utilized in these deals. In addition to allowing for the analysis of previously created ("legacy") assets, such knowledge will allow investors and observers to judge the veracity of future transactions that may emerge once the mortgage debacle and financial crisis recede into memory.

UNDERLYING LOGIC IN STRUCTURING CASH FLOWS

The goal of structuring is to maximize the proceeds received for the sale of any loans through the mechanism of securitization. Dealers, either acting as agents for an originator or as principals, seek to create structures that can be sold at the highest price given market conditions, demand for various structured products, and the cost of creating such securities.

There are two primary ways that structuring cash flows maximizes deal proceeds and thus improves execution. Splitting and tranching cash flows allows bonds to be created to better match the specific risk-and-return profiles of different investor clienteles. As noted earlier in this book, the different segments of the fixed income markets have fairly standard duration and convexity preferences. Investors within a market segment may also vary in terms of their investment objectives and risk appetites. For example, while banks typically invest in short-duration assets, each institution will have its own investment guidelines and performance measures. Cash flow structuring allows bonds to be created that more closely adhere to the investment objectives of a variety of investors and institutions.

Structuring techniques that create bonds with different average life and duration profiles typically are utilized in both agency deals and, allowing for market conditions, the senior (i.e., triple-A) bonds created off a private-label structure. Many of the techniques discussed in later chapters are used to modify the return-versus-risk profiles of these bonds by altering how principal and/or interest can be allocated to the bonds in question. The goal of the dealer is to create a combination of bonds that maximize the proceeds received once all the tranches are sold.

Structuring also allows dealers to create more cost-efficient structures, specifically for private-label structures where the cost of credit enhancement is embedded in the transaction through the mechanism of subordination. (In agency deals, by contrast, credit enhancement is obtained through the mechanism of the guaranty fee, which is obtained at the pool level and does not factor into a deal's costs.) In general terms, cost efficiency involves creating the largest possible amount of senior bonds while simultaneously obtaining the greatest possible proceeds for the resulting subordinated bonds and interests. The latter often are complex, particularly for mortgage ABS deals that utilize both subordination and overcollateralization as credit enhancement techniques.

Note that for a nonagency private-label deal, the transaction is the sole mechanism used to liquefy loan production using the capital markets. Typically, transactions take place in two ways: Either dealers bid for loan packages in whole loan form from originators (through so-called "conduits"), or they bid for parts of the deals to be marketed under the originator's deal name or "shelf." In the latter case, the senior bonds are generally bid as an unstructured senior pass-through with initial subordination assumed to be sufficient to provide it with a triple-A rating; the subordinates are sold separately as a package, with subordination percentages (or "splits") subject to the attributes of the final loan pool. (In both cases, the final sizes are subject to an adjustment when the loan pool collateralizing the deal is assembled.) In either scenario, such bids are dictated by the execution the dealers can obtain by selling the resulting structure to investors. In contrast to an agency transaction (in which the transaction can be viewed as an arbitrage), the private-label deal is an intrinsic part of the process of funding and distributing loan production; therefore, the efficiency of the structure has implications not only for the profitability of the deal, but ultimately affects how loans are priced to the consumer.

STRUCTURING DIFFERENT MORTGAGE PRODUCTS

The mortgage market has long been broadly classified into two "kingdoms" from the perspective of borrower credit. The larger and more traditional sector was generally referenced as "prime" mortgages, in that the loans were expected to exhibit a relatively low incidence of defaults and principal losses. The primary focus of structuring was, and continues to be, to improve the overall deal execution by maximizing the deal's net proceeds.

This is accomplished in agency deals by creating bonds targeted to meet different average life and duration objectives, as well as different degrees of exposure to prepayment and duration uncertainty. Execution is similarly optimized in nonagency transactions backed by prime mortgages, except that structurers must also minimize the overall cost of credit support.

Due to the perceived strong credit quality of the loans, credit enhancement in the prime sector was generally straightforward. As discussed already, credit support for securities backed by prime loans has historically been provided either through the auspices of government agencies (for qualifying loans) or through senior–subordinate structures that create sectors within a transaction that have different priorities with respect to both cash inflows and loss writeoffs. In senior–subordinate (or "senior–sub") structures, multiple classes of bonds are created that have different priorities with respect to allocation of both cash flows and losses. The most senior bonds are typically structured to obtain a triple-A rating, and trade at relatively low yields; the more junior classes can have both investment-grade and noninvestment-grade ratings, and are traded at higher yields and spreads, depending on their exposure to potential losses. (While structurers have some flexibility with respect to creating the most efficient credit enhancement in private-label structures, the subordination structures are fairly straightforward, and the credit support percentages are typically dictated by the rating agencies.)

The smaller "subprime" sector, by definition, consisted of loans made to less creditworthy borrowers. These borrowers may have had a history of late or missed payments, or had less income or assets than required to qualify for prime products. Subprime loans (along with other products such as second liens) were securitized in *mortgage ABS deals*. As with private-label structures in the prime sector, mortgage ABS deals contain bonds with a range of cash flow priorities and ratings. However, the inherent riskiness of the loans, and the large amount of credit enhancement necessary to create senior bonds, meant that the primary objective of mortgage ABS structuring was efficient credit enhancement, with the overriding goal of protecting the deal's senior tranches. While there are similarities between private-label and mortgage ABS deals, the credit enhancement techniques utilized in the private-label prime sector would be very inefficient if applied to subprime loans, especially if utilized as the sole means of credit support. Using subordination as the only form of credit enhancement would be inefficient for two reasons: The subordinate classes would be extremely large, and the incremental interest paid by the borrowers on these loans (which typically carry high rates due to their inherent riskiness) could not be utilized to provide credit support for the senior tranches. As a result, mortgage ABS structures utilized a combination of subordination, overcollateralization (either by issuing less bonds than loans, or by using interest to pay down the bonds more rapidly than the loan collateral backing the deal), and "excess spread" (i.e., the collateral's aggregate note rate in excess of the coupon interest paid to the bonds) to support the senior bonds. The direction of cash flows within the structure was also subject to a series of tests or "triggers" designed to protect the senior securities. Therefore, both the structuring of credit enhancement and the structuring trade-offs in a mortgage ABS structure were typically quite different than those in prime private-label structures. (The techniques utilized in mortgage ABS structures will be addressed in Chapter 9.)

In all types of private-label transactions, the overall size of the deal's subordinate sector depends both on the type of the underlying collateral and the unique attributes of the loan pool. Initial subordination levels (i.e., the deal's subordinate interest as a percentage of the total dollar amount of the pool at issuance) are determined by the rating agencies, and have ranged widely across products. Required initial enhancement levels also change over time. For example, enhancement levels can be high for new products or product attributes where the historical credit data are relatively thin. As additional data become available over time and rating agencies become more comfortable with the quality of the collateral, it is possible that subordination levels may trend lower.

It is important to remember that subordination percentages within deals also change over time. For example, the effective level of a deal's subordination can increase as time elapses, if the levels of defaults and losses experienced by the deal are comparable to expectations at origination. This deleveraging occurs because most structures direct cash to pay down the senior bonds as rapidly as possible. This causes the subordinate bonds to increase as a proportion of the transaction, and thus enhances the creditworthiness of the senior classes as the deal ages or "seasons." Alternatively, unexpectedly large losses can result in significant writedowns of the subordinates. This reduces the amount of credit support to the senior bonds, making them riskier and increasing their exposure to potential losses.

As mentioned in Chapter 2, the straightforward senior–sub deals typically used in the prime sector are often called *shifting interest structures*, while structures used to securitize subprime loans are sometimes referenced as *overcollateralization* or *OC structures*. While there are numerous differences between them, there are also many similarities between the two forms of structures. In addition to utilizing subordination, for example, both types of deals employ a means of directing cash flows within the structure based on cash flow priorities called the *waterfall*. This mechanism dictates the allocation of principal and interest on a monthly basis. In addition, all structured deals have residual tranches, which serve as the equity interest of the deal. In prime deals, however, residuals are almost always "noneconomic" in nature, in that such interests do not receive any cash flows. The only value of a noneconomic residual is that of the associated tax situation, which is negative at issuance (meaning that investors are paid to take the liability). However, subprime residuals were structured to have economic value, since they received cash flows if the deal met predesignated performance standards.

It is also noteworthy that deals securitizing prime loans often utilized the OC structure. In part, this reflects the blurring of the lines between the prime and subprime "kingdoms." In 2005, deals backed by alt-A loans (particularly ARMs) increasingly began to be securitized using OC structures rather than the more straightforward senior–subordinate mechanism, as the techniques traditionally used to structure subprime deals provided more cost-efficient credit enhancement.

FUNDAMENTALS OF STRUCTURING CMOs

The following four chapters cover some of the fundamental concepts in structuring tranches within deals backed by prime loans. The various concepts can be broadly categorized as follows:

- Credit tranching
  - Senior–subordinate structures
  - Overcollateralization or excess spread structures
- Divisions of principal
  - Time tranching
  - Prepayment prioritization
  - Accretion direction
  - Nonaccelerated seniors (NAS) bonds
- Divisions of Interest
  - Coupon adjustment (or IO stripping)
  - Floater, inverse floater, or two-tiered index (TTIB) combinations
  - Floater or inverse IO combinations

While each of these concepts is addressed separately, it is important to note that the concepts are not mutually exclusive. For example, a form of coupon stripping involves a variation on the floater–inverse floater combination called an *inverse IO*. In addition, multiple techniques can be used to structure cash flows. As noted in the next chapter, an example may be the creation of a PAC-support structure, which further involves time tranching the PAC cash flow. In this context, the main PAC cash flows would be considered the "parent" bond with the resulting tranched PACs labeled as the "children." Most concepts are utilized in both agency and private-label structures, although some are the exclusive purview of certain sectors. (NAS bonds, for example, are almost exclusively a nonagency phenomenon.)

Chapters 6 and 7 explain how fundamental structuring techniques for redirecting principal and interest, respectively, are used within agency CMO structures. Chapter 8 focuses on structuring techniques used for private-label deals in the prime sector. While many of the structuring techniques are identical with those used in agency deals, there are nevertheless some noteworthy differences between private-label and agency structures. These differences stem from a number of factors, including the necessity for credit enhancement in private-label structures as well as differences in the assumed prepayment behavior of the collateral backing these structures. Finally, Chapter 9 will detail the overcollateralization structures typically used in mortgage ABS deals.

CHAPTER 6

Fundamental MBS Structuring Techniques

Divisions of Principal

Directing principal cash flows to different tranches within a deal is a primary method of creating bonds to meet the varying needs of different investor classes. Viewing a ***collateralized mortgage obligation*** (CMO) deal as a cash flow allocation mechanism, as described in the previous chapter, means that the allocation of principal is accomplished by the creation of one or more sets of payment rules. The rules specify how cash flows are allocated for each month's payments and will vary depending on what type of bond is being created. For example, the pay rules may state that a bond in the structure receives all principal paid by the collateral until the bond is fully paid; at that point, principal is directed to a different tranche. In this and the following chapter, we describe fundamental structuring techniques used in agency CMO deals, in which no credit enhancement is necessary due to the agency guaranty at the pool level. In both chapters, payment rules are shown for each structuring example, in order to demonstrate how different structuring techniques allocate principal and interest cash flows.

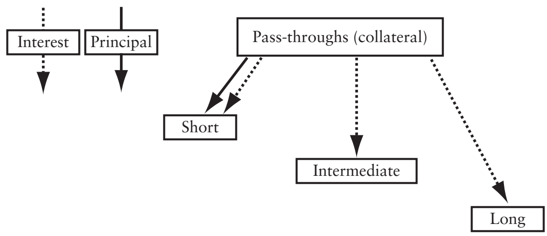
It is important to remember that a CMO deal represents a "closed universe" of principal. A deal with a principal face value of $400 million means that the total amount of principal available to be paid is $400 million—not a penny more. At faster prepayment speeds, for example, principal cash flows are paid to the investor sooner, leaving less cash flow available later in the deal's life. Particularly in discussing the more complex structures, the question becomes not how much principal but *when* principal is paid to the investor. Interest, however, is not fixed; rather, it is a function of the outstanding principal balance at any particular point in time.

A few other points need to be noted. The first step in structuring a deal is to settle on an appropriate base-case prepayment assumption. Depending on the techniques utilized, this "structuring speed" dictates (or strongly influences) the transaction's projected distribution of cash flows, along with the proportions of the various tranches being contemplated. However, it is impossible for the collateral to prepay over its life at the pricing speed. This means that as time passes and the deal ages, all structures will evolve, and the attributes of the various tranches within an individual transaction will change. Therefore, all structures must be viewed, like a corporate balance sheet, as snapshots taken at a single point in time.

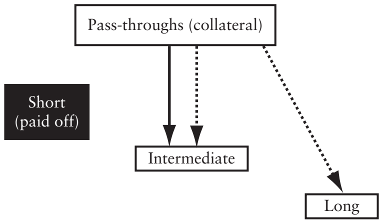
TIME TRANCHING

The most basic form of structuring is ***time tranching***, which creates a series of bonds with different average lives and durations from either a collateral group or a preexisting parent bond. Basically, principal cash flows are allocated sequentially to a series of tranches. All principal payments are directed to the shortest maturity bond until it is fully amortized. Principal is then directed to the second bond until it is fully amortized, and so on until the principal source is fully amortized. A simple representation of the concept is shown in Exhibit 6.1, where pass-throughs are structured into short, intermediate, and long classes. Note that the collateral does not have to be pass-throughs; as noted, other tranche types can be created and subsequently time-tranched.

EXHIBIT 6.1 Sequential Tranching
A. At Issuance



B. First Tranche Paid Off



In structuring a set of sequentials, the first step involves the specification of the number of sequential tranches and the associated average lives at the pricing speed. One bond (typically the long or "last cash flow" bond) acts as a "plug" that receives cash flows after the other bonds receive the principal allocation necessary to achieve their average life target. Using the prepayment pricing speed, the beginning and ending date are calculated such that the average life target of each tranche is met, with the remaining cash flows directed to the plug bond. In some cases, other parameters may also be targeted in the structuring exercise. For example, sequential tranches can be structured to pay off in a particular month, with the average lives being subject to the attributes of the resulting tranche (or "falling out"). Note that since structuring models use cash flows from the collateral, the structuring exercise depends heavily upon the availability of the relevant cash flows. Put differently, not all structures are creatable; the ability to create a structure that meets a series of average life or maturity targets is contingent on the availability of cash flows sufficient to create the desired structure.

To illustrate a sequential-pay CMO, we discuss Deal-01, a hypothetical deal made up to illustrate the basic features of the structure. The collateral for this CMO is a pass-through with a total par value of $400 million and the following characteristics: (1) the pass-through coupon rate is 5.5%; (2) the weighted average coupon (WAC) is 6.0%; and (3) the weighted average maturity (WAM) is 358 months. This is the same pass-through that we used in Chapter 3 to describe the cash flows of a pass-through based on different prepayment assumptions.

From this $400 million of collateral, and using a pricing speed of 165% PSA, four bond classes or tranches are created. Their characteristics are summarized in Exhibit 6.2. The total par value of the four tranches is equal to the par value of the collateral (i.e., the pass-through pool or pools). In this simple structure, the coupon rate is the same for each tranche and also the same as the collateral's coupon rate. (Note that this is often not the case, as bond coupons are often reduced or "stripped" in order that they trade close to par. This is especially true for the bonds in the structure with short average lives during regimes when the yield curve is steep and short rates are relatively low, as it would tend to make the dollar prices of these bonds unacceptably high. We discuss techniques for coupon stripping in the subsequent chapter on structuring interest.)

As discussed previously, a CMO is created by redistributing the cash flow—interest and principal—to the different tranches based on a set of payment rules. The payment rules at the bottom of Exhibit 6.2 set forth how the monthly cash flow from the collateral is to be distributed to the four tranches. There are separate rules for the payment of the coupon interest

EXHIBIT 6.2 Deal-01: A Hypothetical Four-Tranche Sequential-Pay Structure

Tranche	Par Amount	Coupon Rate (%)	Average Life
A	194,500,000	5.5	3.4
B	36,000,000	5.5	7.3
C	96,500,000	5.5	10.9
D	73,000,000	5.5	19.8
Collateral	400,000,000	5.5	8.6

Payment rules:
1. *For payment of periodic coupon interest*. Disburse periodic coupon interest to each tranche on the basis of the amount of principal outstanding at the beginning of the period.
2. *For disbursement of principal payments*. Disburse principal payments to tranche A until it is completely paid off. After tranche A is completely paid off, disburse principal payments to tranche B until it is completely paid off. After tranche B is completely paid off, disburse principal payments to tranche C until it is completely paid off. After tranche C is completely paid off, disburse principal payments to tranche D until it is completely paid off.

and the payment of principal, the principal being the total of the regularly scheduled principal payment and any prepayments.

In Deal-01, each tranche receives periodic coupon interest payments based on its outstanding balance. The disbursement of the principal, however, is made subject to the deal's payment rules. No tranche is entitled to receive principal until the entire principal of the tranche before it has been paid off. More specifically, tranche A receives all the principal payments until the entire principal amount owed to that tranche, $194,500,000, is paid off; then tranche B begins to receive principal and continues to do so until it is paid the entire $36,000,000. Tranche C then receives principal, and when it is paid off, tranche D starts receiving principal payments.

While the payment rules for the disbursement of the principal payments are known, the precise amount of the principal actually received in each period is not. This will depend on the principal cash flows generated by the collateral, which in turn depends on the actual prepayment rate of the collateral. Therefore, there will always be discrepancies between the cashflows and tranche sizes projected at issuance and those realized over time.

To demonstrate how the payment rules for Deal-01 work, Exhibit 6.3 shows the cash flow for selected months assuming the collateral prepays at 165% PSA. For each tranche, the exhibit shows: (1) the balance at the end of the month; (2) the principal paid down (regularly scheduled principal repayment plus prepayments); and (3) interest. In month 1, the cash flow

EXHIBIT 6.3 Monthly Cash Flow for Selected Months for Deal-01 Assuming 165% PSA

	A			B		
Month	Beginning Balance	Principal	Interest	Beginning Balance	Principal	Interest
1	194,500,000	734,171	891,458	36,000,000	0	165,000
2	193,765,829	846,102	888,093	36,000,000	0	165,000
3	192,919,727	957,702	884,215	36,000,000	0	165,000
4	191,962,024	1,068,878	879,826	36,000,000	0	165,000
5	190,893,146	1,179,534	874,927	36,000,000	0	165,000
6	189,713,612	1,289,576	869,521	36,000,000	0	165,000
7	188,424,036	1,398,910	863,610	36,000,000	0	165,000
8	187,025,126	1,507,443	857,198	36,000,000	0	165,000
9	185,517,683	1,615,081	850,289	36,000,000	0	165,000
10	183,902,602	1,721,732	842,887	36,000,000	0	165,000
11	182,180,870	1,827,305	834,996	36,000,000	0	165,000
12	180,353,565	1,931,709	826,621	36,000,000	0	165,000
75	8,508,703	2,190,871	38,998	36,000,000	0	165,000
76	6,317,832	2,170,666	28,957	36,000,000	0	165,000
77	4,147,166	2,150,640	19,008	36,000,000	0	165,000
78	1,996,526	1,996,526	9,151	36,000,000	134,266	165,000
79	0	0	0	35,865,734	2,111,120	164,385
80	0	0	0	33,754,614	2,091,623	154,709
81	0	0	0	31,662,991	2,072,299	145,122
82	0	0	0	29,590,693	2,053,147	135,624
83	0	0	0	27,537,546	2,034,165	126,214
84	0	0	0	25,503,381	2,015,351	116,891
85	0	0	0	23,488,030	1,996,705	107,653
95	0	0	0	4,333,172	1,819,126	19,860
96	0	0	0	2,514,045	1,802,226	11,523
97	0	0	0	711,819	711,819	3,263
98	0	0	0	0	0	0
99	0	0	0	0	0	0
100	0	0	0	0	0	0
101	0	0	0	0	0	0
102	0	0	0	0	0	0
103	0	0	0	0	0	0
104	0	0	0	0	0	0
105	0	0	0	0	0	0

EXHIBIT 6.3 (Continued)

	C			D		
Month	Beginning Balance	Principal	Interest	Beginning Balance	Principal	Interest
1	96,500,000	0	442,292	73,000,000	0	334,583
2	96,500,000	0	442,292	73,000,000	0	334,583
3	96,500,000	0	442,292	73,000,000	0	334,583
4	96,500,000	0	442,292	73,000,000	0	334,583
5	96,500,000	0	442,292	73,000,000	0	334,583
6	96,500,000	0	442,292	73,000,000	0	334,583
7	96,500,000	0	442,292	73,000,000	0	334,583
8	96,500,000	0	442,292	73,000,000	0	334,583
9	96,500,000	0	442,292	73,000,000	0	334,583
10	96,500,000	0	442,292	73,000,000	0	334,583
11	96,500,000	0	442,292	73,000,000	0	334,583
12	96,500,000	0	442,292	73,000,000	0	334,583
95	96,500,000	0	442,292	73,000,000	0	334,583
96	96,500,000	0	442,292	73,000,000	0	334,583
97	96,500,000	1,073,657	442,292	73,000,000	0	334,583
98	95,426,343	1,768,876	437,371	73,000,000	0	334,583
99	93,657,468	1,752,423	429,263	73,000,000	0	334,583
100	91,905,045	1,736,116	421,231	73,000,000	0	334,583
101	90,168,928	1,719,955	413,274	73,000,000	0	334,583
102	88,448,973	1,703,938	405,391	73,000,000	0	334,583
103	86,745,035	1,688,064	397,581	73,000,000	0	334,583
104	85,056,970	1,672,332	389,844	73,000,000	0	334,583
105	83,384,639	1,656,739	382,180	73,000,000	0	334,583
175	0	0	0	71,179,833	850,356	326,241
176	0	0	0	70,329,478	842,134	322,343
177	0	0	0	69,487,344	833,986	318,484
178	0	0	0	68,653,358	825,912	314,661
179	0	0	0	67,827,446	817,911	310,876
180	0	0	0	67,009,535	809,982	307,127
181	0	0	0	66,199,553	802,125	303,415
182	0	0	0	65,397,428	794,339	299,738
183	0	0	0	64,603,089	786,624	296,097
184	0	0	0	63,816,465	778,978	292,492
185	0	0	0	63,037,487	771,402	288,922
350	0	0	0	1,137,498	132,650	5,214
351	0	0	0	1,004,849	131,049	4,606
352	0	0	0	873,800	129,463	4,005
353	0	0	0	744,337	127,893	3,412
354	0	0	0	616,444	126,338	2,825
355	0	0	0	490,105	124,799	2,246
356	0	0	0	365,307	123,274	1,674
357	0	0	0	242,033	121,764	1,109
358	0	0	0	120,269	120,269	551

for the collateral consists of a principal payment of $734,171 and interest of $1.83 million (0.055 times $400 million divided by 12). The interest payment is distributed to the four tranches based on the amount of the par value outstanding. So, for example, tranche A receives $891,458 (0.055 times $194,500,000 divided by 12) of the $1.83 million. The principal, however, is all distributed to tranche A. Therefore, the cash flow for tranche A in month 1 is $1,625,630. The principal balance at the end of month 1 for tranche A is $193,765,829 (the original principal balance of $194,500,000 less the principal payment of $734,171). No principal payment is distributed to the three other tranches because there is still a principal balance outstanding for tranche A. This will be true for months 2 through 78.

After month 78, the principal balance will be zero for tranche A. For the collateral the cash flow in month 78 is $3,081,817, consisting of a principal payment of $2,130,792 and interest of $951,025. At the beginning of month 79 (end of month 78), the principal balance for tranche A is $1,996,526. Therefore, $1,996,526 of the $2,130,792 of the principal payment from the collateral will be disbursed to tranche A. After this payment is made, no additional principal payments are made to this tranche as the principal balance is zero. The remaining principal payment from the collateral, $134,266, is disbursed to tranche B. As projected using the assumed prepayment speed of 165% PSA, tranche B then begins receiving principal payments in month 79.

Exhibit 6.3 shows that tranche B is expected to fully pay off by month 97, when tranche C begins to receive principal payments. Tranche C is not fully paid off until month 172, at which time tranche D begins receiving the remaining principal payments. The expected maturity (i.e., the time until the principal is fully paid off) for these four tranches assuming 165% PSA is 78 months for tranche A, 97 months for tranche B, 172 months for tranche C, and 357 months for tranche D.

The *principal paydown window* for a tranche is the time period between the beginning and the ending of the principal payments to that tranche at the prepayment assumption. So, for example, for tranche A, the principal paydown window would be month 1 to month 78 assuming 165% PSA. For tranche B it is from month 78 to month 97. The window is also specified in terms of the length of the time from the beginning of the principal paydown window to the end of the principal paydown window. The window for tranche A would be stated as 78 months, 19 months for tranche B, and so forth.

Let's look at what has been accomplished by creating the CMO. First, in the previous chapter we saw that the average life of the pass-through is 8.6 years at the assumed prepayment speed of 165% PSA. Exhibit 6.4 shows the average life of the collateral and the four tranches assuming different prepayment speeds. Notice that the four tranches have average lives that are

EXHIBIT 6.4 Average Life For the Collateral and Four Tranches of Deal-01 at Different PSA Assumptions

	100	125	165	250	400	500	600	700
Collateral	11.2	10.1	8.6	6.4	4.5	3.7	3.2	2.9
Tranche A	4.7	4.1	3.4	2.7	2.0	1.8	1.6	1.5
Tranche B	10.4	8.9	7.3	5.3	3.8	3.2	2.8	2.6
Tranche C	15.1	13.2	10.9	7.9	5.3	4.4	3.8	3.4
Tranche D	24.0	22.4	19.8	15.2	10.3	8.4	7.0	6.0

both shorter and longer than the collateral, thereby attracting investors who have a preference for an average life different from that of the collateral.

Note that the average lives of all the tranches in Deal-01 still have considerable variability. The sequential structure does provide some degree of prepayment protection, in that the longer tranches (i.e., tranches B, C, and D) do not receive any principal until the tranches in front of them in priority (beginning with class A) are paid off. Therefore, even at fast prepayment speeds, the later (or "locked-out") tranches receive some protection due to the presence of the shorter tranche, although their average lives and durations will shorten as prepayment speeds increase.

PLANNED AMORTIZATION CLASSES (PACS) AND THE PAC-SUPPORT STRUCTURE

The ***PAC-support structure*** is designed to create mortgage bonds that have reduced exposure to prepayment risk and cash flow uncertainty, and also creates securities targeted to appeal to buyers of bullet structures such as corporate bonds. The structuring process involves dividing the available cash flows within a deal into two or more groups, and assigning one group priority in receiving scheduled amounts of monthly principal payments from the collateral. The result is that the prioritized group (and bonds tranched from it) has average lives, durations, and cash flow windows at issuance that are constant within a predesignated range of prepayment speeds. The bonds that are lower in priority, however, have increased cash flow volatility, and typically trade to higher yields in order to entice investors.

The actual process of structuring PACs involves the following steps:

1. Designating the range of prepayment speeds within which the classes will (at issuance) have unchanged principal cash flows (known as the *PAC band* or *PAC collars*).

2. Generating a schedule of principal payments, using the speeds chosen as the upper and lower limits of the PAC band.

The PAC band at issuance, sometimes designated as the *structuring band*, is generally chosen at a range of prepayment speeds above and below the expected prepayment speed of the collateral, given the prevailing interest rate environment. In agency deals, the lower band (quoted as an assumed PSA) is generally somewhere in the area of 100% PSA, while the upper band is generally 250% PSA or higher. (PACs are less common in private-label structures, but the range of the bands generally exhibits more variability.) The lower and upper limits of the bands, as well as their width, often reflect the perception of risk in the market. For example, bonds might be structured with a 75% PSA lower band in a rising rate environment where speeds are expected to slow, or may have a 300% upper band when fast prepayments are a concern.

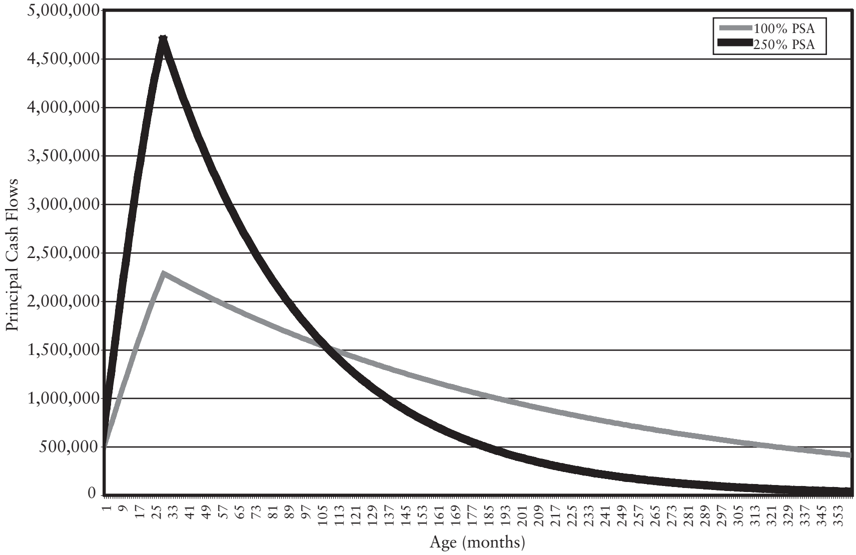
Once the structuring band is designated, the ***PAC schedule*** can be generated. The schedule is calculated from a vector of the principal cash flows generated at the prepayment speeds represented by the lower and upper PAC bands. The schedule is derived as follows:

- Generate principal cash flows for the lower and upper band speeds.
- The lower of the two monthly principal payment derived from the calculations is the cash flow used for the PAC schedule.

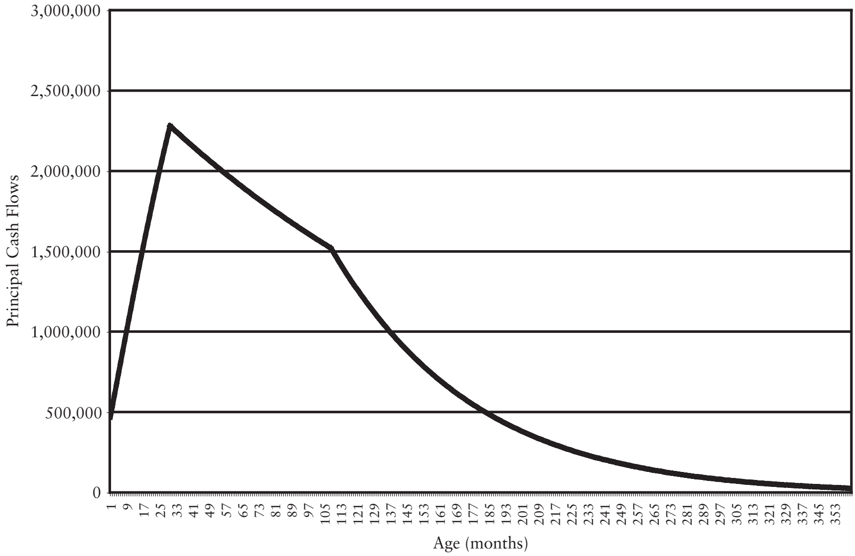
The following discussion uses the example of a hypothetical PAC-support deal collateralized by $400 million 5.5% MBS pass-throughs. The process of creating PACs with a band of 100% and 250% PSA is shown in Exhibit 6.5. Exhibit 6.5(A) shows the principal cash flows at the two designated speeds. Note that the principal cash flows at 250% PSA are much higher during the early years of the deal than at the slower prepayment speed. However, the principal cash flows in the later years are reduced since the effect of the faster speed is to return principal to the investor sooner. In the example, the smaller amount of monthly principal is generated by the lower band until month 109. This "crossover point" occurs when the upper band generates a smaller amount of principal. The resulting PAC schedule is shown graphically in Exhibit 6.5(B). The principal balance of the PACs is the sum of the principal cash flows generated by the schedule, which in Exhibit 6.5(B) is the area below the line. (Note that *PAC schedule* also refers to the schedule of declining principal balances that are used to allocate the PACs' principal cash flows, as discussed later in this chapter. This schedule, however, is generated by first calculating the monthly principal payments at

EXHIBIT 6.5 Creating a PAC Schedule for 5.5% MBS

A. Generating Cash Flows for $400 Million 5.5% MBS at Different Prepayment Speeds



B. The PAC Schedule for 5.5% MBS Pass-Throughs with a 100%–250% PSA Band



the lower and upper bands, using the process described thus far. For the sake of clarity, we reference the PACs' "balance schedule" separately.)

Once the PAC structure is created, the PAC class can be treated as a parent bond and sequentially time-tranched in the fashion described earlier, creating bonds with different average lives. Typically, deals might contain short (one to four years), intermediate (5 to 10 years) and long (greater than 10 years) PACs, depending on demand from different investor segments. While typical PAC deals create bonds with average lives across the curve, the actual structure is subject to market demand and the extent to which available cash flows can be allocated to create bonds desired by investors.

The cash flows remaining after the PACs are paid their scheduled principal are referred to as *support bonds* or *companion bonds*. The average life and duration profiles of such bonds are more variable because of the prepayment leverage introduced by the PACs. Put differently, the average life of the support will extend proportionately more at slower prepayment speeds, and contract more at fast prepayment speeds, than the deal's collateral.

A useful analogy is to view the CMO structure as if it were a corporate balance sheet. In a case where a corporation has no debt, its *earnings per share* (EPS) will be no more volatile than its after-tax earnings. Introducing debt means that the EPS are more volatile because of the effects of leverage, as payments must be made to the debt holders (through the equivalent of a schedule) before earnings flow through to shareholders. In this framework, a structure without PACs is the equivalent of the unleveraged corporation. As such, the PACs are the equivalent of debt, and the support bonds act as leveraged equity.

A graphic representation of the structure at issuance is shown in Exhibit 6.6. Note that since the deal is structured using a 165% PSA pricing speed, the size of the support bonds is the difference between principal cash flows generated at the 165% PSA speed and the PAC schedule.

The process of creating PACs through the schedule mechanism has some interesting implications. For example, the width of the structuring band not only dictates the quality of the PACs (i.e., the range of prepayments within which the band offers protection) but also the size of the PAC classes, as illustrated by Exhibit 6.7. The exhibit shows the same PAC schedule as in Exhibit 6.5(B), along with a schedule created for PACs with a 75% to 300% PSA band. If the latter schedule were inserted into Exhibit 6.6, the lower level of the line representing the PAC schedule means that the size of the PACs is smaller. Since the face value of total bonds is the same, the value of support bonds has increased. However, since there are fewer PACs, the support bonds are less leveraged and as such, the average lives and durations are less sensitive to changes in prepayment speeds and thus less volatile.

EXHIBIT 6.6 Graphic Representation of PAC-Support Structure for $400 Million 5.5% MBS

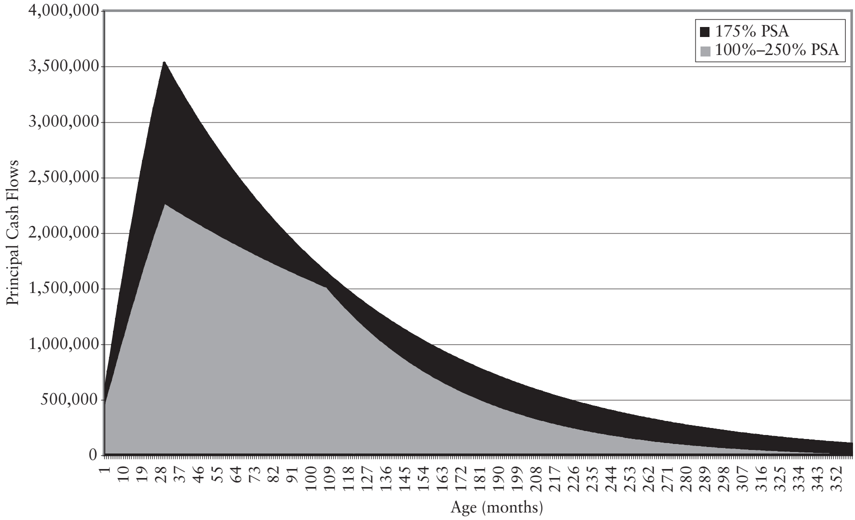
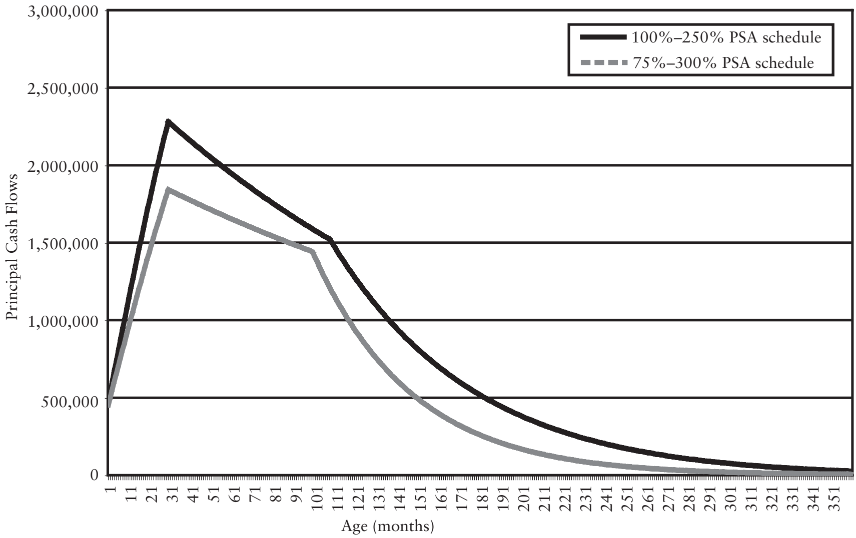


EXHIBIT 6.7 PAC Schedules for $400 Million 5.5% Deals with Different Bands



Conversely, a narrower band creates more PACs with less protection, and less (but more sensitive or "whippy") supports.

A simple deal (referenced as *Deal-02*) structured using the same collateral pool as in the prior section is shown in Exhibit 6.8 The average lives of the bonds created in Deal-02, as well as the MBS collateral, are shown at a variety of prepayment assumptions in Exhibit 6.9. The exhibit highlights the fact that, at the time of issuance the average life of the PAC is designed to remain stable within the PAC bands. The support bond, by contrast, has an average life which is much more volatile than either the PAC or the underlying collateral. This is a result of the prepayment "leveraging" effect of the schedule, as discussed previously in this section. The actual dollar amounts of the PAC schedule at different points in time are shown in Exhibit 6.10.

EXHIBIT 6.8 Deal-02: CMO Structure with One PAC and One Support Bond

Tranche	Par Amount	Coupon Rate
P (PAC)	$284,984,594	5.5
S (Support)	115,015,406	5.5
Total	$400,000,000	

Payment rules:
1. *For payment of periodic coupon interest*. Disburse periodic coupon interest to each tranche on the basis of the amount of principal outstanding at the beginning of the period.
2. *For disbursement of principal payments*. Disburse principal payments to tranche P based on its schedule of principal repayments. Tranche P has priority with respect to current and future principal payments to satisfy the schedule. Any excess principal payments in a month over the amount necessary to satisfy the schedule for tranche P are paid to tranche S. When tranche S is completely paid off, all principal payments are to be made to tranche P regardless of the schedule.

EXHIBIT 6.9 Average Lives of Collateral and Bonds Structured in Deal-02

	PSA (PAC band 100%–250%)								
	0	50	75	100	165	250	400	600	800
Collateral	19.2	14.4	12.7	11.2	8.6	6.4	4.5	3.2	2.6
P	15.8	10.2	8.6	7.7	7.7	7.7	5.5	4.0	3.2
S	27.7	24.9	22.7	20.0	10.7	3.3	1.9	1.4	1.1

EXHIBIT 6.10 Monthly Principal Payments and PAC Schedule for Deal-02 ($400 million 5.5% coupon pass-throughs with a 6.0% WAC and 358 WAM assuming a PAC band of 100% to 250% PSA)

	100% PSA	250% PSA	PAC Schedule
1	603,349	905,962	603,349
2	671,785	1,075,156	671,785
3	740,025	1,243,849	740,025
4	808,033	1,411,824	808,033
5	875,773	1,578,866	875,773
6	943,211	1,744,759	943,211
7	1,010,311	1,909,287	1,010,311
8	1,077,038	2,072,236	1,077,038
9	1,143,357	2,233,394	1,143,357
10	1,209,235	2,392,550	1,209,235
11	1,274,636	2,549,495	1,274,636
12	1,339,527	2,704,025	1,339,527
13	1,403,873	2,855,937	1,403,873
14	1,467,643	3,005,032	1,467,643
15	1,530,802	3,151,118	1,530,802
16	1,593,318	3,294,003	1,593,318
17	1,655,159	3,433,506	1,655,159
18	1,716,294	3,569,446	1,716,294
101	1,561,958	1,641,939	1,561,958
102	1,553,853	1,618,135	1,553,853
103	1,545,791	1,594,665	1,545,791
104	1,537,770	1,571,526	1,537,770
105	1,529,790	1,548,713	1,529,790
211	879,892	312,797	312,797
212	875,297	307,919	307,919
213	870,726	303,113	303,113
346	431,936	29,297	29,297
347	429,646	28,692	28,692
348	427,368	28,097	28,097
349	425,102	27,511	27,511
350	422,848	26,936	26,936
351	420,605	26,369	26,369
352	418,374	25,812	25,812
353	416,154	25,265	25,265
354	413,946	24,726	24,726
355	411,749	24,196	24,196
356	409,563	23,676	23,676
357	407,388	23,163	23,163
358	405,225	22,660	22,660

As with all structures, a PAC-support structure is a snapshot of relative proportions at a point in time, analogous in concept to a corporate balance sheet. However, this is especially important in deals containing PACs. After issuance, as time passes and the deal experiences actual prepayments, the relative proportions of PACs and supports changes, leading to changes in the bands of the remaining PACs. To understand this concept, it is important to understand the actual process of how monthly cash flows are allocated. As an example, assume a simple deal with one PAC (*P*) and one support class (*S*). The monthly principal cash flows would be allocated as follows:

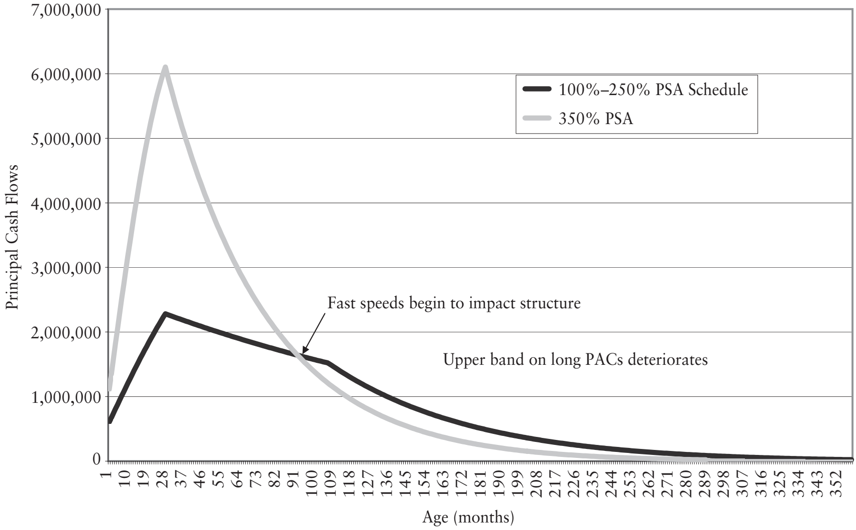
- Pay *P* to its balance schedule.
- Pay remaining cash flow to *S*.
- If *S* is paid off, pay remaining cash flow to *P*.

In the event of sustained faster prepayments, *S* will be prematurely paid off. In that case, the payment rules would essentially be the same as for a sequential structure. Keep in mind that, as noted previously, it is highly unlikely that realized prepayment speeds will be equivalent to those assumed in structuring the deal and creating the PAC schedule. Therefore, the face value of supports, and the proportion of supports relative to the PACs they are supporting, will change as the deal ages. This means that the protection offered by PAC structures is neither constant nor guaranteed, but can erode when prepayments deviate substantially from those established by the structuring band.

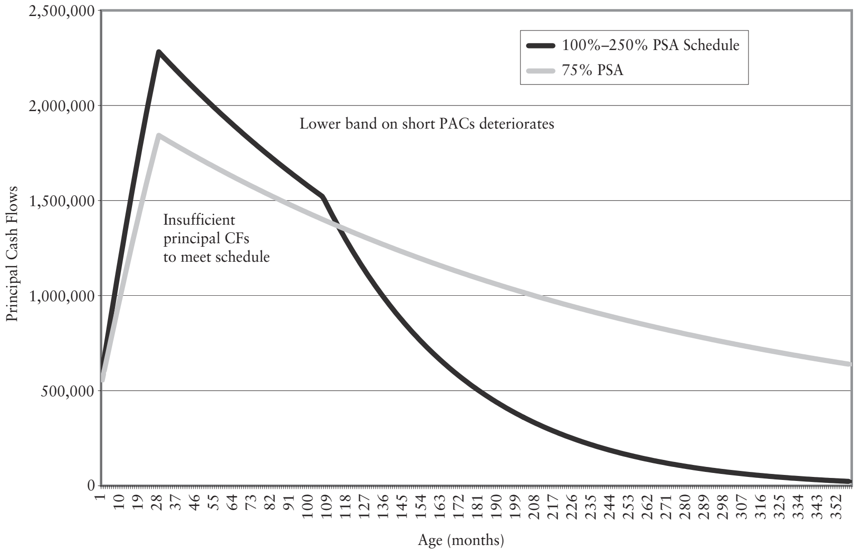
An eroding PAC band might change from 100% to 250% PSA at issuance to 115% to 235% nine months after the deal is closed. The 115% to 235% PSA band is referred to as an *effective band*. If the band deteriorates further, it may at some point be referred to as a "bruised" or "dented" PAC; when the band is entirely eliminated, the bond becomes a "broken" or "busted" PAC. Note also that a broken PAC can still have a schedule; the lack of an effective band means that that there are no prepayment speeds at which the schedule can be met.

In addition, fast and slow realized prepayment speeds impact the structure differently. Because the upper band dictates the schedule for the later cash flows, fast prepayment speeds disproportionately impact the longer PACs, and cause their upper band to deteriorate. The effect on the structure is illustrated in Exhibit 6.11(A). Conversely, as shown in Exhibit 6.11(B), slow speeds tend to cause the lower band on short PACs to increase, as there is not enough principal cash flow to meet the schedule. In this case, the band does not deteriorate, since the slow speeds pay off the support bonds more slowly and give the PACs more support. Rather, the band tends to shift upward, so that an initial band of 100% to 250% PSA might change to 175% to 325% over time.

EXHIBIT 6.11 Impact of Different Realized Prepayment Speeds on PAC Structure
A. Prepayments Above Upper Band



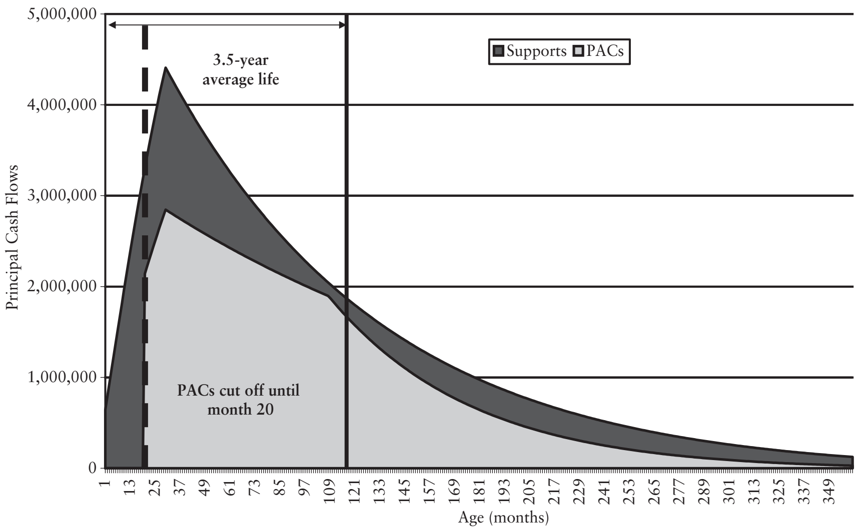
B. Prepayments Below Lower Band



As suggested by Exhibit 6.6, creating PACs from the entire pool of collateral means that the PAC cash flows run for the entire term of the collateral, that is, from month 1 through 360 (or shorter, if the WAM of the collateral is less than 360 months). However, in certain deals only a portion of the PAC cash flows are actually structured as PAC tranches, which creates interesting structuring permutations. In the previous example, suppose that the PACs in a deal begin paying principal cash flows after month 20 (called *locking out* the PACs). In that case, the short PAC cash flows are mixed with the support cash flows early in the life of the deal. Bonds structured from these cash flows are ***barbelled*** in nature, and often have attractive average life and duration profiles at issuance. However, the profile of such bonds changes over time as they age. A major change occurs when the lockout expires and the structured PACs begin to receive principal. Since no more PAC cash flows are available to be directed to the barbell tranche, the bond then becomes a pure support bond.

Exhibit 6.12 shows an example of this technique, using the structure with the PAC schedule derived for the 100% to 250% PSA band shown previously. This structure locks out the PACs until month 20, that is, the PAC cash flows structured and sold as PAC tranches begin with the cash flows in month 20. As previously described, the PAC cash flows from month 1 through 19 are mixed together with the support cash flows to create a

EXHIBIT 6.12 Graphic Representation of PAC-Support Structure with PACs Locked Out until Month 20



3.5-year barbell bond. After that, the PAC cash flows only flow to the PAC tranches. The 3.5-year bond shown in Exhibit 6.12 is, therefore, an amalgamation of PAC and support cash flows with performance characteristics that change over time in an unpredictable fashion. They are typically marketed to depositories, as they are structured specifically to meet regulatory requirements dictating their performance profile in specific scenarios. (We discuss these "FFIEC" rules in a later part of this chapter.)

Note that a similar phenomenon occurs if the longer PAC cash flows are "cut off," meaning that the long PAC and support cash flows are mixed together. This creates tranches with cash flows that are somewhat more volatile than long sequentials. However, demand for these cash flows is often strong because of the perception that the cash flows of very seasoned collateral (which will be collateralizing these tranches when they ultimately begin to pay principal) are inherently stable.

Creating a Series of PAC Bonds

Most CMO PAC structures have more than one class of PAC bonds. Exhibit 6.13 shows six PAC bonds created from the single PAC bond in Deal-07. We

EXHIBIT 6.13 Deal-03: CMO Structure with Six PACs Bonds and One Support Bond

Tranche	Par Amount	Average Life
P-A	23,217,400	1.0
P-B	93,217,500	3.5
P-C	21,889,000	5.9
P-D	44,572,200	7.5
P-E	65,418,800	10.9
P-F	36,669,700	18.3
S	115,015,400	10.7

Payment rules:
1. *For payment of periodic coupon interest*. Disburse periodic coupon interest to each tranche on the basis of the amount of principal outstanding at the beginning of the period.
2. *For disbursement of principal payments*. Disburse principal payments to tranches P-A to P-F based on their respective schedules of principal repayments. Tranche P-A has priority with respect to current and future principal payments to satisfy the schedule. Any excess principal payments in a month over the amount necessary to satisfy the schedule for tranche P-A are paid to tranche S. Once tranche P-A is completely paid off, tranche P-B has priority, then tranche P-C, and so on. When tranche S is completely paid off, all principal payments are to be made to the remaining PAC tranches in order of priority regardless of the schedule.

EXHIBIT 6.14 Average Lives of the PACs in Deal-03 Assuming Different Prepayment Speeds

	PSA (PAC Band 100% to 250%)								
	0	50	75	100	165	250	400	600	800
P-A	2.3	1.3	1.1	1.0	1.0	1.0	1.0	1.0	1.0
P-B	10.2	5.1	4.1	3.5	3.5	3.5	3.1	2.5	2.1
P-C	15.9	8.8	7.1	5.9	5.9	5.9	4.3	3.2	2.6
P-D	18.4	11.1	9.0	7.5	7.5	7.5	5.2	3.7	3.0
P-E	21.8	15.1	12.5	10.9	10.9	10.9	7.3	5.1	3.9
P-F	24.6	19.9	18.5	18.3	18.3	18.3	12.5	8.5	6.3

refer to this CMO structure as Deal-03. The total par value of the six PAC bonds is equal to $284.9 million, which is the amount of the single PAC bond in Deal-02.

Exhibit 6.14 shows the average life for the six PAC bonds and the support bond in Deal-03 at various prepayment speeds. From a single PAC bond in Deal-02 with an average life of 7.7, we have created six PAC bonds with an average life as short as 1.0 years (P-A) and as long as 18.3 years (P-F) if prepayments stay within 100% and 250% PSA.

As expected, the average lives are stable if the prepayment speed is between 100% and 250% PSA. Notice that even outside this range the average life is stable for several of the PAC bonds. For example, PAC P-A is stable even if prepayment speeds are as high as 800% PSA. For the PAC P-B, the average life does not vary when prepayments are between 100% and 250% PSA.

This demonstrates the earlier point, illustrated in Exhibit 6.11(A), that fast prepayment speeds have less of an impact on the short end of the PAC cash flow than on the longer part of the schedule. Put differently, at least some of the support bond is available to protect the P-A tranche throughout its life. Even at 800% PSA, for example, the support bond is not fully paid off until month 21; at that prepayment speed, the P-A is paid off by month 20. (This also highlights the difference between the structuring band and the effective band, as mentioned previously.)

By contrast, the P-B bond does not pay off completely at 800% PSA until month 30, well after the support has been paid off. Thus, the longer the PAC bond's average life, the less chance it has that the support bond will remain outstanding at fast prepayment speeds. In turn, this reduces the effective upper band of the PACs.

EXHIBIT 6.15 Effective Bands for PACs in Deal-03 at Different Prepayment Speeds after 12 Months

		12-Month PSA					
		50	**75**	**165**	**400**	**600**	**800**
P-A	Lower	302	180	100	106	111	117
	Upper	896	896	639	639	639	639
P-B	Lower	116	107	102	108	114	121
	Upper	305	303	298	282	268	253
P-C	Lower	103	102	102	110	118	127
	Upper	278	277	272	260	249	237
P-D	Lower	103	102	103	114	125	146
	Upper	259	258	255	246	238	230
P-E	Lower	102	101	102	115	134	153
	Upper	255	255	253	239	215	188
P-F	Lower	84	83	85	94	103	113
	Upper	253	253	252	243	230	214

A major implication of this discussion is that PAC deals have an implicit time element which is not readily apparent when examining the structure at issuance. One way to demonstrate this is to calculate the effective bands at a point in time in the future if prepayment speeds diverge from the structuring band. This is demonstrated in Exhibit 6.15. The table in the exhibit shows the effective bands for the different PACs in the deal if various prepayment speeds are run for a period of one year. From the table in the exhibit, we note the following:

- The effective bands are not identical to the structuring band even if the deal prepays at the pricing speed. As described previously, the effective upper band for the P-A tranche is significantly higher than the 250% PSA structuring band; the effective lower band for the P-F tranche, however, is lower than the structuring band of 100% PSA.
- At slower early speeds, the effective upper bands of all tranches increase. This is because the slow prepayment speeds leave more support bonds available to support the PACs if speeds subsequently increase. However, the lower band of the short PACs also increases at slow speeds, since there is not enough principal being created to meet their schedule.
- Fast early speeds result in the deterioration of the effective PAC bands of virtually all the tranches. For the short PAC, the erosion only impacts

the lower band. However, both the lower and upper effective bands are impacted for the P-B through P-F tranches since the fast speeds pay-down the support bonds faster than initially planned. This leaves less support for the PACs after the first 12 months.

Note that like the PAC cash flow, the supports can also be tranched sequentially, in order to create different average lives. This does not change the way the support bonds interact with the PACs. This type of time-tranching is done, as in other sectors, to create bonds that more closely match the investment needs of various clienteles. For example, a short support bond might be sold to an investor looking for prepayment speeds to remain fast or increase, while longer supports often appeal to retail investors looking for high current yields who are not particularly sensitive to changes in average lives and durations. In addition, all sectors of the support cash flow may be structured further into *MBS derivatives*.[1]

Finally, note that multiple PAC groups with different cash flow priorities can be structured within a deal. After creating an initial PAC-support structure, the support cash flows may be used to structure second level PACs. This creates what are called *PAC2s*, meaning that they have secondary priority for cash flows behind the first tier of PACs (i.e., the PAC1s). PAC2s generally have narrower bands than the PAC1s, and the balance schedule is met only after that of the PAC1s. Designating the PAC1s as *P*1 and the PAC2s as *P*2, the payment rules for this type of deal might be:

- Pay *P*1 to its balance schedule.
- Pay *P*2 to its balance schedule.
- Pay remaining cash flow to *S*.
- If *S* is paid off, pay remaining cash flow to *P*2.
- If *P*2 is paid off, pay remaining cash flow to *P*1.

This suggests that if prepayments are fast enough to pay off the supports, the PAC2s become the supports for the PAC1s. Additional levels of PAC bonds (and deals can be structured with three and four levels of PACs) also create more leverage in the structure, making the average life and duration profile of the supports and lower-tier PACs increasingly unstable. The important concepts, however, are that multiple schedules can be created within a deal, with differing degrees of priority. This holds true for the PAC structure, as well as other structuring variations that utilize schedules, as we will subsequently discuss.

[1]These typically consist of interest- and principal-only securities, as well as floater–inverse floater combinations. We discuss these structures in Chapter 7.

TARGETED AMORTIZATION CLASS BONDS

A ***targeted amortization class (TAC) bond*** resembles a PAC bond in that both have a schedule of principal repayment. The difference between a PAC bond and a TAC bond is that the former has a relatively wide PSA range over which the schedule of principal repayment is protected against contraction risk and extension risk. A TAC bond, in contrast, has a single prepayment speed from which the schedule of principal repayment is protected. As a result, the prepayment protection afforded the TAC is less than that for a PAC bond. As we shall explain, the creation of a bond with a schedule of principal repayments based on a single prepayment rate results in protection against contraction risk but not extension risk. Thus, while PAC bonds are said to have two-sided prepayment protection, TAC bonds have one-sided prepayment protection.

To understand why this is the case, take a simple deal with one TAC (*T*) and one support class (*S*). Monthly principal cash flows are allocated as follows:

- Pay *T* to its balance schedule;
- Pay remaining cash flow to *S*; then
- If *S* is paid off, pay remaining principal to *T*.

At prepayment speeds faster than the TAC schedule speed, the TAC has call protection as long as the support bond remains outstanding. At speeds slower than the TAC speed, by contrast, there is not enough monthly principal to meet the TAC's schedule, causing the average life of the TAC to extend.

There are a number of different structuring variations where TACs are used. In some cases, TACs are structured as an alternative to PACs, with the highest cash flow priority within the deal. In other cases, a support bond may be structured as a TAC by giving it a schedule. This gives it better protection from contraction risk than a stand-alone support. As with the PAC-support structure, deals with TACs can be viewed as utilizing a structuring technique where a schedule is generated and utilized to allocate principal payments. Both structures also create support bonds, which act to cushion the impact of varying prepayments on the bond(s) structured with a schedule. As with all bonds with schedules, the difference is mainly in how the schedule is created and where it stands in priority within the structure.

Z-BONDS AND ACCRETION-DIRECTED TRANCHES

Z-bonds are tranches where the bond coupon is accrued by adding the interest to the face value of the bond. While the term "Z-bond" or "Z" is borrowed from zero-coupon bonds in the government strip market, it is a misnomer, since the bonds have a coupon that is only paid to the investor in cash at the point where the bonds begin paying principal (i.e., when the lockout expires). The interest that normally would be paid to the parent bond during the lockout period is deferred and added to the Z's principal value in a process called *accretion*. The interest, in turn, is "directed" to a different bond in the structure. This directed cash flow can either form the principal for an entirely new tranche or be combined with an existing tranche to smooth the cash flow profile.

The logic is illustrated in Exhibit 6.16. The timing of principal and interest cash flows on a locked-out tranche at different prepayment speeds is shown in Exhibit 6.16(A), while (B) shows the same cash flows converted into a Z-bond (which only pays interest after the lockout expires) and a separate principal cash flow comprised of the Z-bond's accreted interest. By splitting normal interest-paying bonds into accrual bonds (the Z) and an accretion-directed class, the overall deal execution can be improved by either creating very stable bonds (which trade at narrow spreads) or using the accreted interest to improve the profile of existing tranches to make them more marketable (and ultimately have them trade at tighter spreads). At the same time, the long duration of the Z-bond appeals to investors with longer-dated liability structures. In addition, reinvestment risk is ameliorated; since Zs accrete at the coupon rate, the reinvestment rate is locked in as long as the bond accrues.

EXHIBIT 6.16 Generation of Z-bond and Accretion-Directed Cash Flows
A. Graphic Representation of a Tranche's First and Last Principal Payments by Prepayment Speed

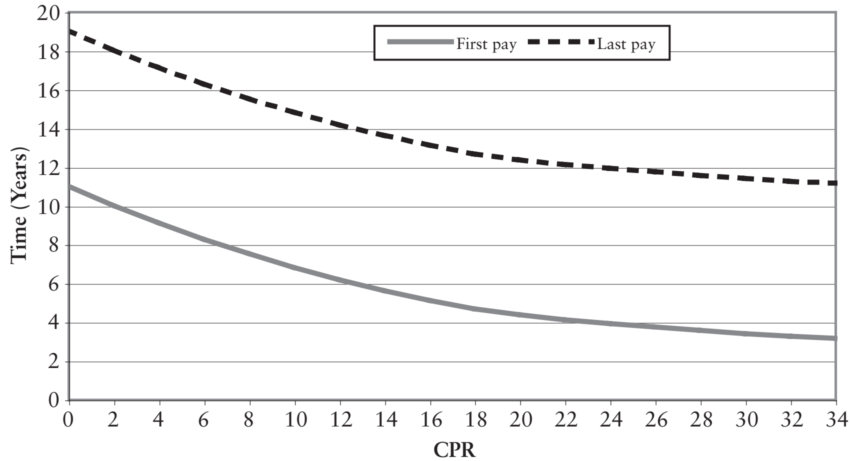
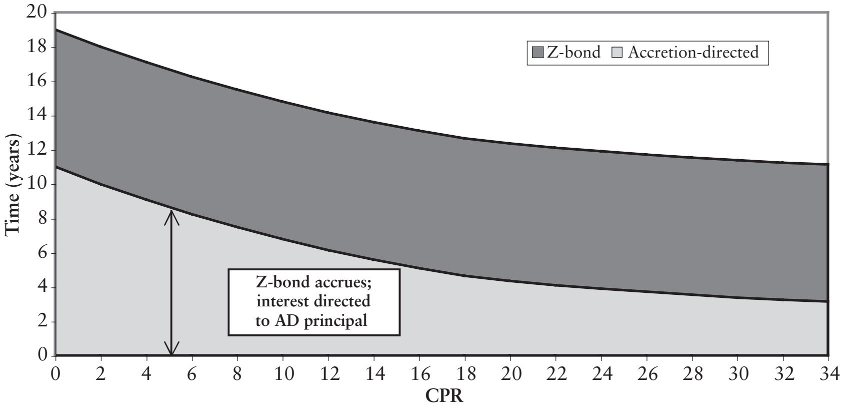


EXHIBIT 6.16 (Continued)
B. Graphic Representation of Hypothetical Tranche Cash Flows



Bonds structured using the accreted interest of the Z-bond (known as *accretion-directed bonds*) have very stable average life and duration profiles because of the characteristics of interest cash flows generated by the parent bond when it is locked out. Pure interest payments on a locked-out tranche cease once the lockout expires. Since the earliest principal payment is not normally delayed greatly even at slow speeds, the AD bond generally has greater stability than other bonds in the structure. Note that in such structures, the principal available is unchanged because the combined face value of the Z-bond and any AD bonds equal that of the original parent tranche.

A subset of the accretion-directed universe is the VADM (an acronym for *very accurately dated maturity*). VADMs are stand-alone AD bonds structured to be free from extension risk even in the absence of prepayments (i.e., if prepayments are 0% CPR). The bonds also have relatively short "legal final maturities," which is the last possible date for principal to be paid in any scenario. In order to create these bonds, the amount of the Z-bond must be relatively large, resulting in large amounts of accretions. Such bonds appeal to investors with no tolerance for extension exposure, as well as depositories and other conservative investors seeking bonds with short legal final maturities (often for regulatory considerations).

The size of the Z-bond is a function of the coupon of the parent tranche and lockout and is calculated as follows:

$$\text{Z-bond face value} = \text{Parent tranche} \div [1 + (\text{Coupon}/12)]^{\text{Lockout (in months)}}$$

EXHIBIT 6.17 Deal-04: A Hypothetical Four-Tranche Sequential Pay Structure with an Accrual Bond Class

Tranche	Par Amount	Coupon Rate (%)	Average Life
A	206,514,000	5.5	3.4
B	46,302,000	5.5	7.3
C	111,726,000	5.5	10.9
Z	35,458,000	5.5	19.5
Collateral	400,000,000	5.5	8.6

Payment rules:

1. *For payment of periodic coupon interest*. Disburse periodic coupon interest to tranches A, B, and C on the basis of the amount of principal outstanding at the beginning of the period. For tranche Z, accrue the interest based on the principal plus accrued interest in the previous period. The interest for tranche Z is to be paid to the earlier tranches as a principal paydown.
2. *For disbursement of principal payments*. Disburse principal payments to tranche A until it is completely paid off. After tranche A is completely paid off, disburse principal payments to tranche B until it is completely paid off. After tranche B is completely paid off, disburse principal payments to tranche C until it is completely paid off. After tranche C is completely paid off, disburse principal payments to tranche Z until the original principal balance plus accrued interest is completely paid off.

As an example, a $50 million face value tranche with a 6% locked out for 60 months can create $37 million Z-bonds, with the remaining $13 million being AD bonds. Note that the amount of Z-bonds that can be created increases either as the lockout period of the parent tranche decreases or the coupon is reduced.

To see this, consider Deal-04, a hypothetical CMO structure with the same collateral as Deal-01 and with four tranches, each with a coupon rate of 5.5%. The difference is in the last tranche, Z, which is an accrual tranche. The structure for Deal-04 is shown in Exhibit 6.17.

There are a number of noteworthy aspects to Exhibit 6.17. Note that while the average lives for tranches A, B, and C are unchanged from the original sequential deal, the principal balance of the tranches are all larger. Tranche Z, by contrast, is smaller than tranche D in Deal-01. Effectively, part of the balance of the parent sequential bond has been pushed forward to the shorter bonds in the deal. In addition, the average life profile of bonds A-C is "smoother" or less volatile than those of the bonds in the original structure, as shown in Exhibit 6.18. This represents the effects of the accreted interest from the Z-bond that is now being directed to the shorter bonds in the structure.

EXHIBIT 6.18 Average Life of Sequential Bonds in Deals without and with Z-bonds (Deal-01 and Deal-04)

		100	125	165	250	400	500	600	700
Tranche A	No Z-bond	4.7	4.1	3.4	2.7	2.0	1.8	1.6	1.5
	With Z-bond	4.5	4.0	3.4	2.7	2.0	1.8	1.6	1.5
Tranche B	No Z-bond	10.4	8.9	7.3	5.3	3.8	3.2	2.8	2.6
	With Z-bond	9.9	8.7	7.3	5.5	3.9	3.4	3.0	2.7
Tranche C	No Z-bond	15.1	13.2	10.9	7.9	5.3	4.4	3.8	3.4
	With Z-bond	14.1	12.7	10.9	8.3	5.9	4.9	4.3	3.8

Z-bonds can be structured from sequential, PAC, or support cash flows. Support Z-bonds often have very complex structures and trade at substantial discounts to parity, appealing to investors looking to make highly leveraged bets on fast prepayments. From the structurer's perspective, the creation of a support Z-bond has a similar purpose to those created in a sequential deal. The accretions created by the support Z (especially at slower speeds) can be directed to a shorter support tranche, serving to smooth the short support's average life and duration profile in order to make it more marketable. We explore this in more depth later in this chapter.

Exhibit 6.19 shows a simple sequential structure (Deal-05) where the Z-bond's accretions are used to create a VADM. The balances of tranches A, B, and C are the same as those of Deal-01, the original sequential deal. In this case, an extra VADM tranche is created that utilizes the accretions to create one bond that has virtually no extension risk. The average life profile of the bonds in Deal-05 is shown in Exhibit 6.20. The table shows that even in the absence of prepayments (i.e., 0% PSA), the average life of tranche V does not extend beyond 8.1 years, the same as at the 165% PSA pricing speed.

A SIMPLE STRUCTURING EXAMPLE

To illustrate how the different structuring techniques can be utilized, the following section shows a simple problem often encountered by structurers: What is the most efficient way to smooth the profile of a short support to make it marketable to relatively conservative investors such as banks and depositories? For background, the bank regulatory agencies, collectively known as the Federal Financial Institution Examination Council (FFIEC), released a set of rules in 1992 governing investments in MBS. Known as the *FFIEC rules*, they stated that structured MBS should meet the following criteria at the time of purchase:

- Their base-case average life should not exceed 10.0 years.
- Their projected average life should not shorten by more than six years, or extend by more than four years, in interest rate scenarios where the yield curve shifts plus or minus 300 basis points in a parallel fashion.
- Their projected price should not decline by more than 17.0% in the event of a 300 basis point rate shift.

EXHIBIT 6.19 Deal-05 CMO Sequential Pay Structure with a VADM Tranche

Tranche	Par Amount	Coupon Rate (%)	Average Life
A	194,500,000	5.5	3.4
B	36,000,000	5.5	7.3
C	96,500,000	5.5	10.9
V	39,602,000	5.5	8.1
Z	33,398,000	5.5	19.8
Collateral	400,000,000	5.5	8.6

Payment rules:
1. *For payment of periodic coupon interest*. Disburse periodic coupon interest to tranches V, A, B, and C based on the amount of principal outstanding at the beginning of the period. The interest earned by tranche Z is to be paid to tranche V as a paydown of principal and accrued as interest to tranche Z.
2. *For disbursement of principal payments*. Disburse interest accrued by tranche Z as principal to tranche V until it is completely paid off. Concurrently, disburse principal to tranche A until it is completely paid off. After tranche A is completely paid off, disburse principal to tranche B until it is completely paid off. After tranche B is completely paid off, disburse principal to tranche C until it is completely paid off. After tranche C is completely paid off, disburse principal payments to tranche V until it is completely paid off. After tranche V is completely paid off, disburse principal payments to tranche Z until the original mortgage balance plus accrued interest is completely paid off.

EXHIBIT 6.20 Average Lives for Tranches in Deal-05

	0	100	165	200	400	500	600
A	12.4	4.7	3.4	3.1	2.0	1.8	1.6
B	21.6	10.4	7.3	6.3	3.8	3.2	2.8
C	25.0	15.1	10.9	9.4	5.3	4.4	3.8
V	8.1	8.1	8.1	8.0	6.1	5.3	4.6
Z	28.6	24.0	19.8	18.1	11.4	9.4	8.0

EXHIBIT 6.21 Average Life and Duration Profile of 3.5-Year Support Bond

PSA	100	115	125	165	200	300	500
Avg. Life	15.4	11.5	9.2	3.5	2.4	1.5	1.0
Duration	10.1	7.9	6.6	3.0	2.2	1.4	1.0

Goal: Creating 3.5-year bond in base case that extends to 7.5-year average life at 115% PSA.

Securities that did not meet these standards were classified as "high-risk investments." In theory, depositories could buy high-risk investments if they could demonstrate that such purchases would reduce the interest rate exposure of the institution. In practice, it meant that bonds purchased by regulated institutions almost always met these standards. (While the rules were rescinded in 1998, some investors continue to utilize the criteria as standards for judging the appropriateness of MBS investments.)

Therefore, a challenge for structurers is to take short support bonds and modify them to the extent that they can comply with the FFIEC rules and thus be sold to depositories. In the following hypothetical examples, we use a number of different structuring techniques to transform a short support bond into a FFIEC-eligible or "bank bond" with a 3.5-year average life. The profile of a short support bond created by time-tranching the support created by Deal-02 is shown in Exhibit 6.21. Note that its average life at 115% PSA (which is the assumed prepayment speed in a rates-up 300 basis points scenario) extends to 11.5 years; the 8.0-year extension of the average life from the base case does not meet the FFIEC test's standards.

One approach would be to take the supports off the base-case PAC-support deal (using 30-year 5.5s with a 100% to 250% PSA structuring band) and give them a schedule, making them PAC2s or lower-priority PACs. To accomplish this, the PAC2 is given a PAC band of 132% to 175% PSA, and targeted to have a 3.5-year average life at 165% PSA. This is shown as Option 1 in Exhibit 6.22, which shows the basic details of the structure, as well as the profile of the bank bond.

As with most structuring options, there are trade-offs that accompany this potential solution. One is that the band of the PAC2 may deteriorate in the fashion discussed previously. This would mean that the bond's profile might become more volatile over time, particularly if interest rates and prepayment speeds "whipsaw." (This highlights the point made earlier in this chapter that a PAC structure is like a balance sheet, in that it is a snapshot at the point of issuance.) The other downside of this option is that the bank bond is relatively small, comprising only about 7% of the deal. As a result, creating this bond has only a marginal impact on the overall execution of the deal.

EXHIBIT 6.22 Options for Creating a Bank Bond

Option 1: Create bank bond as a PAC2
PAC1: 100% to 250% PSA band, no lockout
Bank Bond: PAC2, 132% to 175% PSA band

Bond	Percent of Deal
PACs	71.3%
Bank bond	7.3%
Support	21.5%

PSA	100	115	125	165	200	300	500
Avg. Life	13.1	7.5	4.8	3.5	3.5	3.1	2.1
Duration	9.1	5.7	3.9	3.0	3.0	2.8	1.9

Option 2: Create bank bond as PAC2 with wider PAC1 bands
PAC1: 90% to 300% PSA band, no lockout
Bank Bond: PAC2, 145% to 175% PSA band

Bond	Percent of Deal
PACs	62.6%
Bank bond	12.5%
Support	25.0%

PSA	100	115	125	165	200	300	500
Avg. Life	10.7	7.5	5.8	3.5	3.5	3.5	2.4
Duration	7.7	5.7	4.6	3.0	3.0	3.0	2.2

Option 3: Create bank bond as PAC2 while locking out the PAC1s
PAC1: 100% to 250% PSA band, 20-month lockout
PAC2: Schedule @ 145% PSA

Bond	Percent of Deal
PACs	65.5%
Bank bond	18.1%
Support	16.4%

PSA	100	115	125	165	200	300	500
Avg. Life	10.5	7.5	5.9	3.5	3.6	2.5	1.7
Duration	7.0	5.4	4.5	2.9	3.0	2.2	1.6

EXHIBIT 6.22 (Continued)
Option 4: Create bank bond by using accretions from support Z
PAC: 95% to 250% PSA band, no lockout
Bank Bond: No band, receives accretions from support Z

Bond	Percent of Deal
PACs	69.9%
Bank bond	19.9%
Support Z	10.2%

PSA	100	115	125	165	200	300	500
Avg. Life	9.4	7.4	6.3	3.5	2.6	1.7	1.2
Duration	6.9	5.6	4.9	3.0	2.3	1.6	1.1

A second approach, also creating the bank bond as a PAC2, would be to change the PAC1 structure such that the structuring band is wider, making less volatile support bonds. This approach is shown in Option 2 in Exhibit 6.22. This alternative uses a structuring band for the PAC1s of 90% to 300% PSA. This means that the lower band of the PAC2 can be at a faster PSA speed.

The benefits of this approach vis-à-vis Option 1 are (1) the bank bond is larger and (2) it has less average life extension at prepayment speeds slower than 115% PSA. The downside of this structure, however, is that the wider bands create fewer PACs to sell. Since the PACs reap the highest relative dollar prices, all else equal, creating fewer of them means that the same execution would require that they trade to significantly tighter spreads than those PACs structured at 100% to 250% PSA. This execution is not always attainable in the market. In addition, the bank bond itself must receive stronger execution relative to that created in the earlier deal, since it comprises a larger portion of the structure.

Option 3 shown in Exhibit 6.22 utilizes structuring bands of 100% to 250% PSA for the PAC1s, but locks out the PAC1s for the first 20 months. The bank bond is still structured as a PAC2 with 145% to 175% PSA bands, but the cash flows of the short PACs now flow into the bank bond, smoothing its profile at issuance and making it an even larger percentage of the deal. Note that the bank bond in this structure has, in the base case, even less extension at 100% PSA than the bond structured using the wider band (i.e., Option 2).

The major problem with the structure under Option 3 is that the cash flows of the bank bond are heavily front-loaded because it is partially comprised of the short PACs. This is illustrated in Exhibit 6.23. This exhibit shows the monthly principal cash flows as a percentage of the face value of the bank bonds created by Options 1 and 3. Since both bonds have the same average life, the principal cash flows for the Option 3 bond run for a much longer period of time (i.e., the bond has a longer window), making its principal cash flows barbelled in nature. As noted previously, this means that the bond's profile changes as the deal ages and the short PAC cash flows amortize. This phenomenon is illustrated by Exhibit 6.24, which shows the average life of the bond created in Option 3 at the deal's settlement, and in month 20. Note that the average life profile of the bond is more volatile in month 20, particularly at slower prepayment speeds. In addition, the bond's base-case average life is slightly longer, even though the bond has been outstanding for almost two years. This counter-intuitive behavior is a manifestation of the structuring method illustrated in Exhibit 6.12. While it creates bonds that have an ostensibly stable profile, the technique introduces a time dimension to MBS analysis that is not widely understood.

EXHIBIT 6.23 Percentage of Total Face Value Paid as Monthly Principal for Different Structuring Options

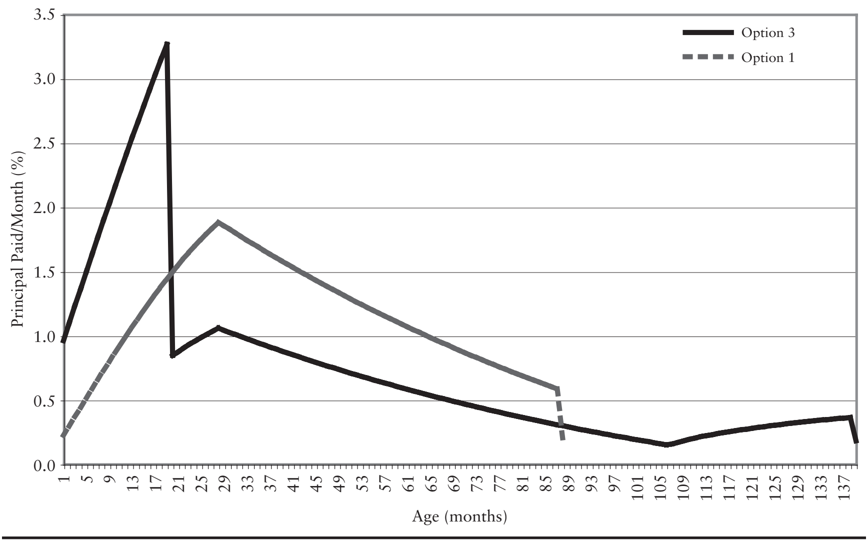


EXHIBIT 6.24 Average Life Profile of Bank Bond Created in Option 3 at Settlement and at Month 20

PSA	100	115	125	165	200	300	400	500
Settlement	10.4	7.5	5.9	3.5	3.5	2.4	1.9	1.7
Month 20	13.1	9.4	7.2	3.6	3.7	1.8	0.9	0.5

The final structuring option, Option 4, uses Z-bond accretions to improve the short support's profile. In this example, there is no PAC2 created. The PACs are structured with a 95% to 250% PSA structuring band. The supports are created by tranching the support bond into a short support and a long support Z, and the deal is structured such that the accretions from the Z are directed to the short (or "front") support. The accretions smooth the profile of the support and allow it to be marketed to banks and depositories.

Structured in this manner, the bank bond's face amount is large, and its profile is fairly robust, in that it does not change a great deal either with small changes in prepayments or as time elapses. The main difficulty with Option 4 is the marketability of the support Z. Such bonds tend to trade at very wide spreads and high yields, and the market for them is not as broad and deep as it is for other segments of the CMO market. Thus, demand for support Zs can be sporadic; unless the demand for this type of bond is unusually high, execution for this structure will not be as strong as for other options. Therefore, this option is only feasible when demand for long support Zs is strong.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Collateralized Mortgage Obligation (CMO)
Time Tranching
PAC-Support Structure
PAC Schedule
Barbelled (cash flows)
Targeted Amortization Class (TAC) Bonds
Z-Bonds
Accretion-Directed Bonds

CHAPTER 7

Fundamental MBS Structuring Techniques

Divisions of Interest

As with the division and structuring of principal cash flows, interest cash flows can also be altered and redirected within a structure. The factors driving the structuring of interest are identical to those in principal structuring discussed in the preceding chapter. The goal is to create bonds that, by appealing to different segments of the fixed income investment community, maximize the proceeds generated by creating and selling the deal. By redistributing interest within the deal, bonds can be created with different coupon levels and structures, thus allowing for different degrees of exposure to interest rates and prepayment speeds. As examples, the following bonds can all be structured off either a pool of collateral or a parent tranche:

- ***Floaters.*** Bonds where the interest adjusts (or "floats") with a benchmark index. They have minimal exposure to changes in interest rates (i.e., their durations are very short), and are tailored to investors looking to reap a spread over short-term funding levels.
- ***Principal-only (PO) tranches.*** Bonds that pay no coupon interest to the holder. Sold at a deep discount to investors, its returns are based on the rate at which principal is returned to the investor. These bonds typically have very long and volatile durations, since their prices are affected not only from the impact of a different discount rate on the cash flow's present value, but by changing prepayment speeds.
- ***Interest-only (IO) tranches.*** Bonds that pay only interest to the investor, based on the remaining balance of a notional principal amount. These bonds can be viewed as a form of an annuity because their value increases the longer they remain outstanding. Since prepayment speeds and interest rates are negatively correlated, this means that the duration of an IO is, in most cases, negative.

There are some fundamental differences in structuring mortgage-related principal and interest. As mentioned previously, there is a fixed amount of principal associated with a deal, and the principal available to be distributed is invariable. Interest, however, is a function of the outstanding principal balance. The total amount of interest available in a deal, therefore, depends on the prepayment speed experienced by the collateral pool. (For securities backed by ARMs, of course, available interest is also based on the note rates of the underlying loans.) However, the amount of interest available to be paid to the tranches in a deal is constant at any particular point in time. Therefore, changing the coupon of a bond is a process of reallocating interest within the structure.

The simplest structure in which interest and principal is redistributed is an ***IO–PO trust***. In this form, a pool of collateral is divided into IO and PO tranches. The PO receives only the principal paid by the obligors on the underlying loans, including both scheduled principal payments and prepayments. The IO class receives only the interest cash flows generated by the collateral. While the IO tranches have a quoted principal face value, it is notional; it represents the outstanding principal balance from which the interest cash flows are generated.[1] Note that an IO–PO trust is actually not a structured security, but is created by using a trust structure. Therefore, cash flows are not reallocated or tranched within the structure, nor is there any residual interest.

Often, however, a structured transaction can be optimized by redistributing interest within the structure. In some cases, the coupon of a bond must be reduced in order to drop its dollar price. This is particularly true for tranches targeted to banks and other depository institutions; securities offered at a significant premium over par often are not attractive to this market segment. Another common technique is to convert some of the existing tranches from fixed rate into floating rate securities. There are a variety of clienteles for floating rate securities, depending on their average life, cap structure, and liquidity, which include:

- Banks and corporate treasurers that will use highly liquid floaters as a higher-yielding alternative to cash.
- More aggressive depository institutions that buy the longer floating rate securities (that typically carry higher margins) as part of their core investment portfolio; these institutions can earn a relative high return on assets and equity with less interest rate risk.
- Investors that take and manage credit risk rather than interest rate risk.

[1]The first IO–PO trusts were structured in the late 1980s, after the Federal Reserve changed the delivery system to accept notional securities (i.e., bonds with no principal component).

This chapter addresses the techniques commonly utilized to redistribute coupon interest within a structured transaction. Note that the different methodologies are not mutually exclusive, as some techniques will serve multiple purposes (i.e., a variation on a floater structure is often used to reduce or "strip" the coupons of bonds in the structure, as we will discuss). Finally, decisions on how to redistribute interest cannot be made without considering the division of principal. For example, a steep yield curve typically means that tranches with short average lives trade above par if their coupons are the same as the underlying collateral. Therefore, the ability to create *short-average-life bonds* (typically targeted to banks in this type of regime) is often contingent on being able to strip the short tranche's coupon to one that creates a bond with a price at or below par.

COUPON STRIPPING AND BOOSTING

One of the common structuring techniques is reducing or "stripping" the coupon of a bond or series of bonds to make such securities more appealing to investors that seek par or discount-priced securities. As noted previously, fixed rate collateral pools and parent bonds in the mortgage-backed securities universe have fixed dollar amounts of interest associated with them at a particular point in time. Changing the coupon of a bond within a prime MBS structure, therefore, is a process of reallocating interest within the structure. As such, stripping the bond coupon creates interest cash flows that must be either directed elsewhere in the structure or sold as IO securities or tranches.[2]

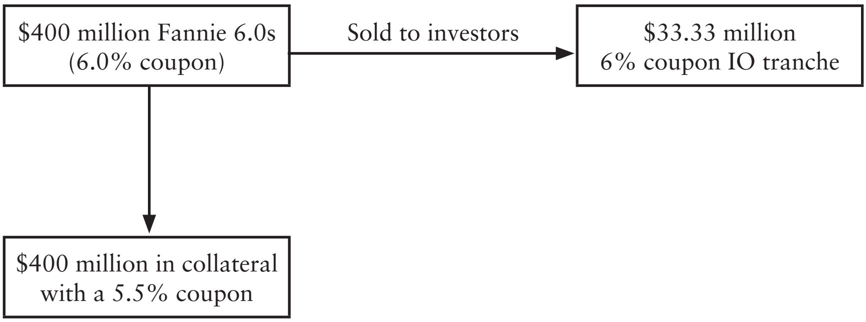
The simplest form of ***coupon stripping*** is to split the parent bond into two equally sized child tranches. Interest taken from one bond (the "discount," in this case) is allocated to the other bond (the "premium"), creating a parallel split. As a simple example, a $10 million face value tranche with a 5.5% coupon can be split into $5 million of bonds with a 5.0% coupon and $5 million of a 6.0% coupon bond. This split suggests that there is greater demand for both the 5.0% and 6.0% coupon bonds (the "children") than the original 5.5% parent tranche.

IOs can be created at a number of different levels within the deal. One approach is to strip the entire pool of collateral. For example, Fannie Mae 6.0s can be stripped into 5.5s by creating an *IOette*, which will be identical in form to a trust IO. This technique is shown in Exhibit 7.1. The notional face value of the IO to be sold is calculated as follows:

$$\text{IO notional face value} = \left(\frac{\text{Coupon of strip}}{\text{Target coupon}}\right) \times \text{Collateral face value} \quad (7.1)$$

[2]In some cases, the coupon of a bond or cash flow has to be increased to appeal to certain types of investors focused on current yield.

EXHIBIT 7.1 Stripping a Collateral Pool by Creating an IO Tranche



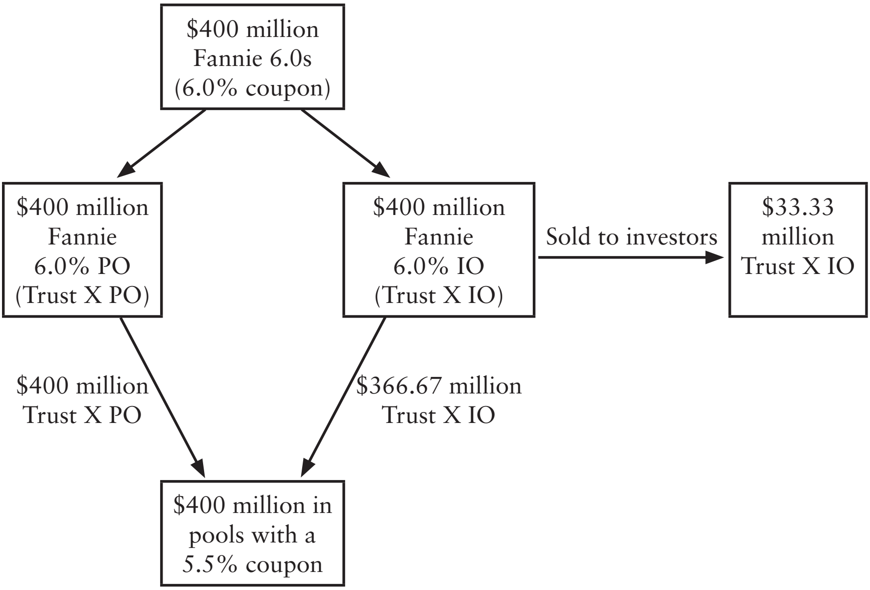
In the example, $400 million face value of 6.0% collateral can be stripped by selling $33.33 million of a 6% IO tranche, creating $400 million of collateral with a 5.5% coupon. However, what is important to understand is that while the coupon of the collateral is now 5.5%, it will continue to exhibit the prepayment characteristics of Fannie 6.0s.

Interestingly, one variation on this technique is to split the collateral into equal face values of POs and IOs, and then partially recombine them, leaving some trust IO to be sold separately. In this case, a trust is actually created; the deal's collateral therefore is a mismatched amount of the IO and PO off the same trust. Exhibit 7.2 illustrates how this technique works for the same $400 million face value of Fannie Mae 6.0s. In this case, $400 million in collateral with a 5.5% coupon is created, leaving $33,333,333 in 6% trust IO to be sold. It should be noted that this methodology is not commonly used since the trust IO created will typically be small and quite illiquid.

A commonly used technique is to create an IO tranche. As with other forms of IOs, such securities receive only interest cash flows, and do not receive any principal payments. Rather, their face value is notional and is used solely to calculate the dollar value of the interest cash flows received by the IO holder in any month. For example, holders of a $10 million notional face value of an IO with a 5.5% coupon receive $45,833 in interest cash flows per month. The notional value of the IO factors down as the parent bond receives principal payments. The IO holder is disproportionately affected by prepayments, since the asset generating interest cash flows declines in size.

As an example, a structurer might attempt to improve the execution on a PAC–support structure by stripping the PACs in a deal. This can either be done by stripping the coupon of the entire PAC group (i.e., before time tranching it) or by stripping only some of the PACs. The latter is commonly

EXHIBIT 7.2 Stripping a Collateral Pool by Creating and (partially) Recombining Trust IO and PO (created as a hypothetical trust X)



seen in regimes of a steep yield curve and low short interest rates; the short PACs may be more attractive at par or near-par prices, while the longer PACs might be more easily marketed with fuller coupons. IOs created off PACs are, logically enough, called *PAC IOs*.

The notional sizing of IO tranches is somewhat arbitrary, and based on the coupon associated with the tranche. For example, a $10 million face value of a 5.5% coupon can be split into a $10 million tranche with a 5.25% coupon, and $10 million notional bonds with a 0.25% coupon. For the sake of appearance, the coupon on this IO will typically be adjusted upward, often so that it is consistent with the parent bond original coupon (i.e., 5.5%). This means that the notional value of the IO must be adjusted downward in order for the IO holder to receive the same cash flows. Using equation (7.1), $10 million of an IO tranche with a 0.25% coupon can be converted to a tranche with a 5.5% coupon and a notional face value of $454,545.

A more general formula calculates the size of an IO to be created, using the original tranche coupon and the target coupon of the tranche, and is

$$\text{IO size} = \text{Tranche size} \times \left(1 - \frac{\text{Tranche target coupon}}{\text{Original tranche coupon}}\right) \tag{7.2}$$

As in the previous chapter, it is often helpful to see the structuring technique in the context of a deal. Exhibit 7.3 shows Deal-04 (a sequential 5.5% structure with a last-cash-flow Z-bond) with 25 basis points stripped off the first tranche (or, as it is sometimes referenced, the *front bond*). The front bond in the resulting Deal-05 has the same face value as in the earlier deal described in the previous chapter; however, an IO with a notional face value of roughly $9.3 million is also created. Note that because the IO is notional, the overall deal still has a principal value of $400 million.

Another variation would involve stripping the 5.5% parent tranche to a 5.0% child tranche and a tranche with a super-premium coupon such as 8%. The super-premium tranche can either be sold as a *cushion bond* to investors that expect prepayments to slow, or used as the parent tranche for a floater–inverse IO combination, a technique discussed later in this chapter.

The formulas for sizing the tranches in a discount–premium split are as follows:

EXHIBIT 7.3 Deal 05: Deal 04 Restructured to Reduce the Coupon Rate of Tranche A to 5.25% by Creating an IO

Tranche	Par Amount	Coupon Rate (%)	Average Life
A	206,514,000	5.25	3.4
IO	9,387,000	5.50	3.4
B	46,302,000	5.50	7.3
C	111,726,000	5.50	10.9
Z	35,458,000	5.50	19.5
Collateral	400,000,000	5.50	8.6

Payment rules:

1. *For payment of periodic coupon interest*. Disburse periodic coupon interest to tranches A, B, and C on the basis of the amount of principal outstanding at the beginning of the period. For tranche IO, disperse periodic interest based on notional principal value of tranche at the beginning of the period. For tranche Z, accrue the interest based on the principal plus accrued interest in the previous period. The interest for tranche Z is to be paid to the earlier tranches as a principal paydown.
2. *For disbursement of principal payments*. Disburse principal payments to tranche A until it is completely paid off. After tranche A is completely paid off, disburse principal payments to tranche B until it is completely paid off. After tranche B is completely paid off, disburse principal payments to tranche C until it is completely paid off. The notional balance of tranche IO is reduced proportionately with the decline in the balance of tranche A. After tranche C is completely paid off, disburse principal payments to tranche Z until the original principal balance plus accrued interest is completely paid off.

$$\text{Discount tranche size} = \left[\frac{\text{Premium coupon} - \text{Parent coupon}}{\text{Premium coupon} - \text{Discount coupon}}\right] \times \text{Parent balance} \quad (7.3)$$

$$\text{Premium tranche size} = \text{Parent tranche size} - \text{Discount tranche size} \quad (7.4)$$

For example, a $10 million face value tranche with a 5.5% coupon can be split into 5.25% and 8% coupon bonds as follows:

$$\text{Size of 5.25\% tranche} = \left[\frac{8\% - 5.5\%}{8\% - 5.25\%}\right] \times 10{,}000{,}000 = \$9{,}090{,}909$$

$$8\% \text{ tranche size} = \$10{,}000{,}000 - \$9{,}090{,}909 = \$909{,}091$$

FLOATER–INVERSE FLOATER COMBINATIONS

As with many structuring techniques, floater–inverse floater combinations can be structured from a variety of cash flows, including the entire collateral pool. The objective in creating floater–inverse combinations is to improve deal execution by taking advantage of the very low yields associated with floating rate bonds, especially when the yield curve is steep. Creating floating rate bonds (i.e., bonds where the coupon changes periodically based on the level of an index) from fixed rate underlying cash flows also implies the creation of a bond where the coupon changes inversely with the floater coupon (and thus the index), known as the ***inverse floater***. In agency and private-label deals, the inverse floater is structured as a separate tranche that mimics the principal cash flow profile of the underlying parent bond. The coupon, however, changes inversely with the change in the index and thus the floater coupon, since interest available to be paid to the inverse is limited by the interest paid to the floater.

There are several noteworthy aspects to structures that include floating rate bonds:

- Early in the inception of such deals, floater deals did not incorporate inverse floaters as tranches. Rather, the inverse floating rate coupon was sold as part of the residual interest.
- Once structured, both floaters and inverses can be treated as parent bonds and retranched, creating highly complex structures.
- Floating rate mortgage ABS structures created from fixed rate subprime collateral generally did not utilize inverse floaters. As discussed

in Chapter 9, the *excess spread* (i.e., the spread between the monthly note rate of the loan and the rate paid to the floating rate bonds) was used to enhance the credit of the senior tranches through a variety of mechanisms.

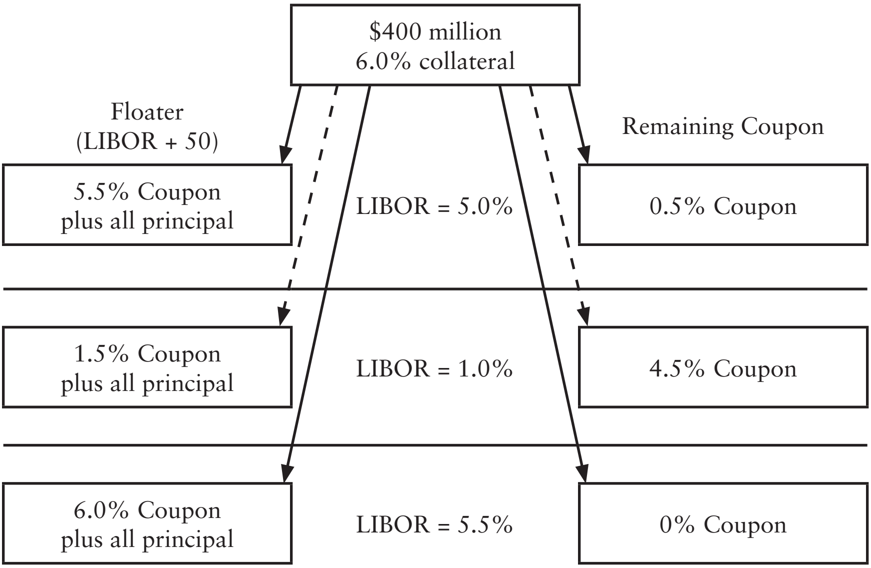
Floaters are structured such that their coupon adjusts periodically (typically monthly) and is derived as the index level plus a fixed margin. A floater quoted as "LIBOR plus 50," for example, means that the floater coupon adjusts monthly to be 50 basis points over the index (which typically is one-month LIBOR), at some point around the record date of the floater. The creation of a floating rate tranche from a fixed rate collateral pool or parent tranche in the prime sector necessitates the simultaneous creation of an inverse floater (or, simply, an inverse). As we will demonstrate, the inverse floater coupon is based on a formula that pays the remaining interest of the fixed rate parent bond after the floater's coupon is calculated.

The fundamentals of structuring floaters off fixed rate collateral are fairly straightforward. The fixed rate coupon of the collateral (either a collateral pool or a parent tranche) generates the total interest available to be paid. In its most simple form, the floater's maximum coupon rate (or cap rate) is the fixed rate coupon. If the floater's coupon (i.e., the index plus the margin) is less than the cap rate, the remaining interest is available to be paid to another tranche. Thus, an inverse floater, or a tranche where the coupon adjusts inversely with the level of the index, is simultaneously created. An illustration of this technique is shown in Exhibit 7.4.

Note that this example only addresses the distribution of interest cash flows. By implication, all principal is assumed to flow to the floater; therefore, the inverse floater receives only interest, and can be described as an ***inverse IO*** (IIO). The inverse is sometimes sold in this form, and this technique serves as an alternative means of stripping coupon and selling an IO to investors.

The previous example is somewhat oversimplified. As we will discuss, *principal-paying inverses* are commonly structured by dividing the parent tranche's principal face value between the floater and inverse floater. In addition, note that the floater cap is the same as the collateral coupon rate. This is typically much lower than the cap level desired by floating rate investors. While it is possible to augment the floater's cap with derivative contracts bought in the capital markets (as we discuss in the section on corridor floaters in Chapter 8), investors typically prefer all the floater's coupon income to be generated by the collateral, eliminating both counterparty exposure and the possibility of a balance mismatch. It is possible to create floaters with cap rates higher than the collateral, with two structural implications:

EXHIBIT 7.4 Allocation of Fixed Rate Interest to a Floating Rate Tranche and the Remaining Coupon (6% collateral, 6% floater cap)



1. Not all the collateral or parent tranche's principal can be allotted to the floater, creating a somewhat smaller floater tranche.
2. Depending on the proportions, the inverse floater's coupon will no longer change pro rata with changes in the index, as it does in Exhibit 7.4. Typically, it will change more rapidly than the index, which means that the inverse's coupon is leveraged with respect to the index.

The ***coupon leverage*** or *multiple* is defined as part of the inverse's structure. The inverse's multiple is a function of both the chosen floater cap and the collateral coupon, which dictates how much interest is available to pay the two bonds. The inverse's leverage is also inversely proportional to its face value, that is, a smaller inverse would typically have the largest multiple. Similar to the coupon on the floater, the inverse's coupon resets on a monthly basis, defined by a predetermined formula.[3]

As shown later in this section, the inverse's leverage increases either as the floater's cap is lowered, or as the collateral coupon is raised. Most

[3]Note that the multiple on an inverse IO is typically 1.0 (i.e., the IIO coupon changes on a one-to-one basis with the index). This is because coupon leverage is a function of the proportion of floater and inverse principal. An IIO has no principal; its quoted balance is strictly a notional value.

floater–inverse combinations are structured to create the smallest possible inverse floater in size. As inverses trade to relatively high yields, minimizing the size of the inverse floater maximizes the proceeds received for the structure. Additionally, inverse buyers typically like the highest possible multiple, since it maximizes the leverage of the position and, by implication, the yield to which it will trade. (This is often called "creating a *max-leverage inverse*.") By implication, this suggests that dealers always have an incentive to market floaters with the lowest possible cap. (Theoretically, floaters with double-digit caps can be created; however, it would create a large, low-leverage inverse floater, which would be uneconomical to the structure.)

The generation of a floater–inverse floater combination using the maximum leverage is a fairly straightforward process of dividing the available interest from the parent bond for the floater and inverse under different scenarios. It is most easily conceptualized under a set of simple scenarios. In a straightforward numerical example, assume that the structurer creates a floater with an 8.0% cap and a 50 basis point margin off a $100 million parent tranche with a 6.0% coupon. (Note that the minimum coupon of the floater is its margin, if LIBOR declines to 0%.) This generates the following calculations:

- Total annual interest available = $100,000,000 × 0.06 = $6,000,000 (which is also the maximum interest available to the floater)
- Maximum amount of floaters that can be created = $6,000,000 ÷ 0.08 = $75,000,000 face value
- Inverse floater face value = $100,000,000 – $75,000,000 = $25,000,000
- Ratio of floaters to inverses = 3:1 = Multiple (coupon leverage) of inverse (for every 100 basis point change in the index, the floater's coupon changes 100 basis points, while the inverse's coupon changes 300 basis points)
- Minimum floater coupon = 0.5% (assuming LIBOR drops to 0%)
- Minimum floater coupon interest at 0.5% = $75,000,000 × 0.005 = $375,000
- Maximum interest available to inverse = $6,000,000 – $375,000 = $5,625,000
- Maximum inverse coupon = $5,625,000 ÷ $25,000,000 = 22.5%

Quoted as formulas, the coupons of the two bonds are expressed as

$$\text{Floater coupon} = 0.5\% + (1 \times \text{LIBOR})$$

$$\text{Inverse floater coupon} = 22.5\% - (3 \times \text{LIBOR})$$

The constant in the floater's formula is the margin, while for the inverse the constant is the maximum possible coupon, that is, if LIBOR declines to 0%.

Assuming an initial LIBOR rate of 3.0%, the floater will have a coupon of 3.5%; the inverse floater's initial coupon will therefore be 13.5%. If LIBOR immediately moves to 5%, the coupons and total interest for the floater and inverse, respectively, are:

- Floater coupon = 5.0% LIBOR plus 50 basis point margin = 5.5%
  Total annual floater interest = \$75,000,000 × 5.5% = \$4,125,000
- Inverse coupon = 22.5% – (3 × 5%) = 22.5% – 15% = 7.5%
  Total annual inverse interest = \$25,000,000 × 7.5% = \$1,875,000
- Total annual floater and inverse interest = \$4,125,000 + \$1,875,000 = \$6,000,000 (which equals the total interest available from the parent tranche)

The dynamics of this example are illustrated in Exhibit 7.5, while Exhibit 7.6 shows how available interest is divided between the floater and inverse at different levels of the index. The slope of the line dividing the floater and inverse interest, given a level of the index, is negative 3, which is the multiple of the inverse. The intercept (i.e., the amount of interest when the index is 0%) is \$5,625,000, reflecting the parent tranche's total interest less the 50 basis points that would be paid to the floater solely from the margin.

Note that the floater formula also contains a coupon multiple. This is typically 1, implying that the floater will change at the same absolute rate as the index. However, floaters are occasionally created that have a multiple that is not equal to 1, creating *super floaters*. Like regular floaters, super floaters in the prime universe are structured to have an inverse floater, with the leverage calculated in the same way as described above.

As a general formula, the inverse multiple (or leverage) is calculated as

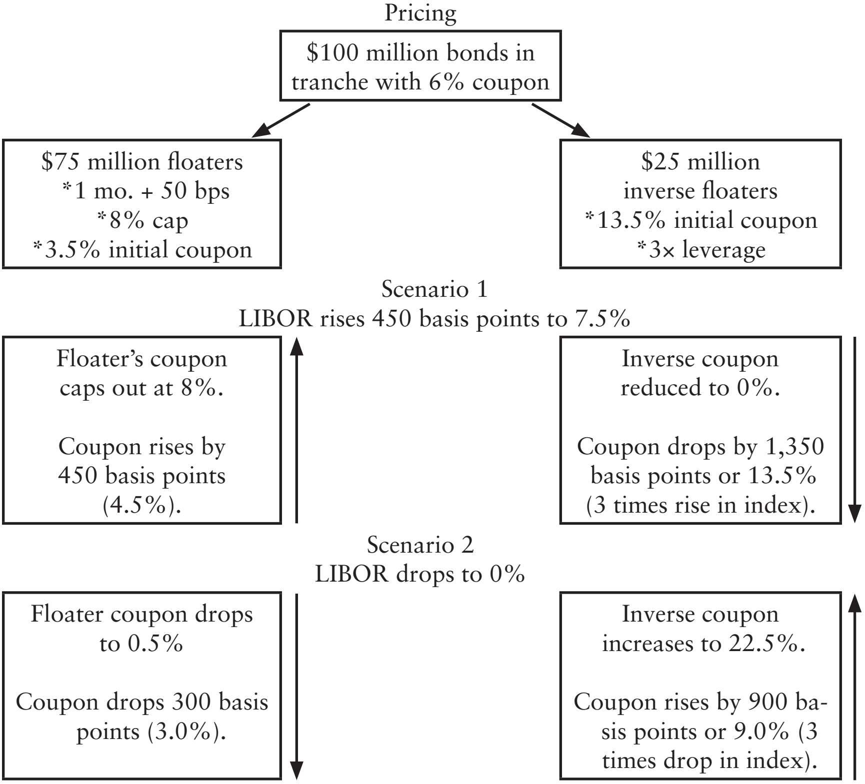
$$\text{Inverse floater multiple} = \frac{\text{Parent coupon}}{\text{Floater cap} - \text{Parent coupon}} \tag{7.5}$$

Returning to the previous example, the inverse floater multiple would be 3.0×, or

$$\frac{0.06}{0.08 - 0.06} = 3.0$$

The formula indicates that the inverse floater multiple (or, more accurately, the inverse's maximum possible leverage) is a function of both the floater cap and the parent coupon. The multiple on an inverse increases as the parent tranche coupon increases or as the floater cap is reduced. More simply,

EXHIBIT 7.5 Mechanics of Floater–Inverse Combination (initial 1-month LIBOR = 3.0%)



the inverse multiple is the ratio of the face values of the floater and inverse floater. In the example, there are $75,000,000 floaters and $25,000,000 inverse floaters, for a ratio of 3:1. As we see in a subsequent section, this is the easiest way to calculate the leverage for more complex combinations.

A sample deal using 5.5% collateral where the front bond is divided into a floater–inverse floater combination is shown in Exhibit 7.7. This deal, labeled *Deal-06*, takes Deal-04 and restructures the A class into a floater (using an 8% cap floater and a 50 basis point margin) and a maximum-leverage inverse with a 2.2× coupon multiple.

Coupon Stripping Using Inverse IOs

As noted previously, inverse IOs or IIOs are frequently used as a means of stripping coupons and selling IO cash flows to investors. This technique

EXHIBIT 7.6 Annual Division of Interest Payments between Floater and Inverse Floater at Different Index Levels

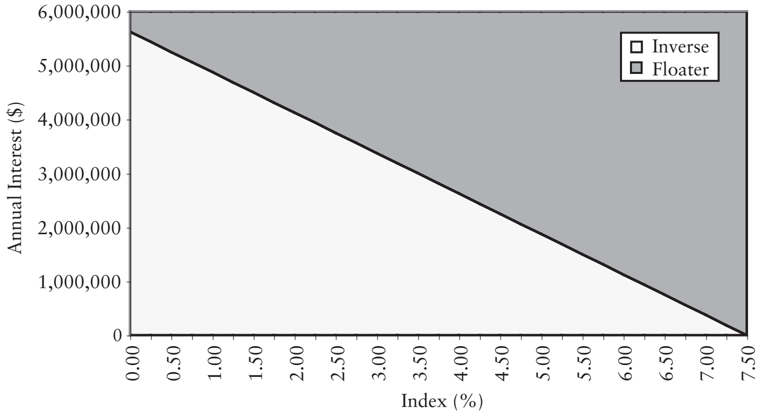


EXHIBIT 7.7 Deal-06: Deal-04 Restructured to Make Tranche A into a Floater–Inverse Floater Combination

Tranche	Par Amount ($)	Coupon Rate (%)	Average Life	Reset Formula
FL	141,978,375	3.5	3.4	0.50 + (LIBOR × 1)
INV	64,535,625	9.9	3.4	16.5 – (LIBOR × 2.2)
B	46,302,000	5.5	7.3	Fixed
C	111,726,000	5.5	10.9	Fixed
Z	35,458,000	5.5	19.5	Fixed
Collateral	400,000,000	5.5	8.6	

Payment rules:

1. *For payment of periodic coupon interest*. Disburse periodic coupon interest to tranches FL, INV, B, and C on the basis of the amount of principal outstanding at the beginning of the period. For tranche Z, accrue the interest based on the principal plus accrued interest in the previous period. The interest for tranche Z is to be paid to the earlier tranches as a principal paydown. The maximum coupon rate for FL is 8%; the minimum coupon rate for INV is 0%.
2. *For disbursement of principal payments*. Disburse principal payments to tranches FL and INV until they are completely paid off. The principal payments between tranches FL and INV should be made in the following way: 68.75% to tranche FL and 31.25% to tranche INV. After tranches FL and INV are completely paid off, disburse principal payments to tranche B until it is completely paid off. After tranche B is completely paid off, disburse principal payments to tranche C unil it is completely paid off. After tranche C is completely paid off, disburse principal payments to tranche Z until the original principal balance plus accrued interest is completely paid off.

uses a combination of structuring techniques. As an example, assume that a structurer wanted to strip a 5.5% coupon parent bond to have a 5.25% coupon (i.e., strip 25 basis points off the bond). In a floater–IIO combination, the structurer would follow the following steps:

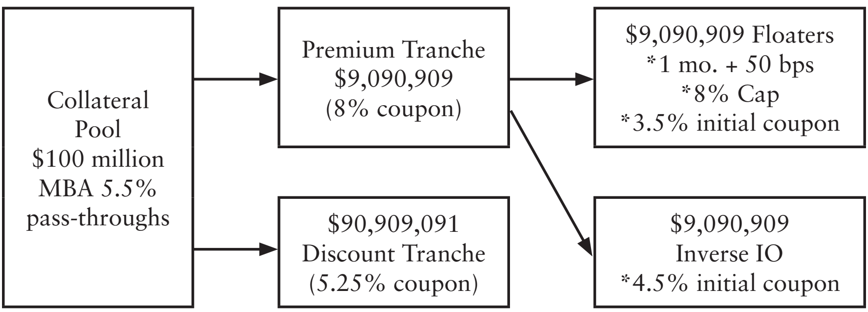
- Create a variation on a discount–premium split, where the premium tranche has a very high coupon equal to the desired floater cap. In this case, assume that the dealer wishes to create a floater with an 8.0% cap. Using equations (7.3) and (7.4), $100 million of a parent bond with a 5.5% coupon would be structured into $90,909,091 of a tranche with a 5.25% coupon, creating $9,090,909 of a bond with an 8% coupon.
- Create a floater–inverse IO combination from the 8.0% coupon premium bond, using the technique described previously.

Assuming that one-month LIBOR is 3.0% at the time the deal is priced, and the floater has a margin of 50 basis points, the coupon of the floater would initially be 3.5%. As in the example in Exhibit 7.4, the inverse IO receives all coupon interest remaining after the floater is paid LIBOR + 50 basis points, until the coupon of the floater reaches 8.0% (i.e., it is paid all the interest from the parent tranche). The inverse IO would initially have a coupon of 4.5%. An illustration of this technique is shown in Exhibit 7.8.

Because the IIO has no principal component, both the floater and IIO have coupon leverage of 1.0×; the multiple on the floater would be positive 1.0, while the IIO multiple would be negative 1.0. However, even though the coupon leverage is 1.0×, the yield of the bond is highly sensitive to the level of the index, that is, it has a high ***yield leverage***.

The target market for inverse IOs consists of investors looking to make highly leveraged bets on the level of short interest rates and prepayment

EXHIBIT 7.8 Example of Stripping 5.5% Collateral Using a Floater–Inverse IO Combination (initial 1-month LIBOR = 3.0%)



speeds. For example, investors that look for a steeper yield curve might buy inverse IOs. The coupons on IIOs rise commensurately with a drop in short rates, while the steeper yield curve imputes higher long interest rates, which typically drive expected and realized prepayment speeds.

To illustrate how this technique works in the context of a deal, Exhibit 7.9 shows Deal 07. This deal takes Deal 04 (i.e., the sequential deal with the last-cash-flow Z) and strips the front tranche to a 5.25% coupon by creating a floater–inverse IO combination.

It is interesting and useful to note that the floater–inverse IO structuring technique was used almost exclusively as a method of coupon stripping until 2005. Its advantage to the deal execution is twofold. First, the normal

EXHIBIT 7.9 Deal-07: Deal-04 Restructured to Reduce the Coupon Rate of Tranche A to 5.25% by Creating a Floater and Inverse IO

Tranche	Par Amount ($)	Coupon Rate (%)	Average Life	Reset Formula
A	187,740,000	5.25	3.4	Fixed
FL	18,774,000	3.50	3.4	0.50 + (LIBOR × 1)
IIO	18,774,000	4.50	3.4	8.0 – (LIBOR × 1)
B	46,302,000	5.50	7.3	Fixed
C	111,726,000	5.50	10.9	Fixed
Z	35,458,000	5.50	19.5	Fixed
Collateral	400,000,000	5.50	8.6	

Payment rules:

1. *For payment of periodic coupon interest*. Disburse periodic coupon interest to tranches A, B, and FL based on the basis of the amount of principal outstanding at the beginning of the period. For tranche IIO, disperse periodic interest based on notional principal value of tranche at the beginning of the period. For tranche Z, accrue the interest based on the principal plus accrued interest in the previous period. The interest for tranche Z is to be paid to the earlier tranches as a principal paydown. The maximum coupon rate for FL is 8%; the minimum coupon rate for IIO is 0%.
2. *For disbursement of principal payments*. Disburse principal payments to tranche A and FL proportionately until they are completely paid off. After tranche A and FL are completely paid off, disburse principal payments to tranche B until it is completely paid off. The notional balance of tranche IIO is reduced pro rata with the decline in the balance of tranche FL. After tranche B is completely paid off, disburse principal payments to tranche C until it is completely paid off. After tranche C is completely paid off, disburse principal payments to tranche Z until the original principal balance plus accrued interest is completely paid off.

positively sloped yield curve allows the floater to be sold at relatively low yields, maximizing the proceeds garnered from this structure (as opposed to either selling a premium coupon tranche or a straight IO). In addition, the demand for floating rate bonds is consistently strong, making that part of the structure relatively easy to sell.

However, the size of the floater created by this mechanism is generally small. In the example in Exhibit 7.8, stripping $100 million in 5.5s to have a 5.25% coupon would create just over $9 million of floaters with an 8.0% cap, and just over $14 million of 7.0% cap floaters. The relatively small size of the floater is a disadvantage to the floater–inverse IO technique since floater investors are typically institutions seeking to make large leveraged investments.

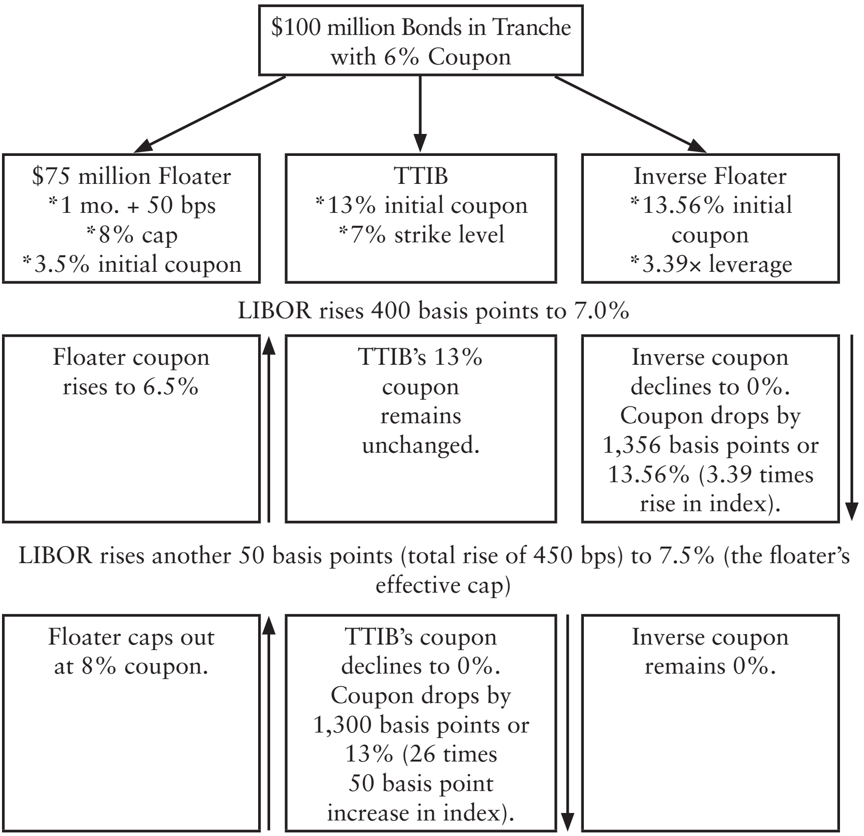
In 2005, structurers began creating floaters where the coupon cap was the same as the parent bond's coupon, creating much larger floating rate tranches and IIOs with very high yield leverage. (This structuring derivation is effectively the same as the example in Exhibit 7.4, where pass-throughs with a 6.0% coupon are structured to create LIBOR floaters with a 6.0% cap.) To structure floaters with a cap high enough to entice investors, the cap was augmented by a cap corridor purchased in the derivative markets. This type of structure was only utilized in the private-label market, as the GSEs do not allow derivative contracts to be included in their structures. We explore these bonds, called *corridor-cap floaters*, in Chapter 8, where we discuss private-label CMO structures.

TWO-TIERED INDEX BONDS (TTIBS)

A ***two-tiered index bond*** (TTIB) is a bond, created as part of a floater–inverse floater combination, which combines elements of both fixed rate tranches and inverse floaters. The bonds are designed to have a fixed coupon rate as long as the reference index is below a certain threshold level. If the index breaches that level, the TTIB's coupon floats inversely with the index, causing it to drop precipitously from its initial level. This makes an investment in a TTIB similar in concept to being short-cap contracts, giving the investor large interest cash flows so long as the index remains below the threshold (or strike) level. The term "two-tiered index bond" derives from the creation of two levels of the index that drive the combination's coupon rate. The TTIB's strike rate is the rate where the inverse floater coupon reaches 0%, and the TTIB begins to float inversely to the index. (The strike on a regular inverse is the same as the effective cap of the floater; for a LIBOR floater with an 8.0% cap and a 50 basis point margin, that level is 7.5%.)

In addition to meeting the demand for MBS that have the attributes of a short position in caps, the creation of TTIBs increases the possible leverage

EXHIBIT 7.10 Mechanics of Floater–Inverse Floater–TTIB Combination (initial 1-month LIBOR = 3.0%)



on the resulting inverse floater. This results from diverting a fixed portion of the coupon interest available to the inverse to the TTIB, making its coupon more sensitive to changes in the index. The structuring of a hypothetical floater–TTIB–inverse floater combination is illustrated in Exhibit 7.10. The diagram takes the floater–inverse floater combination shown in Exhibit 7.5 and inserts a TTIB into the combination, increasing the coupon multiplier of the inverse. The exhibit also indicates what would happen to the combination's coupons if LIBOR rose to different levels, illustrating the "two-tiered" character of the previously described bond.

The size of the TTIB (as well as the inverse floater) is dictated by the TTIB's coupon and strike level, and is similar to the calculation for the floater–inverse floater combination (i.e., without the TTIB). Referring to the earlier example (i.e., LIBOR + 50 basis points, 8.0% cap), we have the following values:

- Total interest available = $6,000,000
- Maximum amount of floaters = $75,000,000
- Combined face value of inverse floaters and TTIB = $25,000,000
- Maximum interest available to inverse floater and TTIB = $5,625,000
- Interest paid to floater at 3.0% LIBOR = $2,625,000

In order to calculate the sizes of the inverse and TTIB, the coupon and strike level of the TTIB are utilized. In the example, we assume that the strike rate and coupon are 7.0% and 13%, respectively, as shown in Exhibit 7.10. (Note that the strike must be less than the floater's effective cap, that is, the cap less the margin.) In this case, the calculations are as follows:

- Minimum interest available to floater = $6,000,000 – $5,625,000 = $375,000
- Face value of TTIB = $375,000 ÷ 13% = $2,884,615
- Face value of Inverse = $25,000,000 - $2,884,615 = $22,115,385
- Inverse floater leverage = $75,000,000 ÷ $2,884,615 = 3.391×
- Inverse floater initial coupon = [$6,000,000 – ($2,625,000 + $375,000)] ÷ $22,115,385 = 13.56%
- TTIB leverage = $75,000,000 ÷ $2,884,615 = 26.0×

The constant in the TTIB's formula (which is only effective if LIBOR exceeds the strike rate of 7%) is calculated as follows:

$$\begin{aligned}\text{TTIB constant} &= (\text{TTIB Leverage} \times \text{Strike Level}) + \text{TTIB Coupon}\\ &= (26 \times 7.0\%) + 13\% = 195\end{aligned}$$

The TTIB reset formula is thus

$$\text{TTIB coupon} = 195 - (26 \times \text{LIBOR})$$

when LIBOR exceeds 7%. If LIBOR is 7.25%, the coupon drops to 6.5%; the coupon is 0% once LIBOR reaches the floater's effective cap rate of 7.5%

It is useful to observe how changes in the coupon and strike level of the TTIB impact the sizing of both the inverse and TTIB. If the TTIB's coupon is reduced, all other factors unchanged, the TTIB becomes larger in size, and the inverse becomes both smaller and more leveraged. Assuming an 8.0% coupon and 7.0% strike for the TTIB, the calculations are:

- Face value of TTIB = $375,000 ÷ 8% = $4,687,500
- Face value of inverse = $25,000,000 – $4,687,500 = $20,312,500
- Inverse floater leverage = $75,000,000 ÷ $20,312,500 = 3.692×
- Inverse floater initial coupon = [$6,000,000 – ($2,625,000 + $375,000)] ÷ $20,312,500 = 14.77%

Now assume that the strike rate is reduced to 6.0%, effectively reducing the cap of the floater and thus increasing the leverage of the nonfloater portion of the combination. (As shown earlier, the inverse multiple is inversely related to the cap of the floater.) If we hold the TTIB coupon at 13.0%, the calculation is as follows:

- Amount of interest available to floater at strike (i.e., 6.5% coupon rate) = $4,875,000
- Interest available to inverse and TTIB at strike level = $6,000,000 – $4,875,000 = $1,125,000
- TTIB face value = $1,125,000 ÷ 13% = $8,653,846
- Inverse face value = $25,000,000 – $8,653,846 = $16,346,153
- Inverse leverage = $75,000,000 ÷ $16,346,153 = 4.588×
- Inverse initial coupon = [$6,000,000 – ($2,625,000 + $1,125,000)] ÷ 16,346,153 = 13.76%

Holding the strike rate at 6.0% while dropping the TTIB's coupon to 8.0% gives the following calculation:

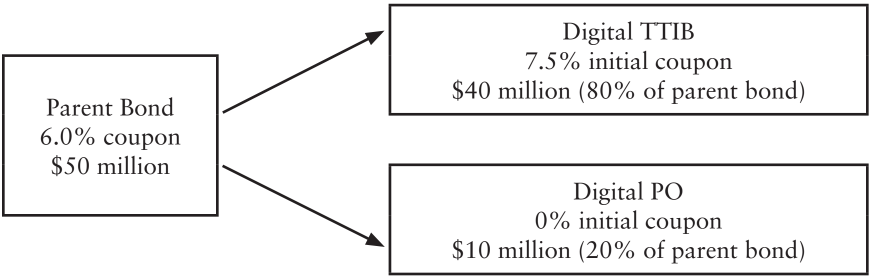
- TTIB face value = $1,125,000 ÷ 8% = $14,062,500
- Inverse face value = $25,000,000 – $8,653,846 = $10,937,500
- Inverse leverage = $75,000,000 ÷ $10,937,500 = 6.857×
- Inverse initial coupon = [$6,000,000 – ($2,625,000 + $1,125,000)] ÷ 10,937,500 = 20.57%

These examples indicate that the inverse floater's multiple or leverage is inversely related to both the strike level and coupon of the TTIB. Put differently, reducing the TTIBs strike and coupon rate has the effect of increasing the leverage of the inverse floater in the combination.

It is important to remember that in this framework, the TTIB is still an inverse floater. If LIBOR exceeds the strike rate, the TTIB no longer has a fixed coupon; at that point, its coupon will adjust based on its reset formula, in the same fashion as a regular inverse.

A variation on a TTIB, called a *digital TTIB,* allows for the creation of bonds where the interest rate is either a fixed rate (as in all TTIBs) or 0%, without the creation of a true floating rate tranche. In this case, a TTIB and

EXHIBIT 7.11 Example of Digitial TTIB and Digital PO



Note: Coupon of TTIB is 7.5% until LIBOR > 7.0%, then TTIB coupon is 0%. Coupon of PO is 0% until LIBOR > 7.0%, then PO coupon is 30%.

another bond (sometimes called a *digital PO* or an *anti-TTIB*, which has an initial coupon rate of 0%) are created. The TTIB has a fixed coupon; it receives all the interest allocated to the parent bond until the benchmark index reaches a certain level. Once the threshold is reached, all interest is directed to the anti-TTIB, and the coupon of the TTIB drops immediately to 0%. A simple example of this variation is shown in Exhibit 7.11. Note that the face value of the digital TTIB is calculated as a variation on equation (7.2), as the two children effectively have fixed coupons. The size of the TTIB is the ratio of the parent coupon to the child coupon times the face value of the parent. The remainder is the face value of the digital PO.

EXCESS SERVICING IOs

The ***excess servicing IO*** trust is an offshoot of the IO market discussed earlier in this chapter. The logic behind the creation of these deals is unlike the other techniques mentioned previously, since it is not based on taking loans and redistributing their cash flows to improve execution. Rather, it is a means of distributing interest cash flows to investors that are created as part of the pooling process. Instead of holding excess servicing, originator–servicers use the excess servicing IO trust as a means of liquefying their balance sheets and free up capital by efficiently distributing the excess servicing asset to investors.

By way of background, we discussed the process of pooling loans in Chapter 2. Excess servicing is the cash flow strip off individual loans securitized in agency pools, as part of the process of pooling loans. This portion of the *mortgage servicing right* (MSR) is a result of the process of creating fixed coupon pools from loans with a variety of note rates. Excess servicing is analogous to IO cash flows in that it represents part of the stream of interest generated by each loan. (By contrast, the holder of base servicing typically accrues additional benefits, such as the names and addresses of borrowers for cross-marketing purposes, as well as interest earned from holding payments such as property tax impoundments.)

There have been markets for unsecuritized servicing for many years. Like the market for raw loans, trading excess servicing assets can be a cumbersome process, with a significant amount of paperwork accompanying each trade. In addition, a pool of servicing assets has a weighted average or WAC coupon. WAC coupons are common in some products, such as ARM pools, but they are associated with a degree of uncertainty. For example, imagine three loans with a face value of $100,000 that have note rates of 6.125%, 6.25%, and 6.375%. The WAC of a pool holding these loans would initially be 6.25%. However, if the 6.125% loan is paid off, the WAC of the pool increases to 6.3125% (not accounting for the effects of amortization). The same phenomenon occurs with unsecuritized excess servicing, where the coupons are weighted by the face value of the associated loans. The uncertainty caused by the WAC coupon, as well as the difficulties in accounting for and trading servicing, made it difficult for hedge funds and other investors that buy IOs to invest in servicing.

Excess servicing IOs were designed to overcome the difficulties associated with holding servicing as an asset. These deals are a means of converting excess servicing held by servicers into tradeable securities. By creating a structured security transaction, a pool of excess servicing is converted into a liquid trust where the bulk of the deal has fixed coupons. The process creates securities that are indistinguishable from trust IOs that are created as part of IO–PO deals, and that can be traded and financed fairly easily.

Excess servicing IO structures produce a series of fixed rate IO tranches, along with a small WAC tranche, from pools of excess servicing stripped from fixed rate loans.[4] The pools represent excess servicing strips accumulated from an issuer's production over a period of time. The initial step involves grouping the excess servicing cash flows into narrow note rate buckets (typically in 50 basis point increments), based on the WAC of the underlying loans. In a hypothetical deal, Group A may be comprised of all loans with note rates between 6.5% and 6.99%, Group B might have all loans with note rates between 7.0% and 7.49%, and so on. Each group is then structured independently, as described next, in order to produce fixed and WAC coupon tranches. The initial process of creating the different groups from a population of excess servicing is illustrated in Exhibit 7.12.

[4]The excess servicing strips have, to this point, been from conforming balance loans since the deals were designed to be created as agency-backed trusts.

EXHIBIT 7.12 A Hypothetical Example of Structuring Excess Servicing into an Excess Servicing IO Deal

1. Excess Servicing Portfolio Representing 95,000 loans issued in Q2 2005 *$15,000,000,000 face value of loans *15 basis points weighted average strip *Note rates ranging from 5.5% to 8.0%

2. Portfolio Divided into Five Groups A—Note rates 5.5–5.99%, 1,000 loans, $100 million face value B—Note rates 6.0–6.49%, 22,000 loans, $4.2 billion face value C—Note rates 6.5–6.99%, 55,000 loans, $8.2 billion face value D—Note rates 7.0–7.49%, 14,000 loans, $2.0 billion face value E—Note rates 7.5–8.00%, 3,000 loans, $500 million face value

3. Groups Are Structured into Fixed Coupon and WAC Tranches A—1 fixed coupon tranche, 1 WAC tranche B—3 fixed coupon tranches, 1 WAC tranche C—4 fixed coupon tranches, 1 WAC tranche D—1 fixed coupon tranche, 1 WAC tranche E—1 fixed coupon tranche, 1 WAC tranche

Note that the grouping of loans in narrow note rate buckets has the additional benefit of limiting the dispersion of note rates within a group. Agency pools, for example, can have significant dispersion in the note rates of the loans within pools. While normal execution economics typically cause pool WACs to be within roughly 45 to 65 basis points of their coupon rates, there are often small amounts of loans that have note rates significantly higher than the pool WAC. This dispersion can cause prepayment speeds to be faster than anticipated, adversely impacting the value of securities created from pools, such as IOs, that are highly sensitive to prepayment speeds. However, the practice of grouping servicing into groups defined by a small range of WACs causes the dispersion of note rates within the group to be limited, improving the performance of IOs structured from the group.

Once the groups are created, fixed rate portions of the servicing are sliced from each loan in the group, based on how much excess servicing is attached to the loan. As an example, imagine that Group A was comprised of four loans with face values and excess servicing as follows:

- Loan 1—$100,000 face value, 23 basis points
- Loan 2—$250,000 face value, 19 basis points

- Loan 3—$175,000 face value, 17 basis points
- Loan 4—$225,000 face value, 12 basis points

The structuring process involves iteratively stripping a constant amount of servicing off as many loans in the group as possible. The first iteration might create a tranche with a face value of $750,000 and a coupon rate of 12 basis points. This would leave the following:

- Loan 1—$100,000 face value, 11 basis points (23 less 12)
- Loan 2—$250,000 face value, 7 basis points
- Loan 3—$175,000 face value, 5 basis points
- Loan 4—$225,000 face value, 0 basis points

The second iteration would strip 5 basis points from loans 1 to 3, creating a tranche with a face value of $525,000 and a 5 basis point coupon rate. This would leave:

- Loan 1—$100,000 face value, 6 basis points (11 less 5)
- Loan 2—$250,000 face value, 2 basis points
- Loan 3—$175,000 face value, 0 basis points
- Loan 4—$225,000 face value, 0 basis points

The next iteration would strip 2 basis points off loans 1 and 2, creating a tranche with a 2 basis point coupon and a face value of $350,000. Loan 1 would be left with 4 basis points of servicing. This would create the following structure:

Tranche 1: $750,000 face value, 12 basis points coupon rate
Tranche 2: $525,000 face value, 5 basis points coupon rate
Tranche 3: $350,000 face value, 2 basis points coupon rate
Tranche 4: $100,000 face value, 4 basis point coupon rate

Tranche 4 in this example represents the WAC tranche or, more accurately, is the tranche from the group that has a WAC coupon. It is the residual of the structuring process, in that it is comprised of the cash flows left over after the iterative stripping process is completed. The process is illustrated in Exhibit 7.13. Note that once the note rates of the groups are defined, as shown in Exhibit 7.12, each group is structured independently.

In actuality, the loan groups are comprised of many thousands of loans. Therefore, the process of creating each group's structure is complex and is often treated as a constrained optimization process. The following are some constraints used by issuers to generate a structure:

EXHIBIT 7.13 Schematic Representation of the Process of Structuring One Group into Excess Servicing IO Tranches

Initial Collateral

Loan 1—$100,000 face value, 23 basis points
Loan 2—$250,000 face value, 19 basis points
Loan 3—$175,000 face value, 17 basis points
Loan 4—$225,000 face value, 12 basis points

	Process	Resulting Structure	Remaining Collateral
Iteration 1	Strip the loan with the least excess servicing (12 bp) to 0 and then remove the same strip from the other loans.	Tranche 1—$750,000 face value, 12 basis point coupon	Loan 1—$100,000 face value, 11 basis points Loan 2—$250,000 face value, 7 basis points Loan 3—$175,000 face value, 5 basis points Loan 4—$225,000 face value, 0 basis points
Iteration 2	Strip the loan with the least excess servicing (5 bp) to 0 and then remove the same strip from the other loans.	Tranche 2—$525,000 face value, 5 basis point coupon	Loan 1—$100,000 face value, 6 basis points Loan 2—$250,000 face value, 2 basis points Loan 3—$175,000 face value, 0 basis points Loan 4—$225,000 face value, 0 basis points
Iteration 3	Strip the loan with the least excess servicing (2 bp) to 0 and then remove the same strip from the other loans.	Tranche 3—$350,000 face value, 2 basis point coupon	Loan 1—$100,000 face value, 4 basis points Loan 2—$250,000 face value, 0 basis points Loan 3—$175,000 face value, 0 basis points Loan 4—$225,000 face value, 0 basis points
Iteration 4	When no more excess servicing can be stripped, remainder is pooled into WAC tranche.	Tranche 4 (WAC)—$100,000 face value, 4 basis point coupon	

- Create fixed rate tranches with a minimum face value and proceeds. (Typical minimum sizes are $10 million notional face value or $2 million in proceeds; anything smaller is considered an odd lot by the market, and will trade to a concession.)
- Create as small a WAC tranche as possible. (WAC tranches also trade at a concession, since they are less liquid and more difficult to value.)
- Keep the WACs of the tranches similar to that of benchmarks used in the IO market. (Excess servicing IOs are typically valued at a percentage of a liquid benchmark IO trust. If the WAC of a tranche diverges significantly from that of the benchmark, it will be difficult to value, and will trade poorly.)

However the deal is structured, the goal of the process is to maximize the proceeds generated from converting a large pool of WAC servicing into a structure comprised largely of fixed rate IO tranches.

To convert the coupons into normal, 50 basis point increment coupons, the nominal coupon is divided by the desired coupon and then multiplied by the face amount of the loans. The process of calculating the notional value of each tranche is identical to the method used in calculating notional face values for tranched IOs discussed earlier in this chapter, using equation (7.1). For example, if a tranche has a coupon rate of 14 basis points and a face value of $2.6 billion, it could be converted into a tranche with a 5.5% coupon and a notional value of $66.1 million as follows:

$$\text{Notional value} = \left[\frac{0.14}{5.5}\right] \times 2{,}600{,}000{,}000 = \$66{,}181{,}818$$

Note that the face value of tranches is typically large, as it includes the amount of every loan contributing cash flow to the tranche. In addition, the "desired coupon" for the excess servicing trust does not have to be the same as the coupon into which the loans were pooled. For example, a loan with a 6.375% note rate can be securitized into a Fannie 5.5% pool. However, the excess servicing from that loan could also be placed in a group to be structured into 6.0% fixed rate IO (as well as the WAC tranche). This decision is made at the point where the servicing is segregated into note rate buckets, using the process shown in Exhibit 7.12.

Exchangeable Tranches

In their REMIC structures, both Fannie Mae and Freddie Mac allow structurers to designate groups of *exchangeable securities*, for which tranches can either be split or recombined after the transaction is settled. While the ability to engage in retroactive restructuring is limited to combinations outlined in the deal's Prospectus Supplement, the economic limitations governing such transactions are the same as those outlined in Chapters 6 and 7.[5] Note also that the transaction is not free; both Fannie and Freddie charge a fee in order for investors to execute the exchanges.

As an example, a tranche with a 5.5% coupon may be associated with a series of classes with the same principal cash flows but different coupon rates, ranging from 0% to 8%, along with a 5.5% IO tranche. An investor seeking to hold a lower-coupon security can exchange $10 million face value of the 5.5% tranche for $10 million of a 4% coupon and $2,727,272 of the 5.5% IO tranche.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Floater
Principal-Only (PO) Tranches
Interest-Only (IO) Tranches
IO -PO Trust
Coupon Stripping
Inverse Floater
Inverse IO (IIO)
Coupon Leverage
Yield Leverage
Two-Tiered Index Bonds (TTIBS)
Excess Servicing IO
Exchangeable Tranches

[5]Fannie Mae references these types of tranches "related combinable and recombinable" or RCR certificates, while Freddie Mac calls these tranches "modifiable and combinable REMIC" classes, or MACRs.

CHAPTER 8

Structuring Private-Label CMOs

The private-label CMO market has traditionally encompassed a variety of product and structuring variations. Technically, any deal that is not securitized under an agency or GSE shelf (i.e., Ginnie Mae, Freddie Mac, or Fannie Mae) can be considered ***private label***, as the issuing entity has no connection to the U.S. government (either explicit or implicit). Such deals must have some form of credit enhancement in order to create large amounts of investment-grade bonds. The convention in the markets, however, has been to divide nonagency MBS into two sectors. In this scheme, the private-label sector is defined as the securitization of prime, first-lien fixed and adjustable rate loans. Other products, such as deals backed by subprime and second-lien loans, are classified as *mortgage-related asset-backed securities* or *mortgage ABS*, a subset of the ABS category.

In some ways, this classification scheme is fairly arbitrary. Mortgage credit evolved over time from discrete sectors to a continuum. As the dividing lines between prime, alt-A, and subprime loans blurred, the structuring form became the primary factor distinguishing the different sectors. For example, if one type of structure offered superior execution for a loan, chances are good that it would be securitized using such a structure, irrespective of the classification of the loan. Thus, the two sectors are distinguishable as much by their structural forms as their collateral classification. For the purposes of this book, *private-label deals* addressed in this chapter are those using the fairly straightforward form of credit enhancement called *senior–subordination* or *shifting interest* structures (described in Chapter 5). *Mortgage ABS* utilized more complex credit enhancement schemes, combining subordination with other mechanisms to create the largest possible amounts of investment-grade tranches. This mechanism, called the *overcollateralization* or *OC structure*, is examined in Chapter 9. (Note that some concepts and techniques introduced in this chapter can also be utilized in OC structures.)

Aside from the presence of credit enhancement, there are other significant differences between the structuring conventions and techniques used for private-label and agency transactions. These are due to both differences in the nature of the loans collateralizing the deals, as well as legal and regulatory issues associated with the different issuers.

These include the following issues:

- Private-label deals can be structured such that derivatives, such as caps and cap corridors, can be inserted into the structures as risk mitigators. The GSEs, by contrast, do not allow for their inclusion in deals.
- The loans collateralizing private-label deals are generally assumed to prepay differently than those in agency pools. The convention in the agency market is to structure deals using a base-case prepayment speed consistent with median prepayment speeds reported by Bloomberg. However, jumbo and alt-A loans have long been assumed to have base-case prepayment speeds that are faster than conforming-balance collateral. This convention has meant that private-label deals have been structured either to a market convention (i.e., PSA speeds ranging from 250% to 300%) or a predefined ramp (i.e., 6% to 18% CPR ramping over 12 months). The ramp is defined in the prospectus and, as described in Chapter 3, is typically called the *prospectus prepayment curve* (PPC). (One hundred percent PPC is simply the base ramp defined at the time of pricing.)
- Private-label deals typically have cleanup calls. These are inserted into deals to relieve the trustees from the burden of having to oversee deals with very small remaining balances. The calls are triggered when the current face of the deal and/or collateral group declines below a predetermined level; the percentages triggering the call can vary, but are typically either 5% or 10% of the remaining balance. (As we discuss in Chapter 9, OC structures typically are structured to insure that the call is exercised, using a stepup provision.)

This chapter first outlines the mechanisms involved in creating the internal credit enhancement typically utilized in private-label deals. It also details some of the factors involved in gauging optimal execution (i.e., private-label versus agency pooling) for conforming balance loans. It will then discuss a number of structuring variations unique to the sector. Finally, it briefly describes the various documents that govern all types of nonagency MBS transactions.

As we've discussed previously, the dislocations in the MBS market have fundamentally altered issuance practices. No area of the market has been more substantially impacted than the private-label MBS market. As an example, issuance of deals backed by jumbo-balance loans has declined from roughly $220 billion in 2006 to $5.5 billion in all of 2009. This is mainly due to the disruptions to the market caused by the poor performance of earlier vintages, the decline in confidence in the rating agencies, and the uncertain regulatory treatment of the product. (In addition, the future form of the GSEs also remains under discussion, which will impact the entire MBS market.) Therefore, this chapter (as well as the following one, which describes mortgage ABS deals) should be read in the context of practices utilized up to late 2007. We suspect that many of these earlier techniques will be utilized in the future, which is why we describe them primarily in the present tense. However, we recognize that the future form of the private-label MBS market(s) is in the process of evolving, and at this writing is unknowable.

Note that while the focus of the chapter is on the structuring of fixed rate loans, hybrid ARMs can be structured in a similar fashion. Deals typically divide the collateral into groups based on their product type (i.e., 3/1s, 5/1s, etc.); the senior bonds are then either sold as pass-throughs or time-tranched.

PRIVATE-LABEL CREDIT ENHANCEMENT

The first step in structuring the credit enhancement for a private-label deal is to split the face value of the loans into senior and subordinated interests. The senior bonds have higher priority with respect to both the receipt of interest and principal and the allocation of realized losses, and are generally created with enough subordination to be rated AAA by the credit rating agencies. In most cases, the subordinate interests are subdivided (or tranched) into a series of bonds that decline sequentially in priority. The subordinate classes normally range from AA in rating to an unrated first-loss piece. These securities are often referenced as *six-pack* since there are six broad rating grades generally issued by the rating agencies. In the investment-grade category, bonds range from AA to BBB; noninvestment grade ratings decline from BB to the unrated first-loss piece. The structure (or "splits") of a hypothetical deal is shown in Exhibit 8.1, while a schematic detailing how and losses are allocated within the structure is contained in Exhibit 8.2.[1]

Internal credit enhancement requires two complimentary mechanisms. The cash flows for deals are allocated through the mechanism of a *waterfall*, which dictates the allocation of principal and interest payments to tranches with different degrees of seniority. At the same time, the allocation of realized losses is also governed by a separate prioritization schedule, with the subordinates typically being impacted in reverse order of priority.

While the original subordination levels are set at the time of issuance (or, more precisely, at the time the attributes of the deal's collateral are finalized),

[1]Note that 3.5% subordination was fairly common for prime deals prior to 2007. In retrospect, subordination levels were clearly too low at that time, and higher levels will be used in the future. The 3.5% level should be viewed simply as an example.

EXHIBIT 8.1 Measuring Subordination by Percentage of Deal Size and Credit Support for a Hypothetical $400 Million Deal with 3.5% Initial Subordination

A. Tranche Size as a Percentage of the Total Deal

	Face Value ($)	Percent of Deal
AAA	$386,000,000	96.50%
AA	6,000,000	1.50%
A	2,600,000	0.65%
BBB	1,800,000	0.45%
BB	1,200,000	0.30%
B	1,200,000	0.30%
First Loss (nonrated)	1,200,000	0.30%
Total Subordination	14,000,000	3.50%

B. Tranche Size Measured by Percentage of Subordination for Each Rating Level (i.e., credit support)

	Face Value ($)	Credit Support (%)[a]
AAA	$386,000,000	3.50%
AA	6,000,000	2.00%
A	2,600,000	1.35%
BBB	1,800,000	0.90%
BB	1,200,000	0.60%
B	1,200,000	0.30%
First Loss (nonrated)	1,200,000	0.00%

[a]Calculated by summing the deal percentages of all tranches junior in priority. As an example, if cumulative losses on the deal were 0.60%, the First Loss and B-rated tranche would be fully exhausted, but the BBs and above would not be affected.

deals with internal credit enhancement are designed such that the amount of credit enhancement grows over time. Private-label structures generally use a ***shifting interest mechanism***, in which the subordinate classes (or subs) do not receive principal prepayments for a period of time after issuance, generally five years for fixed rate deals. (This is the origin of the "shifting interest" term, introduced in Chapter 5, by which the structuring form is often referenced.) After the lockout period expires, the subs begin to receive prepayments on an escalating basis. It is only after 10 years that the subs receive a pro rata allocation of prepayments. Locking out the subs means that as

EXHIBIT 8.2 Schematic of Hypothetical Structure with Cash Flow and Loss Allocations

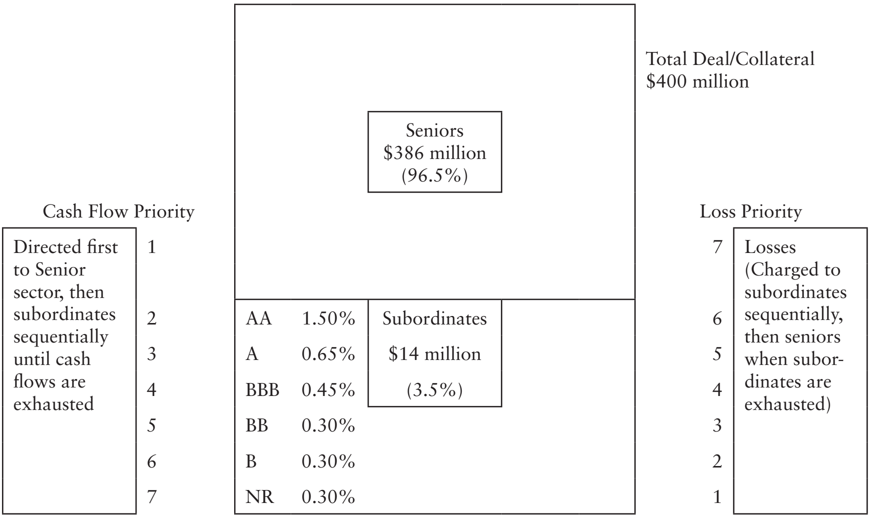


EXHIBIT 8.3 Shifting Interest Example for Subordinates on a Fixed Rate Prime Deal

Months 1–60	Subs completely locked out from prepayments (receive amortization only)
Months 61–72	Subs receive 30% of pro rata share of prepayments
Months 73–84	Subs receive 40% of pro rata share of prepayments
Months 85–96	Subs receive 60% of pro rata share of prepayments
Months 97–108	Subs receive 80% of pro rata share of prepayments
Month 109+	Subs receive 100% of pro rata share of prepayments

Effects of Shifting Interest Structure:
1. Senior bonds pay down faster than subs.
2. Seniors make up proportionately less of the deal.
3. Subordination grows, providing senior bonds more protection.
4. Subordinate bonds have to protect fewer senior bonds (deleveraging).
5. Subordinate bonds have excellent call protection.

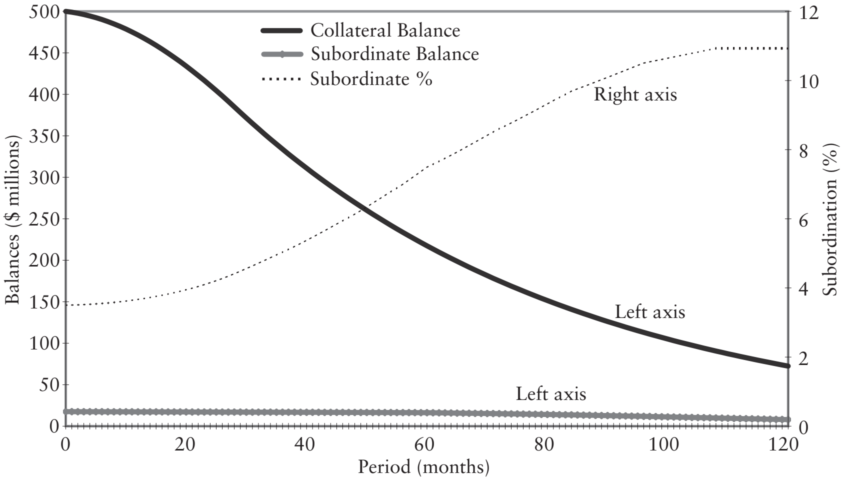
the collateral experiences prepayments, the face value of the subs grows in proportion relative to the senior classes; the senior classes receive all the collateral prepayments during the lockout period and therefore decline proportionately over time. A typical shifting interest schedule, along with notes on the effect of the principal reallocation, is shown in Exhibit 8.3.

The shifting interest mechanism in private-label ARM deals is similar but not identical to that utilized in fixed rate structures. In order to determine when the subordinated tranches can begin to receive prepaid principal, ARM deals combine a longer initial lockout schedule with a credit enhancement test. The subordinate tranches are scheduled to be locked out from receiving prepayments for 120 months, after which prepayments are allocated to the subordinates based on a schedule that scales in over five years. The proportions (30% in year 11, 40% in year 12, 60% in year 13, 80% in year 14, and 100% thereafter) are the same as those of fixed rate structures. However, once the ARM deal's total subordination percentage doubles, the subordinate tranches can begin to receive prepayments. Once the *doubling test* has been satisfied, the subordinates receive 50% of their pro rata share of prepayments up to the 36th month after issuance; after that point, they receive their full pro rata share of prepaid principal.

The shifting interest mechanism (and its equivalent in OC structures) became standard features in structured deals for a number of reasons. The most obvious reason stems from the desire to insure that the senior securities retain their triple-A rating. At any prepayment speed greater than zero, the effective amount of subordination is designed to grow as the loan collateral prepays. The prepayment lockout also augments the deal credit enhancement to compensate for the effects of unexpectedly fast prepayments. The assumption in the mortgage world has traditionally been that prepayments are faster for better-quality borrowers who have the means and sophistication to refinance and thus decrease their payments. However, as the higher credit loans prepay over time, the loans remaining in the pool are presumed to be weaker in credit, a situation that is generically referred to as *adverse selection*. Due to the existence of the shifting interest mechanism, the proportional amount of subordination grows faster at higher prepayment speeds, causing the deal to deleverage faster. Exhibit 8.4 shows how the sizes of the senior and subordinate classes of the previously described hypothetical structure change over time at the pricing speed, and also shows the resulting growth of the subordination percentage (excluding the effects of realized losses and writedowns).

Deals often have more than one collateral group securitized in the same transaction to minimize costs. Typically, the collateral groups will have different characteristics that make them difficult to commingle. For example, a deal may have separate collateral groups comprised of 30- and 15-year loans. Depending on the collateral in question, the two groups can have separate subordination groups. Alternatively, one set of subs can serve as credit support for both groups, in a so-called "Y structure." This creates larger subordinate classes, which generally are more liquid and have traditionally traded to tighter spreads.

EXHIBIT 8.4 Collateral and Subordinate Balances over Time for Hypothetical Deal at 300% PSA, Initial Subordination 3.5%



Another variation is to take the AAA-rated senior bonds in the structure and further credit-tranche them. While the resulting bonds are all also rated AAA, the bond or bonds with lower priority (generally called *mezzanine tranches*) are hit first with losses that would otherwise have been allocated to the entire parent tranche, and receive principal only after the highest-priority or ***super-senior bonds*** are paid. The parent tranche can either be the entire senior passthrough or a tranche created from the senior securities. The sizes of the mezzanine pieces are dictated by market demand, not the rating agencies, since the parent tranche is already rated AAA. In addition, more than one ***mezzanine (mezz) bond*** can be created; in ARM deals, it was common to create senior and junior mezz bonds as well as super-senior tranches. As with other structuring techniques, execution is based on the sizes of the super-senior and mezzanine bonds, as well as the prices at which all the pieces can be sold.

Agency Pooling versus Private-label Deal Execution

While this chapter primarily addresses the securitization of jumbo loans, conforming balance loans have also been securitized in private-label transactions. The dynamics of this market evolved over time, however, due to the changing level of involvement in the sector by the GSEs. An examination of this process and how it evolved over time will be helpful, given the previously noted uncertainty with respect to the futures of both private-label MBS issuance and the GSEs.

By the late 1990s, most conforming alt-A production was securitized in private-label structures and commingled with jumbo balance loans. As research indicated that conforming balance alt-A loans exhibited favorable prepayment performance relative to similar loans with larger balances, issuers increasingly segregated their conforming alt-A production into separate private-label deals. The GSEs subsequently began to actively include alt-A loans in their MBS pools. In addition to their desire to increase their share of a growing market, they became increasingly (and unjustifiably) comfortable with their ability to accurately predict the product's credit performance and therefore accurately price the guaranty fees.

By 2004, issuers increasingly sought to maximize their sale proceeds by comparing the execution of securitizing alt-A loans as agency pools versus private-label transactions. As with all execution decisions, the calculation of optimal execution for conforming balance loans is a question of maximizing the loan's proceeds, taking into account all revenues and costs associated with the competing securitization vehicles. This is particularly true for loans with "alty" characteristics that increase the costs associated with credit enhancement. There are a number of trade-offs that must be taken into consideration when evaluating relative execution, including:

1. *The proceeds realized from the sale of the senior securities created.* The proceeds from the agency pass-through are derived from the TBA price for the coupon created, adjusted for different settlement dates. The proceeds for the private-label deal are primarily those received for the triple-A senior tranche, and are typically quoted as a spread behind same-coupon Fannie Mae TBAs.
2. *The cost associated with credit enhancement.* For an agency pool, the cost is the guaranty fee (g-fee) paid to the agency which, as described previously, is akin to an insurance wrap on the individual loan. Credit enhancement in a private-label deal is the cost of the subordination, resulting from selling some of the loan's principal at a concession to the price of the senior tranches. This cost is also quoted as the spread behind Fannies Mae TBAs of the weighted average price of the subordinate classes.

The impact of the first item is fairly clear: the smaller the concession between agency and the senior private-label securities, the better the execution for the private-label option. With respect to the second point, however, the dynamics of the credit enhancement trade-off can be impacted by the level of interest rates and expected prepayment speeds, as well as the guaranty fee associated with a particular loan. We noted in Chapter 2 that the guaranty fee is quoted in terms of basis points from the loan's interest cash flow. This means that the monetized value of the guaranty fee (i.e., the actual dollar cost of GSE credit enhancement) is a function of either inter-coupon swaps or guaranty fee buydown multiples. Since these are essentially interest-only cash flows, their value is strongly influenced by prepayment speeds and the level of mortgage rates. By contrast, subordination is a direct dollar cost to the securitization and is independent of prepayment speed expectations. Therefore, optimal execution on alt-A loans in a rising rate environment often swung to private-label transactions because the dollar cost of credit enhancement for the agency pooling option rose relative to the private-label alternative, even if both subordination levels and guaranty fees remained constant.

As a hypothetical example, we compare execution alternatives for a 5.75% loan under the following assumptions:

- Best coupon execution for both options is a 5.5% coupon.
- Both options require the retention of 25 basis points of base servicing.
- The senior portion of the private-label deal trades 23/32s behind Fannie Mae 5.5% TBAs.
- The guaranty fee paid to the GSE in question would be 20 basis points.
- The private-label deal has 5% subordination.
- The guaranty fee buydown multiple quoted by the GSE is 6.0×.
- The subordinates collectively trade 12 points behind Fannie 5.5% TBAs.
- Total costs for the deal are 1/8 of a point (i.e., 0.125% of the deal's face value).

The results of the analysis are shown in Exhibit 8.5. In the example, the best execution would be as an agency pool because the dollar cost of credit enhancement (1.2% of the loans's face value) would be lower than that associated with private-label execution (1.475%). However, Exhibit 8.5 also indicates that the breakeven cost of subordination is a guaranty fee of 24.6 basis points. Therefore, a guaranty fee of 25 basis points or more would offer optimal execution in a private-label transaction.

As noted previously, the execution dynamics are not static in the face of changing interest rates and prepayment speeds, even if guaranty fees and private-label pricing are left unchanged. Since guaranty fees are part of the interest cash flow generated by the loan, their value (like any interest cash flow) is sensitive to prepayment expectations. Therefore, changes in interest rates and prepayment expectations will also cause buydown multiples to change. Using the example shown in Exhibit 8.5, a decline in the guaranty fee buydown multiple from 6.0× to 4.0×, reflecting declining interest rates

EXHIBIT 8.5 Comparison of Execution for Conforming Balance 5.75% Loan as a 5.5% Agency Pool and a Private-Label Security

Agency Pool		Private-Label Deal	
1. Guaranty fee (g-fee) assumed (basis points)	20	1. Senior tranches (95% of deal trading 23/32s behind Fannie 5.5s)	0.75
2. G-fee multiple	6.0	2. Subordinates (5% of deal trades 12 points behind Fannies)	0.6
		3. Deal costs	0.125
Dollar Cost of Guaranty Fee		*Dollar cost of private-label credit enhancement*	
G-fee multiple × G-fee (1 × 2)	1.20	Total cost of subordination (1 + 2 + 3)	1.475
Breakeven level of g-fee (in basis points) to private-label execution (1.475/6.0)			24.6

and faster prepayment speeds, would increase the breakeven guaranty fee for an impaired loan (i.e., the level of the guaranty fee where the issuer would be indifferent between execution options) to almost 37 basis points. This reflects the declining dollar value of the g-fee buydown, which serves to improve agency execution relative to private-label securitization in this scenario.

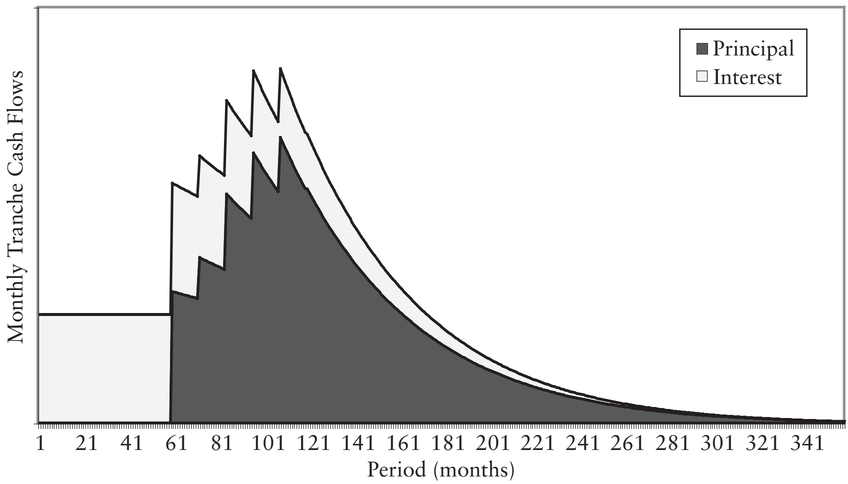
This suggests that there is an element of rate directionality to execution dynamics. All things equal, private-label execution becomes more economical when rates rise and prepayment expectations are reduced, even if subordination levels, subordinate pricing, and guaranty fees remain unchanged.

PRIVATE-LABEL SENIOR STRUCTURING VARIATIONS

Nonaccelerated Senior Bonds

Nonaccelerated senior bonds or ***NAS bonds*** have their origins in the profile of prime subordinate tranches. The lockout and prepayment protection inherent in the shifting interest structure creates long-duration bonds that have stable average life and duration profiles. However, many investors that have a need for these types of tranches cannot invest in subordinate securities, often because of regulatory prohibitions (such as ERISA rules for pension funds). The NAS bond mimics the cash flow structure of subordinates while creating bonds that are senior in loss priority. While the initial concept

EXHIBIT 8.6 Cash Flows for Representative NAS Bond at 300% PSA



was introduced in the prime market, mortgage ABS deals also are structured with NAS tranches, although the bonds are created in a slightly different fashion.

Similar to subordinate tranches, NAS bonds do not receive principal payments for the first five years. After year 5, the proportional amount of principal received generally scales up on a yearly basis, in the same fashion as the shifting interest and lockout schedule shown in Exhibit 8.3. One difference between NAS and subordinate bonds is that subs receive amortized principal during the first five years, while NAS bonds typically have a complete (or "hard") lockout of both amortized and prepaid principal. After the lockout schedule expires (generally after year 10), the NAS tranches receive their full pro rata share of principal cash flows from the collateral. The resulting cash flow pattern is serrated in appearance, as shown in Exhibit 8.6, reflecting the stepped nature of the principal cash flows and the impact of the schedule on their timing.

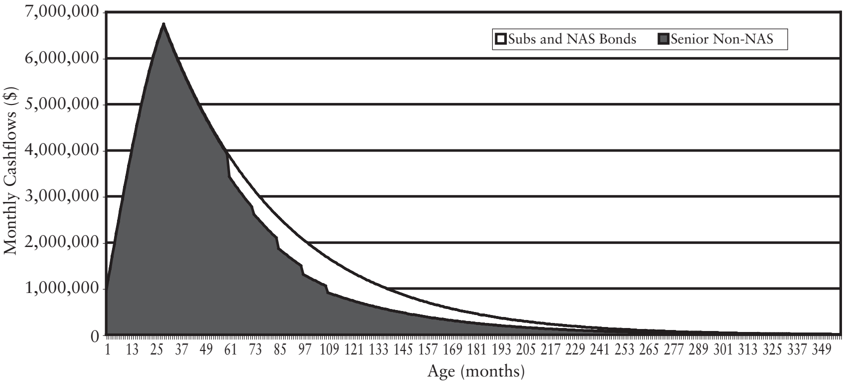
NAS tranches have typically comprised 10% of original face value of a deal, although some structuring derivations have had original NAS percentages of 20% or higher. Allocation of cash flows is very similar in concept to the shifting interest mechanism utilized in the senior–sub structure. The principal allocation is accomplished by taking the NAS bonds as a percentage of the outstanding balance of the collateral—the "NAS Percentage" in the prospectus—and multiplying it by the proportion of principal it is scheduled to receive, denoted in the prospectus as the "NAS Distribution Percentage" or "Shift Percentage." The schedule is generally the same as that used to define the shifting interest mechanism (as illustrated in Exhibit 8.3), although the NAS schedule is referenced in the prospectus separately. As an example, assume that the NAS distribution percentage in month 65 is 30% (meaning it receives 30% of its pro rata share of principal). At that point, the rest of the senior bonds will have partially paid down such that the NAS bond at that point comprises 20% of the deal (growing from the original 10% at origination). Multiplying the 30% distribution percentage by the 20% prevailing NAS percentage suggests that in month 65 the NAS bond receives 6% of the principal generated by the collateral pool.

There are some structuring derivations designed to improve the profile of the NAS bonds by creating *super-NAS bonds*. One method is to time-tranche the NAS bond into two bonds. The cash flows (and thus the profile) of the front bond are dictated by the schedule, while the longer tranche is essentially a sequential cash flow. Another technique is to accelerate the NAS bond slightly by changing the way the NAS percentage is calculated. Instead of the traditional calculation described earlier (i.e., the NAS bond balance divided by the outstanding collateral balance), a constant amount is added to the NAS balance. This constant is sometimes referenced as the *catalyst*. By changing the numerator of the fraction, more cash flow is directed to the NAS bonds than by using the standard proportional calculation, which subsequently causes the average life and duration of the NAS to extend less at slower prepayment speeds.

The presence of NAS bonds (along with the shifting interest subordinates) in a deal changes the profile of the remaining (i.e., senior non-NAS) bonds. These bonds (which are also categorized as *accelerated seniors*) have more volatile average life and duration profiles than those of pure sequentials created through simple time-tranching. This is because the subordinates and NAS bonds have schedules; the accelerated seniors only receive principal after the schedule is met, in the same fashion as supports in a PAC-support deal.

The impact of the shifting interest bonds on the profile of the accelerated seniors is, however, less pronounced than that of PACs on the support bonds in a structure. This is because the combined proportion of the subordinates and NAS bonds is much smaller than the 50%–70% PACs typically comprising a PAC-support deal. The impact of the shifting interest schedule on the accelerated seniors is also somewhat different due to the nature of the schedule. As discussed previously, the schedule typically begins after month 60, and scales in over the following 60 months. The cash flows of the senior non-NAS bonds are "accelerated" for the first 60 months by the fact that they receive more than their pro rata portion of principal; after that point, they only receive principal once the schedule for the shifting interest bonds is met.

EXHIBIT 8.7 Monthly Principal Cash Flow Allocations in a Private-Label Deal: $500 Million Face Value, 6.0% Net Coupon Rate, 300% PSA Pricing Speed



This pattern is illustrated in Exhibit 8.7. The area under the curve is the total principal cash flow at the pricing speed of 300% PSA. For the first 60 months, the senior non-NAS bonds receive almost all the principal generated by the collateral. (As noted previously, the subordinates typically receive a pro rata allocation of scheduled principal payments.) After month 60, the shifting interest bonds receive an increasing share of principal, and by month 120 the two groups receive roughly the same amount of principal cash flow.

There are a number of implications to this cash flow structure. As noted, the presence of a schedule causes the bonds to have more volatile profiles than pure sequentials. The delay of the allocation of principal until month 60 means that the leveraging effect of the NAS only impacts the bonds that receive cash flows at the time the schedule takes effect. The effect is analogous to the performance of bonds with barbelled cash flows discussed in Chapter 6 in that the profile of the cash flows changes over time. This is illustrated in Exhibits 8.8 and 8.9. Both exhibits take the cash flows generated by straight sequential and shifting interest structures and carve them up into a series of 12-month sequential cash flows based on the final payment date of the tranche at the pricing speed of 250% PSA. Put differently, tranche A captures the cash flows from issuance through month 12, tranche B uses the cash flows from month 13 through month 24, and so on. (For the purposes of this discussion, we reference sequentials from shifting interest structures as *leveraged sequentials*; the bonds from the straight sequential structure will be called *unleveraged sequentials*.)

Exhibit 8.8 shows the average life of a few of the leveraged and unleveraged sequential tranches at prepayment speeds of 175% and 100% PSA. The exhibit indicates that the very short bonds in the structures (i.e., bonds

EXHIBIT 8.8 Average Lives of Different Cash Flows in Leveraged and Unleveraged Sequential Structures, Cash Flows Time-Tranched Yearly

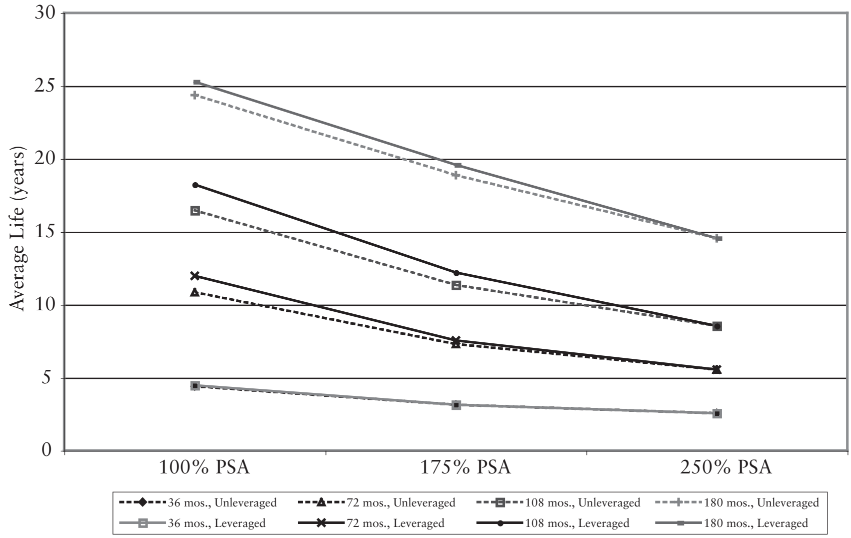
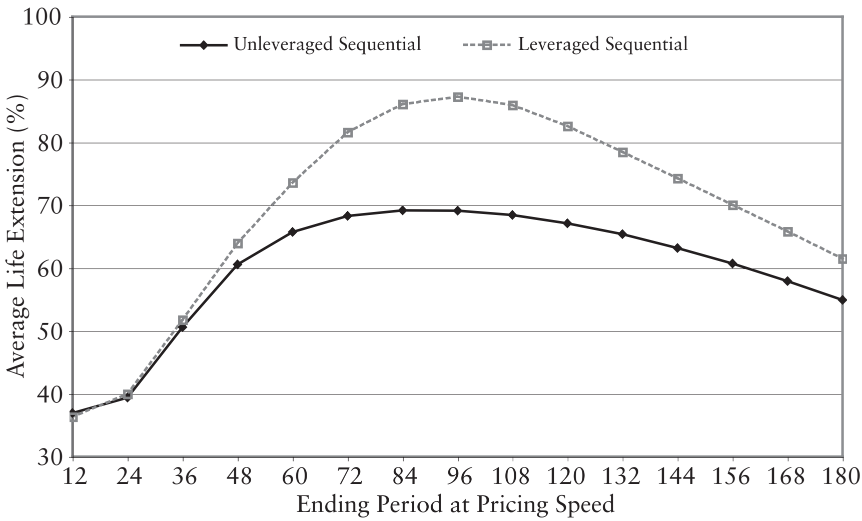


EXHIBIT 8.9 Percentage Increase in Average Life from 250% PSA to 125% PSA for Leveraged and Unleveraged Sequential Structures, Pass-Through Cash Flows Time-Tranched Yearly



with cash flows from month 25 through 36 at the pricing speed) have virtually identical extension profiles. The intermediate cash flows in the leverage structure exhibit significantly more average life extension; however, reflecting the diversion of principal from the accelerated seniors to the subordinates and NAS bonds. This effect is further illustrated in Exhibit 8.9, which shows the extension in percentage terms for all "tranches" in both structures when speeds are slowed from 250% to 125% PSA. It is clear from this exhibit that the greatest incremental extension is concentrated in the middle of the shifting interest or leveraged sequential structure.

This attribute of private-label deals complicates some structuring decisions. As an example, time tranching a *wide-window front sequential*, which would typically have an average life of roughly 3.5 years, creates a very stable short bond, but a volatile intermediate class, with around a 6.0-year base-case average life and significant extension at slower speeds. In order to create the tranched structure, the structurer would typically need to have expressions of interest for the 6.0-year, as there is a limited constituency for volatile intermediate tranches.

In light of these considerations, an important attribute of private-label deals is the front-loaded nature of the principal cash flows. Put differently, the short cash flows in the structure typically comprise a larger proportion of the face value of the transaction than in agency deals. This reflects both the above-referenced acceleration of principal along with the faster prepayment assumptions used in structuring private-label deals, particularly those collateralized by jumbo loans. One implication of this phenomenon is that private-label deal execution is highly dependent on the level at which the short cash flows are sold.

Localized PACs and Super-Stable Bonds

Both the structure and collateral characteristics of private-label deals make it difficult to structure PACs in the fashion discussed in Chapter 6. In agency CMO deals, the PACs and supports are typically comprised of principal cash flows generated over the full term of the collateral. This is very difficult to do in most private-label structures, due to a number of issues, which include:

- The front-loading of principal cash flows, as described in the previous subsection.
- The limited amount of longer senior non-NAS principal cash flows.
- The leveraging created by the shifting interest bonds.

Together, these factors make it difficult to create PAC schedules that are effective for intermediate and long bonds. This means that somewhat different structuring techniques must be utilized in order to optimize deal execution and meet the demand from different investors for a variety of profiles.

As the private-label PAC market has traditionally been less standardized than in the agency sector, there is more flexibility with respect to the PAC bands utilized. While bands based on the PSA model are often utilized, it is not uncommon to see PAC bands generated as a multiple of the pricing ramp or even in CPR terms. The lack of standardization, however, reflects the difficulties inherent in creating traditional PACs within private-label structures.

One structuring variation is the creation of localized PACs. In Chapter 6, we noted that in its basic form PAC schedules are typically created for the life of the deal; the resulting PAC and support bonds are then time-tranched. In a structure creating localized PACs, the process is reversed. The accelerated sequentials are first time-tranched; at that point, a PAC schedule is generated for one of the sequential tranches (normally the front sequential for reasons described already) and the parent tranche is then divided into PAC and support tranches.

Another variation used to structure the front sequential cash flows is to create ***super-stable tranches*** (SST). The SST is conceptually similar to that of the localized PACs in that the front sequential is used as the parent bond. Once the sequential structure is created, the SST bond is then created using the following steps:

1. Time-tranche the front sequential into a short, current-pay sequential bond and a longer, locked-out tranche.
2. Redirect a fixed dollar amount of monthly principal cash flow from the short sequential to the locked-out bond. This bond then becomes the SST bond, and the fixed principal payment acts as the SST bond's schedule. The short sequential now has a much more volatile average life profile, and acts as a support bond for the SST.

The presence of the schedule has a number of effects on the SST bond. In addition to stabilizing its profile, it both shortens the average life of the SST bond and makes it a current payer (i.e., it pays principal concurrently with the support bond). The schedule is similar to sinking funds seen in corporate bond structures; for this reason, the bonds are sometimes referenced as *sinkers*. An illustration of this process is shown in Exhibit 8.10.

The primary difference between structuring PACs and SSTs is in how the schedule is created. In PACs, the schedule is generated as a function of principal cash flows calculated at the prepayment speeds dictated by the PAC bands. The monthly scheduled principal payment for the SST is typically generated as a percentage of the original face value of the tranche, and

EXHIBIT 8.10 Example of Creating a Structure with a Super-Stable Bond where All Average Lives Run at 100% PPC Pricing Speed (8%–20% CPR over 12 months)

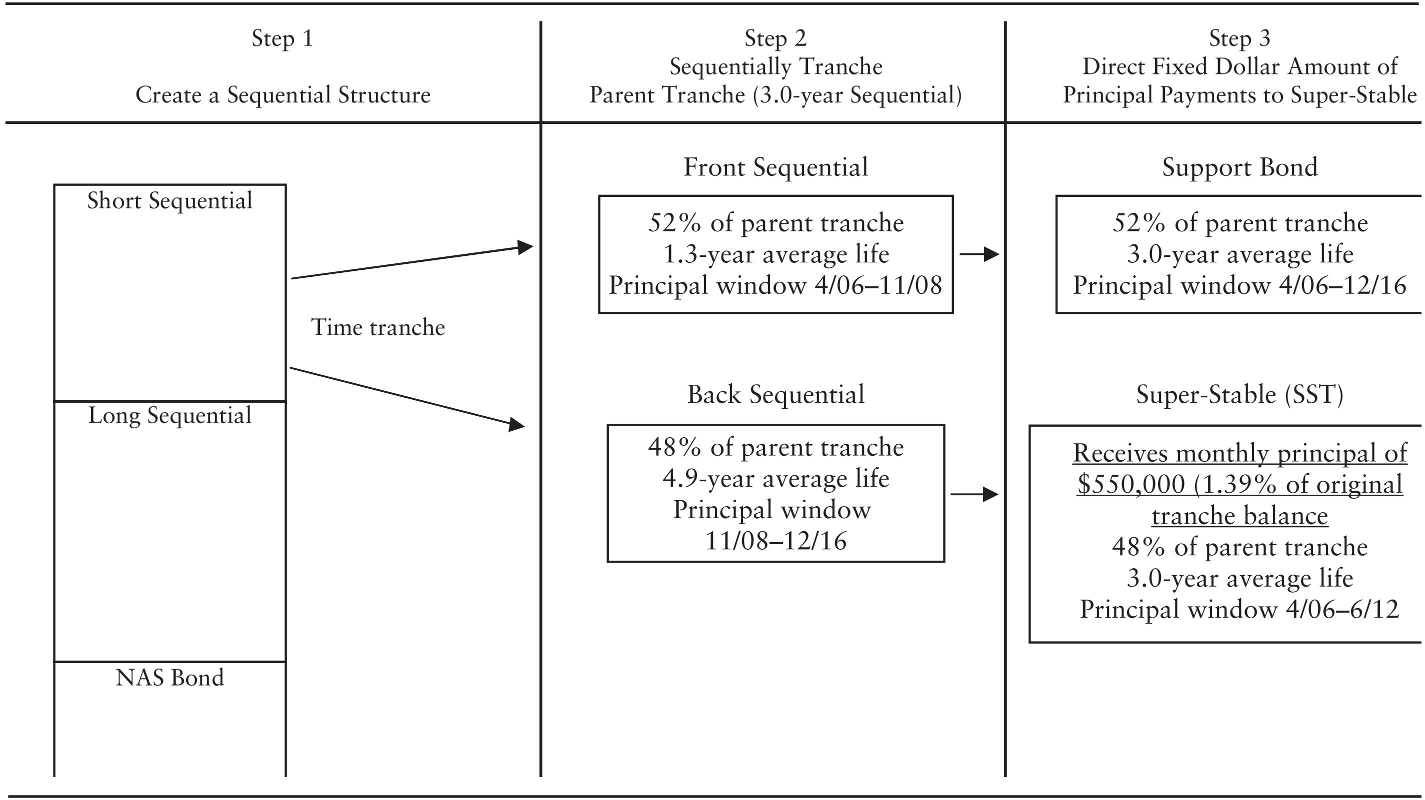
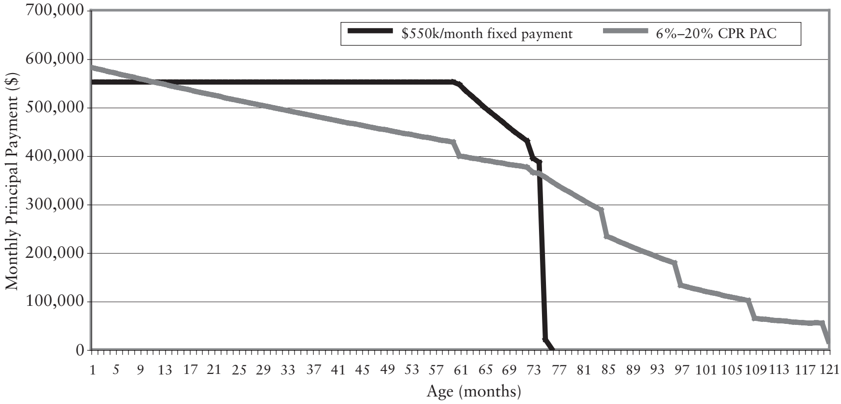


EXHIBIT 8.11 Payment Schedules for Localized PAC and Super-Stable Bonds



is stable in dollar terms. This is illustrated by the example in Exhibit 8.11, which shows cash flows for hypothetical SST and localized PAC bonds created from the same 3.0-year average life parent bond. The SST comprises 48% of the parent bond's face value, and receives $550,000 per month (roughly 1.4% of the bond's face value). The PAC is structured with a 6%–20% CPR band.

One implication of Exhibit 8.11 is that the SST bond receives more principal from its schedule than does the PAC. All things equal, this gives the SST better extension protection than the PAC, as long as enough principal is generated to meet the schedule. Note also that the scheduled principal payments to the SST drop below the $550,000 level at month 60, when the shifting interest bonds (i.e., the subordinates and NAS bonds) begin to receive principal.

To create SST bonds with the desired average life and profile, structuring is an iterative process of both sizing the SST (i.e., the different sizes of the two bonds created in step #1 above) and allocating different fixed monthly payments to the schedule. While the process can be somewhat cumbersome, the ability to specify both the proportions of the two bonds and the amount of cash directed to the super-stable tranche gives the structurer more flexibility in creating bonds and tweaking their average life and profile. By contrast, the attributes of localized PACs are a function of the assigned PAC bands. (The average lives of localized PACs also typically fall out based on the structuring bands, as well as the average life of the parent bond. While it is possible to specify average lives, the highly front-loaded cash flows of private-label sequentials make it difficult to target an average life for the PAC without skewing the relative proportions.)

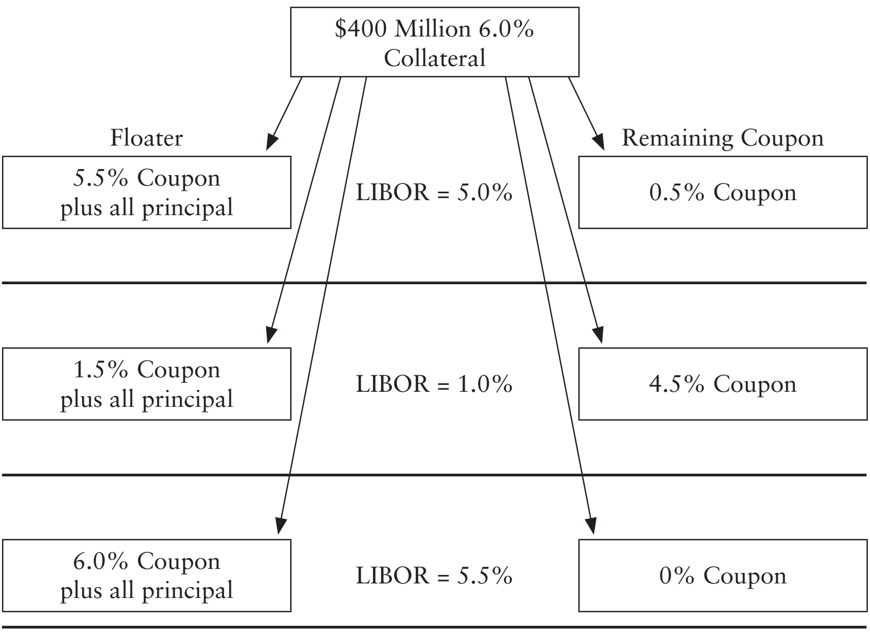
Variations of the structuring technique have evolved over time, reflecting the desire to have more flexibility in tweaking the profile of both the SST and support bonds. For example, one method generates the schedule as a function of the declining balance of the SST bond, instead of as a fixed dollar amount. This typically creates stable sinker bonds that nonetheless have more average life variability than a true SST bond, while the profile of the support bond is improved.

Corridor-Cap Floaters

As noted in the previous section, the relative size of the front-end, senior non-NAS cash flows makes their execution highly important to the execution of the entire deal. One structuring variation used in all MBS sectors (both agency and private-label) is to split cash flows into floater–inverse floater combinations. This acts both to improve the deal execution and meet the strong and persistent demand for floating rate assets.

The basic techniques for structuring floating rate bonds were discussed in Chapter 7. Exhibit 8.12 uses an exhibit from that earlier chapter to demonstrate how a simple floater–inverse IO combination can be structured

EXHIBIT 8.12 Allocation of Fixed Rate Interest to Floating Rate and Inverse IO Tranches If Collateral Coupon Equals Floater Cap



from collateral or a parent tranche with a 6.0% coupon. As we noted previously, however, there are trade-offs associated with this technique. If the whole tranche is to be utilized, the cap of the floater equals the coupon of the collateral; this level is typically lower than that desire by investors in floating rate bonds. If the floater cap is to be raised to a higher level, a premium–discount split must be used to create parent bonds with a high enough cap, limiting the proportion of the parent that can be structured into the floater–inverse IO combination.

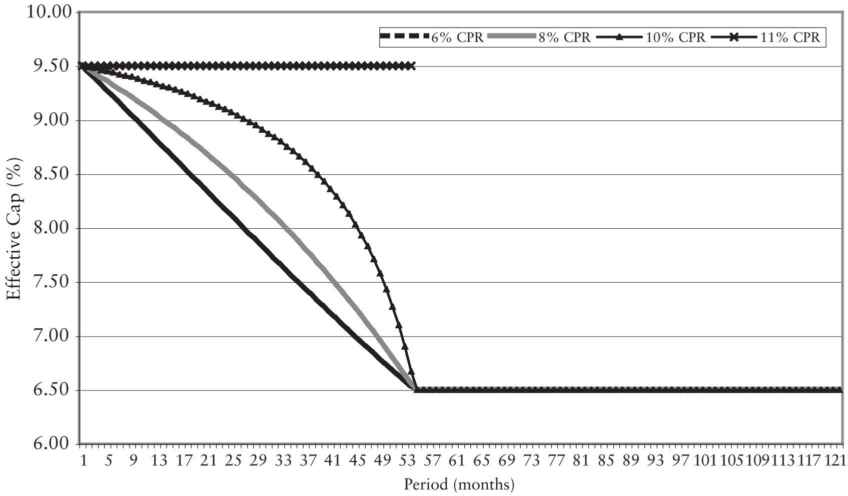
A solution to this limitation in private-label deals is the inclusion of amortizing cap corridors. In general terms, corridors are offsetting long and short positions in caps with the same expiration but different strike rates. An investor seeking to raise the cap on a floating rate asset would buy the lower strike cap and sell the one with the higher strike. Since the premium on a lower strike cap is greater than on the one with a higher strike, the resulting corridor has a positive cost.

Utilizing cap corridors allows dealers to structure entire tranches into floater–inverse IO combinations. This creates large floater tranches with a cap, referred to as the *hard cap*, equal to the parent tranche's coupon. The cap corridor is then used to raise the cap on the floater to a level acceptable to investors. The revised cap level, referenced as the *effective cap*, is the strike level of the higher cap in the corridor. The corridor is purchased from derivative dealers and embedded in the structure, with the effect of increasing the effective cap of the floater to the higher cap's strike rate. The cost associated with the corridor is effectively deducted from the floater's margin. As we discuss in the remainder of this chapter, this means that both the strike levels and longevity of the corridor have a direct impact on the return and risk profile of the corridor-cap floater.

While this concept is quite simple, the behavior of corridor-cap floaters is not straightforward. Because of the way the corridors are structured, the effective cap is not necessarily constant, and can deteriorate over the life of the floater under certain conditions. The value and riskiness of different corridor-cap floaters are a function of both how the corridors are structured and the level of the hard cap associated with the floater. As we will demonstrate, the floater's effective cap can change over time, unlike the hard cap, which is a constant level equal to the parent tranche's coupon.

Since mortgage cash flows are impacted by both scheduled and unscheduled principal payments, the corridors must be written with an amortization schedule. This schedule is defined at the time of issuance and can be quoted as either a percentage of the pricing ramp or at a static CPR. Since the corridor is structured (or "struck") at a predetermined speed, but the floaters receive principal cash flows based on the underlying prepayment rate of the collateral, the potential exists for a mismatch between the balances of the floater

EXHIBIT 8.13 Effective Cap for Corridor Floater at Different Prepayment Speeds: 6.5% Hard Cap, Corridor Struck at 11% CPR



and the cap corridor. When the deal's prepayment speeds exceed the ramp, the floater tranche pays down faster than the corridor, leaving more corridors than bonds. In theory, this should raise the effective cap to a level higher than the strike level of the higher cap. However, the effective cap of the floater normally never rises above the higher strike, since the corridor is typically quoted as the lesser of the preset amortizing balance or the balance of the floater. (For accounting reasons, some investors will not invest in floaters where the effective cap is greater than the level of the higher cap's strike.)

The effective cap is, however, impacted when realized prepayment speeds are slower than the speed at which the corridor is struck. At slow prepayment speeds, the balance of the floater will exceed that of the corridor, causing the effective cap of the floater to decline. Persistently slow prepayment speeds will eventually cause the effective cap to decline to the level of the floater's hard cap. This is shown in Exhibit 8.13, which shows the effective cap at prepayment speeds both equal to and slower than the 11% CPR strike speed of a hypothetical corridor-cap floater. At 11% CPR and faster, the effective cap is unchanged; however, at even slightly slower constant speeds, the effective cap eventually declines to 6.5%, the floater's hard cap.

This suggests that the cap corridor's pricing speed is a critical driver of value for the corridor floaters. Floaters with a corridor struck at a faster prepayment speed have a greater risk that the effective cap will deteriorate. However, the corridor is effectively a shorter derivative (since its average life is reduced at faster speeds). This means that the cost of the cap corridor is reduced, thereby increasing the amount of margin that can be paid to the floater. The opposite is the case if the corridor is struck at a slow speed. The risk that the effective cap will erode over time is reduced, at the cost of a lower floating rate margin. (Note that the speed at which the corridor is struck has no impact on the cash flows directed to the inverse IO.)

The type of loan collateral backing the deal also has an impact on the corridor floater's attributes. Because of the risks associated with slow prepayment speeds, the ideal collateral consists of loans expected to exhibit relatively fast prepayment speeds. As a result, most deals containing corridor floaters were backed by alt-A and other impaired loans (such as reperforming loans) that had consistently exhibited relative fast prepayment speeds. However, the extremely slow speeds experienced for many products and cohorts caused by the sharp decline in home prices after 2007 resulted in dramatic declines in the effective caps, and therefore the prices, of many corridor-cap floaters issued in 2005 and 2006.

Finally, the floater's hard cap also impacts its value. As mentioned previously, the level of the hard cap cannot change over the life of the floater. Thus, a higher hard cap provides increased protection to the floater's coupon in the event that the corridor deteriorates. As an example, a floater with a 5.5% hard cap that resets at LIBOR plus 30 basis points would "cap out" when LIBOR reaches 5.20% without the benefit of the corridor. The same bond with a 6.5% hard cap would not cap out until LIBOR reaches 6.20%. The value of the higher hard cap is especially important when more aggressive (i.e., faster) pricing speeds were used to structure the corridor.

Re-REMICS

Resecuritizations of real estate mortgage investment conduits (re-REMICs) have been created in both the agency and private-label markets for many years. The term simply means that an existing tranche is used as collateral for a new and separate transaction issued after the original deal has been closed. It is quite similar to the normal practice of using a tranche as a parent bond in structuring a transaction. (The designation of "exchangeable tranches" is, in fact, a way of avoiding the need to create a re-remic in order to restructure existing tranches.) With a few small exceptions, the techniques and calculations are the same as those used to restructure a parent bond within a transaction.

A re-remic is often created from bonds owned by investors, with the investor taking back one or more of the new bonds. The technique is also used by dealers as a means of restructuring large tranches created in earlier transactions that were left unsold. Common examples would include capitalizing on the demand for inverse floaters by taking an existing tranche and splitting it into floaters and inverse floaters, or taking a long sequential tranche and splitting it into a Z-VADM combination.

In the private-label market, a technique that was commonly used in 2009 and 2010 was to restructure senior bonds that had been downgraded by the rating agencies. In many deals, unexpectedly high levels of defaults and losses led to either the partial or fully exhaustion of the senior bond's credit support. In addition, the rating agencies dramatically increased the amount of credit support necessary to create AAA-rated senior bonds backed by earlier-vintage collateral. For some investors, such downgrades created serious capital shortfalls, as 100% of the face value of bond holdings that were not investment grade (i.e., was rated below BBB) had to be held as capital against the position.

In order to free up capital, the downgraded senior tranches was used as collateral for new deals by creating senior and subordinate tranches using fairly standard structuring techniques. The new senior (and AAA-rated) bond could then be sold at fairly attractive levels, even while the subordinate tranches were repurchased and held by the investor. Although subordination levels for many types of collateral were large (often 33% or more), the transaction made economic sense for investors, since they could reduce the capital held against their private-label portfolio by the amount of the senior bond sold.

GOVERNING DOCUMENTS

Given the high levels of delinquencies and subsequent writedowns in nonagency transaction, many investors have claimed that the actions of issuers and/or loan servicers have damaged their interests and caused them to reap unfair losses. In order to understand such claims, a brief discussion of the documents that govern all nonagency MBS transactions is required.

The two most important documents associated with private-label transactions are the *Prospectus Supplement* (ProSup) and the *Pooling and Servicing Agreement* (PSA). The ProSup typically contains the following information:

- Statistics on the loan collateral pool(s). These include information on all the collateral groups, as well as breakdowns of their average note rates, credit scores, and other metrics.
- Descriptions of the tranches (or, as generally described in legal documents, the Certificates), including their coupon rate and type (i.e., fixed versus floating), their rating, and their average life at issuance.

- Descriptions on how the deal structure works. Such information includes the cash flow waterfalls and loss allocations, any schedules embedded in the deal, and the presence of corridors or other derivatives in the structure.
- Information on how the balances of each bond will decline at various prepayment speeds (*decrement* or *DEC* tables).
- Other factors, such as tax treatment, ERISA considerations, and investor risk factors.

The PSA typically contains detailed information on:

- How the loans are transferred or "conveyed" into the trust;
- Information on the administration and servicing of the loans;
- Limitations defined under ***Representations and Warranties*** (Reps and Warranties) on the attributes of the loan collateral; and
- Events that constitute default by the servicer.

Of these, the section outlining the Reps and Warranties of the mortgage loan issuer(s) is of the greatest interest to investors. This section describes in detail what attributes of the loans are being "represented" to investors and the trustee by the issuer(s). Such attributes include assurances that the loans comply with all state and Federal laws, and that they were underwritten in a fashion consistent with the applicable loan program. While fairly consistent, provisions in the Reps and Warranties can differ across originators. (For example, some large issuers did not represent against fraud on the part of borrowers.)

Investors that can identify and document Rep and Warranty violations for loans that have gone into default can request that the loans in questioned be repurchased by the issuer or servicer from the trust. Such "buybacks" benefit investors, since the cash from the buyback is passed through to investors through the trust, using the waterfall mechanism that outlines all cash disbursements within the trust. Conversely, they are costly to (and have been fiercely resisted by) originators since they are effectively being asked to buy valueless assets at face value. However, buybacks are complicated by a number of factors:

- Investors must be able to examine the underwriting files in order to document violations. These files, however, are generally held by the servicer of the loans. There are a series of hurdles that need to be satisfied before investors must be granted access to the documents. The most important of these is a "quorum" requirement for which a minimum proportion of a transaction (typically 25%) must be held by investors in order to receive access to the loan files.

- For each buyback request, investors must show that they were "materially impacted" by a violation of the Reps and Warranties. Put differently, the servicer is only obligated to buy back a defaulted loan if the default can be directly linked to the violation.
- As noted, a standard provision is that loans must conform to the guidelines of the lending program. While the ProSup outlines the generalities of the loan programs, the details of each program (e.g., minimum credit scores, maximum LTVs, required documentation, etc.) are possessed by the originators, who are under no obligation (and have no incentive) to divulge them to investors.

At this writing, buybacks of loans alleged to have Reps and Warranties violations (sometimes called "manufacturing defects") are a contentious issue in the MBS issuer and investor community for securities issued prior to 2008. While investors have requested billions of dollars in buybacks for defaulted loans in private-label transactions, relatively small numbers of loans have to date been repurchased. (By contrast, lenders have repurchased billions of dollars worth of loans from Fannie and Freddie pools for violations of the GSEs' Selling and Servicing guidelines, the equivalent of the PSA for GSE-backed transactions.)

It is likely that investors in future deals will require changes to the legal structure of MBS transactions, including their governing documents. Such changes may include the separation of a deal's servicer from the originator of the loans in the collateral pool, in order to minimize conflicts with investors; greater clarity in the wording of Reps and Warranties; and the publication of the program specifications for all loans contained in a transaction.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Private Label
Shifting Interest Mechanism
Super Senior Bonds
Mezzanine(mezz) Bonds
Nonaccelerated Senior (NAS) Bonds
Localized PACs
Super-Stable Tranches
Corridor-Cap Floaters
Re-REMICs
Prospectus Supplement (ProSup)
Pooling and Servicing Agreement (PSA)
Representations (Reps) and Warranties

CHAPTER 9

The Structuring of Mortgage ABS Deals

In the previous chapter, we noted that the emphasis in structures in the mortgage ABS sectors is different from that in structures involving prime first-lien residential loans. Loans that fall into the general category of mortgage ABS are riskier than those in prime deals, either because the loans are granted to borrowers with impaired credit (which greatly increases their expected defaults and losses) or are in an inferior lien position (which creates high-loss severities). As such, these loans are characterized by higher note rates than those in the prime first-lien sector, reflecting risk-based pricing on the part of lenders.

As with other types of private-label deals, the challenge in structuring mortgage ABS transactions is to create cash flow protection and credit enhancement for the senior securities in the most efficient possible way. The optimal form of credit enhancement for deals backed by risky loans with high note rates is the overcollateralization (OC) structure, introduced in Chapter 5. These structures allow the higher note rates associated with riskier loans to be converted into credit enhancement. Our primary objective is to explore the various mechanisms associated with the OC structure, which by necessity are more complex than the simpler shifting interest structures utilized in the prime sector and discussed in Chapter 8.

For the purposes of this chapter, mortgage ABS deals are also simply referred to as ABS deals. As such, these deals should not be confused with ABS deals securitizing assets such as auto loans and credit cards, which have many different features. Note also that the term *residential deal* is used interchangeably with *prime deal* in this chapter, utilizing the admittedly oversimplified terminology used in the market. The following discussion focuses on structures that used subprime loans as collateral, a common practice in the market up to late 2007. However, other types of collateral (such as alt-A ARMs) have also been securitized using OC structures, if they provided issuers with the most efficient form of execution.

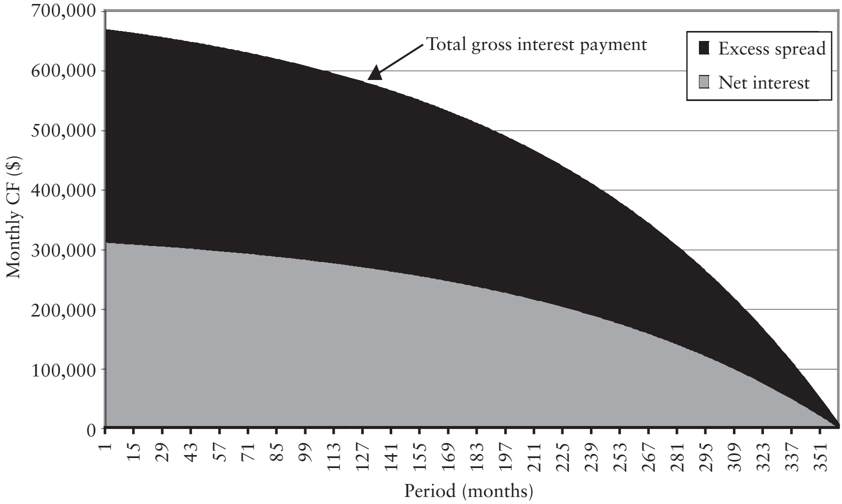
As with other aspects of mortgage lending, the market for deals backed by lower-quality loans has changed dramatically since the onset of the mortgage and financial market crises. While the subprime lending industry has effectively disappeared at this writing, small amounts of loans continue to be made to borrowers with weaker credit characteristics, albeit with offsetting factors that mitigate default risk. Moreover, deals backed by these loans have also been issued utilizing some or all of the techniques commonly used in ABS structures during the period that ended in 2007. This discussion of mortgage ABS deals is thus intended to facilitate both an understanding of how "legacy bonds" issued before 2008 were structured, as well as how future transactions might employ some or all of these structuring mechanisms.

FUNDAMENTALS OF ABS STRUCTURES

ABS deals employ various forms of credit enhancement, which is typically greater than that associated with residential deals. For residential deals issued before 2008, credit enhancement levels (i.e., the credit support for the senior, AAA-rated tranches) typically did not exceed 10%. By contrast, similar-vintage ABS deals generally had initial enhancement levels in excess of 20%. ABS deals also require structurers to efficiently utilize the incrementally higher note rate of the underlying loans to provide additional credit support, effectively converting interest cash flows into principal. Understanding this requires the introduction of two concepts. One is ***excess spread***, which is the difference between interest received from borrowers on the loans and paid to the securities. While all deals technically have excess spread, it is not large enough in residential deals to supplement credit enhancement. However, the amount of excess spread in a typical ABS deal is relatively high, because of the high note rates typically associated with high-risk loans. In many transactions, excess spread was designated as the first form of credit support, that is, it was used to protect investors from credit losses before the subordinates. A diagram of a hypothetical deal's cash flows and excess spread is shown in Exhibit 9.1. (Note that the exhibit was constructed for expository purposes; the rates chosen do not necessarily represent real-world examples.)

The other concept is ***overcollateralization*** which simply means that the face value of loans collateralizing the deal is greater than the amount of bonds. OC is created through two mechanisms. One way is to structure fewer bonds than the face value of the loan collateral at issuance, which is referenced as ***initial* OC**. The other mechanism is to utilize some or all of the excess spread to pay down bonds faster than simply through the return of principal. This is called acceleration or ***turboing***. A depiction of the allocation

EXHIBIT 9.1 Gross and Net Interest and Excess Spread for a Hypothetical $100 Million Subprime Collateral Pool (8% GWAC, 3.75% net coupon)

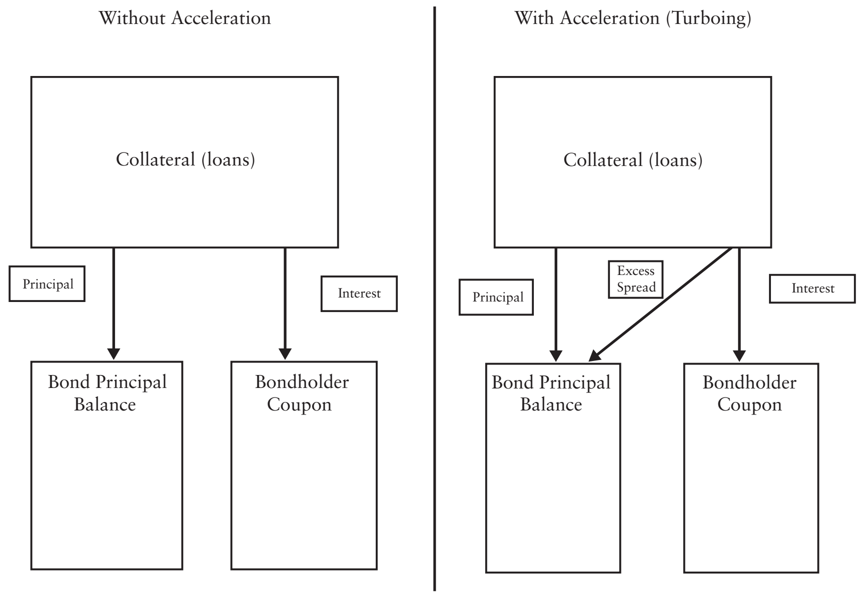


of cash flows with and without turboing is shown in Exhibit 9.2. These two techniques were utilized in conjunction with subordination to provide credit support to the senior bonds in ABS deals.

The credit support mechanisms utilized in ABS deals have a number of implications. The *credit enhancement percentage* is typically quoted as the subordinates' size relative to the total face value of collateral at issuance. Quoting the percentage of credit enhancement in this fashion for an ABS deal can be misleading. In part, this is because the excess spread, while not factored into the credit enhancement percentage, is nevertheless available to make up losses. In addition, deals that do not have initial OC but rather achieve the target level through turboing will not have the OC show up in initial enhancement levels.

Another difference is that OC by definition is equity in a deal. Therefore, the residual (which represents the deal's equity interest) in an ABS structure has much more importance than that in residential deals. In the latter, the residual usually does not receive any cash flows, since the amount of collateral and bonds is the same. The residual has value only as an entity for tax purposes and, as noted earlier, is referred to as a *noneconomic residual*. As such, tax effects generally cause the noneconomic residuals to have a negative value at issuance. In an ABS structure, by contrast, the residual has economic value, meaning that it is expected to receive cash flows when other, more senior interests are satisfied. As such, the residual is positioned at the

EXHIBIT 9.2 Normal Cash Flow Allocation and Allocation with Turboing to Create Overcollateralization



lowest point of the waterfall with respect to cash flow priority.[1] Exhibit 9.3 shows a graphical depiction of a simple waterfall in an ABS structure.

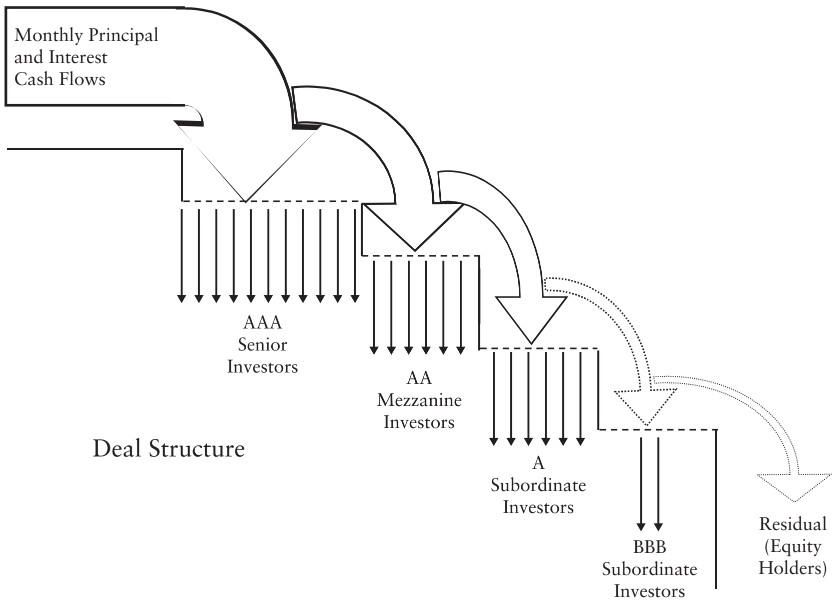
Moreover, what is commonly referred to as "the residual" in an ABS deal is really a combination of two entities: the excess cash flows (securitized either as the C or XS tranches) and the noneconomic residual (created as an R or NER tranche). While the face value of the R bond is typically small, the C tranche's face value in notional terms can be significant, depending on how much OC is created, either as up-front OC or through the turboing mechanism. In addition, the residual sometimes receives the proceeds from prepayment penalties paid by borrowers.[2] As we will discuss later in this chapter, some structuring techniques attempt to further enhance execution by effectively tranching the residuals.

Mortgage ABS deals are typically structured such that the senior and subordinate bonds are largely comprised of LIBOR-based floaters. Depending on the composition of the collateral and the level of short interest rates, this type of structure often creates large amounts of excess spread. The

[1]As described in Chapter 8, a deal's waterfall describes how principal and interest cash flows are allocated within the structure.

[2]Prepayment penalty proceeds were frequently dedicated to separate tranches. We discuss these P tranches later in this chapter.

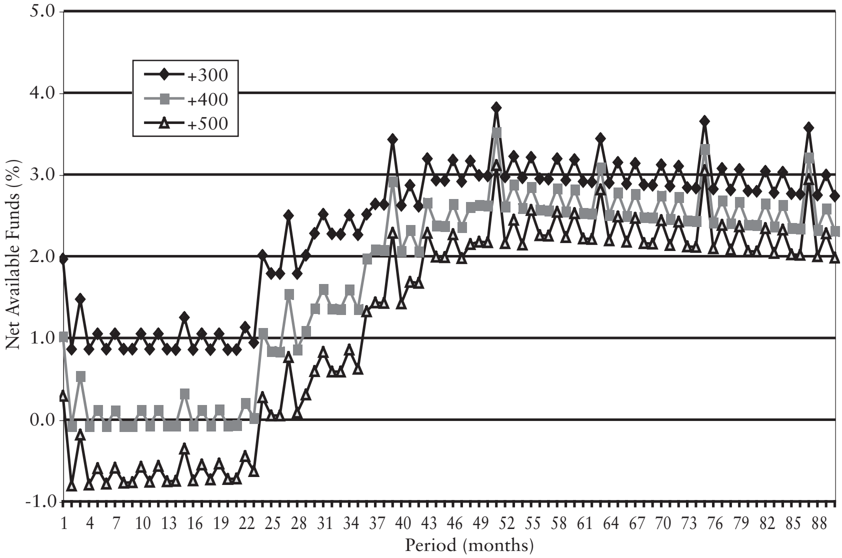
EXHIBIT 9.3 Schematic Representation of Cash Flow Waterfall for Mortgage ABS Deal (with economic residual)



excess spread allows for the creation of floaters, since it is sufficient enough to obviate the need for inverse floaters (as utilized in prime deals). However, there are often mismatches between the timing of rate adjustments on the collateral and the underlying bonds. Most floaters are structured to reset monthly, while the loan collateral may be comprised of hybrid ARMs (which typically have a fixed coupon for two or three years after funding) or fixed rate loans. This potential mismatch creates an ***available funds cap***. This means that in certain extreme rate scenarios, there might not be enough interest to fully pay the coupon of the floating rate bond. (For example, structures backed by hybrid ARMs have significant available funds cap risk immediately after issuance, since the collateral does not begin to reset for two or three years.) Exhibit 9.4 shows the available funds exposure for a representative deal over time given different instantaneous rate shocks.

Note that the *basis risk* implicit in ABS structures also has implications for the credit protection of the senior bonds in the structure. In a scenario when rates increase sharply immediately after issuance, the structure's excess spread is reduced; the bond coupons reset higher immediately, while the loan collateral continues to pay a fixed coupon rate until the reset date. In addition to creating available funds cap risk, a sharp spike in short rates

EXHIBIT 9.4 Example of Available Funds in Different Instantaneous Rate Shift Scenarios



also reduces the amount of excess spread available for either direct credit support (i.e., to be paid to the bonds in the structure if they experience losses) as well as to turbo the bonds and build OC.

The available funds cap exposure and basis risk is often mitigated by the utilization of derivative contracts in the structure. For example, a series of cap contracts or corridors can be purchased and placed within the structure, with the cap premiums paid for at issuance and treated as a cost to the deal. The contracts are often structured to be based on amortizing balances at a designated prepayment speed or vector to create a declining balance schedule. (Some deals utilize derivatives written to a ***lesser-of schedule***. This means that the contract is first structured at a predetermined amortization schedule. The contract is then written such that cash flows are exchanged based on the lesser of the actual amortized balance or the balance run at the pricing speed.) The purpose of the cap contracts is generally to smooth out the available funds schedule; eliminating available funds cap risk entirely would typically be prohibitively expensive, as the option premium would absorb too much of the excess spread necessary for credit enhancement.

Alternatively, swap contracts have also been used to minimize a deal's basis risk. Costs associated with the swap are paid out of the transaction's excess spread. Embedded swaps serve the dual role of augmenting the deal's credit support while reducing the bonds' available funds cap exposure.

Similar to the cap contracts discussed previously, the swaps are sometimes structured with lesser-of schedules in order to minimize the possibility of a mismatch between the balance of the bonds and the swap contract. (The role of derivatives in supporting credit enhancement is discussed in depth later in this chapter.)

CREDIT ENHANCEMENT FOR MORTGAGE ABS DEALS

As noted thus far, mortgage ABS credit enhancement utilizes a combination of subordination, excess spread, OC, and derivatives. The structure ultimately utilized for any particular deal is a function of (1) the attributes of the collateral and (2) the amount of enhancement necessary to secure the desired ratings on different bonds from the rating agencies. In addition to the utilization of excess spread and OC, there have typically been a few differences between subordination in the prime and ABS sectors. The mechanism for growing ABS subordinates as a portion of the deal and allocating principal to the subordinates is structured somewhat differently from the shifting interest mechanism in residential structures. ABS transactions typically do not have as many low-rated subordinates as residential deals. As described in the previous chapter, prime deals typically have a "six-pack" of subordinates, with the lowest tranche in the credit spectrum being an unrated first-loss piece. ABS deals were generally structured down to the triple-B-minus level (i.e., the lowest level considered investment-grade), although some deals had subs rated as low as double B. In these deals, the excess spread and the residual serve as the first-loss components.

As described previously, OC can be created at issuance (by structuring initial OC) or generated over time by utilizing excess spread to turbo the deal. In either case, a deal would have a target OC amount, which is the OC (as a percentage of the face value of the deal's loan collateral) scheduled to be generated by a certain point in time. This ***stepdown date*** is the point after issuance at which principal and interest cash flows can be released to the residual, depending on how the deal's waterfall is specified. It is either defined as a point in time (e.g., 36 months after issuance) or the month where the deal's total subordination reaches a certain point (typically twice the original subordination percentage). Prior to the stepdown date, excess spread is directed to the bonds in the deal (beginning with the senior bonds) until the OC target is met. (Typically, the OC target is defined as a percentage of the original collateral balance prior to the stepdown date; after the stepdown, the target is typically twice the stated percentage of the current balance of the collateral.) In addition to creating OC, the mechanism insures that the principal of the senior bonds is reduced before any principal is released to the subordinates. In addition, the subordinates are locked out from receiving principal payments, typically for 36 months (as long as the balance of the seniors remains above zero.) This is similar in concept to the shifting interest allocation of principal in the prime sector. Both these mechanisms act to deleverage the senior classes and increase their credit protection after the deal is settled. (One difference is that while the shifting interest structure locks out unscheduled principal, the subs are locked out from receiving all principal in OC structures prior to the stepdown.)

Credit enhancement on mortgage ABS deals can be characterized as a series of decision trees that control the distribution of monthly principal and interest. Cash flows are allocated within a structure based on specific factors designed to protect the integrity of the bonds. The factors driving the allocation of cash flow (or, put differently, the nodes of the decision trees) are:

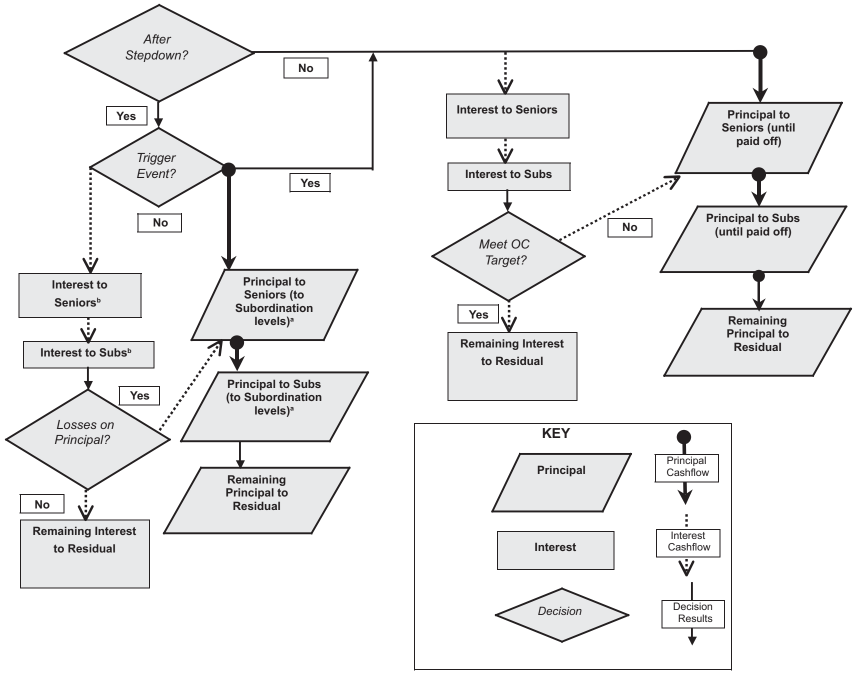
- Whether stepdown date has been reached.
- Whether a trigger event has occurred.
- Whether the OC target is met.
- Whether the deal has absorbed any principal losses.

A flow chart showing how a typical deal works is shown in Exhibit 9.5.

Prior to the stepdown date, interest available after paying the coupon of the senior and subordinated bonds is used to turbo the bonds and create OC until the target OC is met. Principal is allocated in priority order to the senior and subordinate classes, respectively, until they are paid off. After the deal steps down, and assuming the deal's triggers are passed, interest remaining after the bond coupons are paid can be passed to the residual holder, provided that the bonds have not absorbed principal losses. (If losses have been taken by the bonds, the excess interest is directed to recoup such losses, again in order of their priority. Interest shortfalls are also paid to the bonds before the residual can receive cash.) Principal is paid to the senior and subordinate bonds, subject to limits on principal distribution described in the prospectus. (This amount, called the *optimal distribution percentage*, dictates how large the subordinate classes must be relative to the outstanding principal balance of the senior bonds.)

The deal's triggers are tests embedded in the structure to protect the senior bondholders in the event the underlying collateral exhibits unexpectedly high levels of delinquencies and losses at any point in time. The tests are specified to be met on a monthly basis. However, they are often specified as trailing average levels of delinquencies, as well as the cumulative level of losses, relative to the remaining balances of either the deal or the subordinates. Triggers are highly deal- and issuer-specific, depending on both the type of collateral backing the deal and how it was expected to perform at

EXHIBIT 9.5 Flow Chart of Principal and Interest in a Typical Subprime ABS Structure



[a]Subject to limits on how much is paid to each tranche described in the prospectus.
[b]Subject to the availability of funds.

issuance. If a trigger event occurs (i.e., the trigger is failed) after the stepdown date, cash flows are distributed as if the stepdown had not occurred. In this case, excess spread is used to reduce the balance of the seniors (and the subordinates, if the seniors are fully amortized), and the subordinates are locked out from receiving principal until the senior tranches are paid off.

FACTORS INFLUENCING THE CREDIT STRUCTURE OF DEALS

As with residential deals, the rating agencies have played a key role in determining the credit enhancement required for a deal. As in prime deals, the rating agencies dictate the levels of subordination needed to allow the bonds in the structure to attain the desired rating, based on the attributes of the collateral pool. In addition to the subordination levels, the rating agencies also outlined other structural components of ABS deals. These included both the necessary levels of target OC, as well as how much of the target could be expected to be met by turboing the bonds using the transaction's expected excess spread.

The structuring decisions made for ABS transactions structured through 2007 were based on a number of interacting considerations. For example, losses were not expected to begin accumulating until the collateral had seasoned by 12 to 24 months, mitigating the need for initial OC. However, the rating agencies sometimes required initial OC for a specific deal based on either collateral- or bond-specific factors. Some examples included the following:

- If the rating agencies believed that the excess spread on risky loans was not sufficient to build OC in time to meet the target OC level, initial OC was often required in the deal.
- A larger proportion of longer hybrids (e.g., 3/27s instead of 2/28s) generally results in higher available funds cap risk. In turn, the amount of excess spread available to turbo the bonds was assumed to be limited, necessitating the inclusion of initial OC.
- A pool of collateral perceived as being particularly risky might have had a higher target OC level, which created the need for initial OC in spite of high excess spread levels.

At this writing, the future involvement of the rating agencies in all private-label transactions remains open to question. The credibility of the rating agencies was severely damaged by the poor record of their ratings for bonds issued through 2007. This led to legislative action intended to create greater accountability on the part of the rating agencies. The Dodd-Frank Wall Street Reform and Consumer Protection Act, signed into law in July 2010, suspended a rule in the Securities Act of 1933 that had previously shielded the rating agencies from "expert liability." The shield meant that the rating agencies could not be held liable for failed ratings (i.e., ratings downgrades), since bond ratings were effectively treated as opinions.

After Dodd-Frank became effective, some of the rating agencies stopped allowing their ratings to be included in transactions' official documents. This forced the Securities and Exchange Commission to relax the requirements that such ratings be included in asset-backed bond offering documents. This "temporary" solution was indefinitely extended by the SEC in November 2010. Possible resolutions to the problem include:

- Revisions to the Dodd-Frank bill restoring the "opinion shield."
- Altered structuring norms that involve structuring credit enhancement without quoting ratings.
- Increased use of private-placement transactions that are not subject to the same regulations.

ADDITIONAL STRUCTURING ISSUES AND DEVELOPMENTS

Derivative Contracts and Credit Support

As discussed in the section addressing available funds caps, transactions are also commonly structured with embedded derivatives as part of the credit support mechanism. The presence of a swap within a structure, for example, acts to augment its credit support by reducing the basis risks embedded in the deal. There is often a fundamental mismatch in many deals between the bonds within a deal and the collateral backing it. Under scenarios of sharply rising rates, the amount of excess spread is reduced, particularly soon after the deal is issued; the collateral continues to pay a fixed note rate, while the coupons on the bonds within the deal (which reset on a monthly basis) rise.

In addition to mitigating potential available funds shortfalls, embedded swaps act to augment the excess spread in scenarios where interest rates spike. For ABS deals originated through 2007, this allowed the rating agencies to reduce the amount of required credit enhancement at each rating level, and typically reduces both the target OC percentage and the amount of initial OC.

The notional value of the swap is calculated in a number of different ways, and based on economic and accounting considerations. The term of the swap and the swap's declining balance are based on the composition of collateral backing the deal, along with the speed assumption utilized. The swap is typically structured as declining balance derivative contracts, with the speed determined at the time of issuance. The swaps are sometimes structured to have a lesser-of balance guarantee; as noted previously, this means that the swap balance cannot exceed the balance of the bonds and create a mismatch if prepayment speeds for the collateral are fast. (As with other elements of the swap, this calculation can vary across issuers.)

The swap obligates the structure (or some entity within the structure) to pay fixed cash flows in exchange for floating rate payments, based on an amortizing notional balance. Since the rate on the fixed rate component or "leg" is typically higher than that of the floating rate leg, the swap initially has a net cash outflow. The net outflow initially reduces the deal's excess spread by the difference in rate between the fixed and floating legs. From the perspective of credit enhancement, the utilization of swaps involves trading off slightly lower initial excess spread under unchanged rate scenarios versus enhanced excess spread levels if rates were to spike. This is particularly true early in the life of the deal (i.e., before the collateral begins to reset), when the basis exposure is greatest.

To illustrate this trade-off, Exhibit 9.6 shows comparisons of excess spread levels under different interest rate scenarios for hypothetical ABS deals with and without embedded swaps. The deals are representative of transactions structured in mid-2006 using adjustable and fixed rate subprime loans (although roughly 93% of the loans backing the structures were ARMs). The deal without the swap was structured to have initial OC of 3.8%, with a target OC percentage of 4.7%; the deal with the swap had initial and target OC of 3.65%. Comparing the two structures, of Exhibit 9.6(A) indicates that the deal containing an embedded swap had slightly lower levels of excess spread in unchanged LIBOR scenarios vis-à-vis the deal structured without a swap. (The average difference between the excess spread of the two deals was 22 basis points over the deal's first 40 months.) This difference is attributable to the net initial cash outflow associated with the swap. However, the excess spread when the swap is present is projected to be much greater when forward LIBOR is assumed to rise by 300 basis points immediately after issuance, as illustrated by Exhibit 9.6(B). In this scenario, the average difference between the excess spread for the two deals is 168 basis points over the first 40 months; the difference is 210 basis points for the first 18 months, when the structure is most vulnerable to a spike in LIBOR.

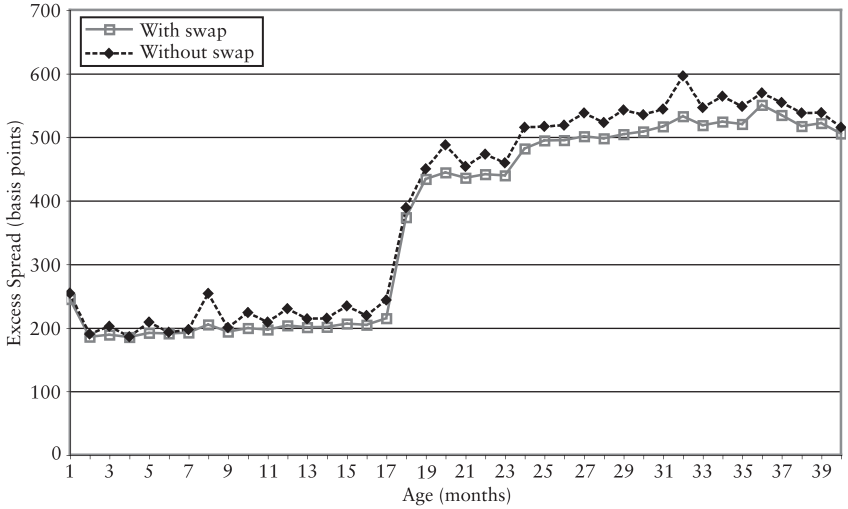
Residuals, NIMs, and P Bonds

As noted, the residual is the equity interest in the deal and is entitled to receive cash at certain points in the life of the deal, assuming the underlying collateral exhibits adequate performance. Some subprime originators sought to maximize the amount of cash received at securitization rather than receiving cash over time through the residual. In this case, a ***net interest margin bond*** (NIM) was created through a separate transaction.

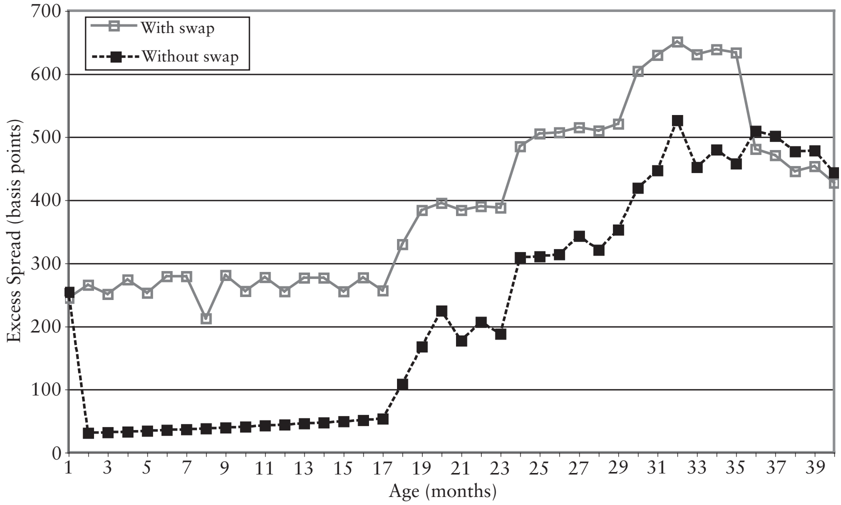
The NIM was, in part, comprised of the portion of the residual that receives cash in excess of that needed to fund OC, referenced earlier in this chapter as either the C or XS tranches. In addition, the NIM often was entitled to the proceeds from the payment of prepayment penalties. Prepayment penalties are costs associated with prepaying the loan that serve as a refinancing disincentive. When loans having prepayment penalties are prepaid, the proceeds of the penalties traditionally have gone to the loan servicer. Generally, the penalties were not part of the cash flow waterfall and, therefore, were not utilized to cover losses. A commonly seen alternative was to create separate tranches, called ***P bonds***, which received the proceeds of prepayment penalty payments. In many cases, the P bond was repurchased by the servicer, providing the same prepayment penalty cash flows in certificated form. P bonds were also sold to investors as a hedge against prepayments. However, in transactions with NIMs, the P bond served in combination with the C bond to collateralize the NIM.

EXHIBIT 9.6 Excess Spread for Representative ABS Structures with and without Embedded Swaps

A. Forward LIBOR Unchanged



B. Forward LIBOR +300 Basis Points



NIMs were generally created as a separate securitization, taking the C and P bonds from deals and using them as collateral to back the NIM. (This technique is comparable to the creation of re-REMICs discussed in an earlier chapter.) NIMs were typically fixed rate securities with short average lives that were entitled to substantial amounts of the cash flows from the C and P bonds. Note that in order to structure the NIM with the desired rating (typically triple-B), the rating agencies required the NIMs to be funded up front, that is, through initial OC.

Additional Considerations

A variety of forms of external credit enhancement were often utilized in ABS deals. A common way was for the issuer to obtain an ***insurance wrap*** on one or more tranches from a monoline insurance company, that is, a company that specialized in writing such policies. While wraps have long been used by corporations and municipalities to insure their bonds, they began to be used to insure individual tranches of ABS deals after 2000. The wraps were typically structured to reimburse investors after the other forms of credit enhancement were exhausted. Beginning in 2007, the monolines encountered severe financial difficulties as a result of the mortgage crisis, as claims against bondholder losses were much higher than anticipated.

Mortgage insurance (MI) is different from an insurance wrap in that it insures the underlying loans collateralizing a structure, rather than one or more of a transaction's tranches. In the prime market, loans with loan-to-value (LTV) ratios greater than 80% typically require private mortgage insurance to guarantee the loan principal value in excess of 80%. As an example, if all the loans in a deal had an 85% LTV, mortgage insurance covering 5% of the loan's face value would be required at loan funding. Mortgage insurance was typically not utilized in subprime lending; however, insurance could be purchased on a package of subprime loans as part of the securitization process. A variation on standard MI is called ***deep MI***. In subprime structures utilizing deep MI, the underwriter bought a policy from an mortgage insurance company that would cover the loans to a lower LTV (typically to 60% or below). In a deep MI structure covered to 60%, a fee was paid out of the excess spread to a mortgage insurance provider in exchange for insuring the difference between the LTV of each loan in the structure and the lower LTV ratio.

Due to the incremental protection of the deep MI policy, this type of structure typically required significantly lower subordination levels. However, deal execution was contingent on the cost of the mortgage insurance policy. In periods of perceived increased defaults, when such policies become more expensive, the usage of deep MI became less attractive as a structuring option. Additionally, investors generally preferred credit enhancement based on the built-in support mechanism of the typical senior–sub structure, as opposed to that provided by a mixture of internal credit enhancement and the MI insurer's ability and willingness to pay claims. (This was true even before the financial difficulties encountered by the MI companies in 2007 as a result of the mortgage performance crisis.) For example, the MI provider often denied claims that they perceive are due to fraud, which ultimately required either a workout or litigation between the servicer and MI insurer. Therefore, quantifying the true level of incremental credit protection offered by deep MI is always difficult.

In both the residential and ABS markets, deals are often issued using different pools of collateral, each of which collateralizes a separate group of bonds. With respect to credit enhancement for multiple collateral groups, the deal structure might be based upon one set of subordinates supporting both groups of senior bonds in what is called a *Y-structure*. However, when the collateral groups are materially different, execution may be enhanced if each group is supported by its own subordination and credit enhancement mechanism. A related mechanism is ***cross-collateralization***. Typically, cross-collateralization is structured where excess spread from different collateral groups supports one another under some circumstances. An example would be a deal with two fairly similar collateral groups, 1 and 2. If collateral group 1 steps down before group 2, the excess from group 1 can be used to rebuild the OC of group 2. However, deals usually contain some restrictions on so-called "crossing." Using the previous example, they typically allow OC from group 1 to be replenished, in the event that it has absorbed losses, by the excess spread from group 2. However, excess from one group generally cannot be used to build OC in the other under normal circumstances.

While the primary focus of ABS deal structuring relates to credit enhancement issues, there are some noteworthy aspects to the structuring of these deals' senior tranches. Both fixed and floating rate senior cash flows can be time-tranched. Fixed rate senior tranches can also be structured with NAS bonds, in order to meet investor demand for very stable intermediate assets. As noted in the previous chapter, however, ABS NAS bonds were typically created using different structuring conventions. Typically, the NAS bonds were structured to have first priority on senior cash flows, subject to a lockout percentage that dictates the portion of pro rata cash flows received. A typical lockout schedule might be as follows:

Months 1–36: 0%
Months 37–60: 45%
Months 61–72: 80%
Months 73–84: 100%
Month 85 and thereafter: 300%

The resulting NAS bond was structured such that cash flows are fully locked out for three years. The principal cash flows were scaled up in years four through six, and the bond received its pro rata share of principal in the seventh year after issuance. At the conclusion of the seventh year, the bond receives three times its pro rata share of principal in order to incur rapid amortization and eliminate a long principal "tail." As with any bond subject to a schedule, however, the bond's structure was contingent on the existence of other "support" bonds that can absorb cash flow volatility. For instance, if prepayments were fast enough to pay the non-NAS tranches off very quickly, the lockout schedule could no longer be met.

Finally, ABS structures typically contain cleanup calls. Similar to those in the prime private-label market, the calls eliminate the need for the master servicer to monitor and service large numbers of deals with small unpaid balances. To ensure that the call is exercised, most mortgage ABS deals contain step-up provisions for coupons on the bonds potentially impacted by the call. Senior floating rate bonds typically have their margins double after the call becomes effective, while the margin on floating rate subordinate tranches typically increases by 50%. In fixed rate deals, the coupon of the longest sequential bond normally increases by 50 basis points after the optional redemption date.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Excess Spread
Overcollateralization
Initial OC
Turboing
Basis Risk
Available-Funds Cap
Lesser-of Schedule
Stepdown Date
Net Interest Margin Bond (NIM)
P Bonds
Insurance Wrap
Mortgage Insurance (MI)
Deep MI
Cross-collateralization
Y-Structure

PART Four

Valuation and Analysis

CHAPTER 10

Techniques for Valuing MBS

The fourth and final part of this book is devoted to describing the various methodologies, models, and techniques used to measure and quantify the returns and risks of MBS. This chapter discusses various measures used to gauge potential returns, while Chapter 11 is dedicated to explaining the methods for estimating the interest rate risk of MBS. Chapters 12 and 13 conclude with discussions of the actual processes for evaluating agency and private-label MBS. Because many approaches to measuring the interest rate risk of MBS require the values of a security at different interest rate levels, we begin with the topic of valuation before introducing risk measures. Valuation is also critical in applying other analytical tools such as total return analysis because the value of an MBS at the end of some investment horizon must be estimated.

We begin the current chapter by reviewing static cash flow yield analysis and the limitations of the *nominal spread* that results from this simple form of analysis. We then look at a better spread measure, Z-spread, but point out its limitation as a measure of relative value. The most commonly used and robust methodology used for valuing MBS, Monte Carlo simulation, is then described. A by-product of this model is *option-adjusted spread*. This measure is superior to the nominal spread and the Z-spread because it takes into account how cash flows may change when interest rates change. Put differently, it explicitly values changes in cash flow patterns that result from the homeowners' prepayment option when interest rates change. While the option-adjusted spread is far superior to the two other spread measures, it is based on a series of assumptions and projections that must be understood by an investor. Finally, we analyze *total return*, which we discuss in more detail in Chapter 12.

STATIC CASH FLOW YIELD ANALYSIS

The yield on any financial instrument is the internal interest rate that makes the present value of the expected cash flow equal to its market price plus accrued interest. For MBS, the yield calculated is called a ***cash flow yield***. The problem in calculating the cash flow yield of an MBS is that the security's cash flows are unknown, due to the effects of prepayments. Consequently, to determine a cash flow yield some assumption about the prepayment rate must be made. The assumed prepayment speed may be a constant rate (quoted as a percentage CPR), a percentage of some established ramp (e.g, the PSA model described in Chapter 3), or a prepayment path or vector created by the investor.

The cash flows of an MBS typically occur monthly. The convention is to compare the yield on a mortgage-backed security to that of a Treasury coupon security by first calculating the MBS's ***bond equivalent yield*** (BEY). The BEY for a Treasury coupon security is found by doubling the semiannual yield. However, it is incorrect to do this for an MBS because the investor has the opportunity to generate greater interest by reinvesting the more frequent cash flows. The market practice is to calculate a yield so as to make it comparable to the yield to maturity on a BEY basis. The formula for annualizing the monthly cash flow yield (or the *mortgage yield*) for an MBS is as follows:

$$\text{BEY} = 2\left[\left(1 + i_m / 12\right)^6 - 1\right]$$

where i_M is the mortgage yield, that is, the interest rate that will equate the present value of the projected monthly cash flow equal to the market price (plus accrued interest) of the MBS. As an example, a 6.0% mortgage yield would be converted to a BEY of 6.07%.

All yield measures suffer from problems that limit their use in assessing a security's potential return. The yield to maturity has two major shortcomings as a measure of a bond's potential return. To realize the stated yield to maturity, the investor is assumed to: (1) reinvest the coupon payments at a rate equal to the yield to maturity; and (2) hold the bond to maturity. The reinvestment of the coupon payments is critical, and for long-term bonds can comprise as much as 80% of the bond's return. The risk of having to reinvest the interest payments at less than the computed yield is called ***reinvestment risk***.

These shortcomings are equally applicable to the cash flow yield measure since (1) the projected cash flows are assumed to be reinvested at the cash flow yield and (2) the MBS is assumed to be held until the final payout based on the prepayment assumption utilized. The impact of reinvestment risk (i.e., the risk that the cash flow will have to be reinvested at a rate less than the cash flow yield) is particularly important for many MBS because payments are monthly and both interest and principal must be reinvested. In particular, returns for high-yielding bonds are overstated; the yield to maturity method assumes that the proceeds will be invested in similar bonds that offer the same yield. Moreover, an additional assumption is that the projected cash flow is actually realized. If the prepayment experience is different from the prepayment rate assumed, the cash flow yield will not be realized.

Given the computed cash flow yield and the average life for an MBS based on some prepayment assumption, the next step is to compare the yield to the yield for a comparable Treasury security. “Comparable” is sometimes defined as a Treasury security with the same maturity as the average life of the MBS. Alternatively, it is defined as the interpolated yield of Treasury securities, using the average life of the MBS as the “maturity” for the Treasuries. The difference between the cash flow yield and the yield on a comparable Treasury security is called the ***nominal spread***.

The nominal spread is the most commonly quoted measure of incremental returns. However, this spread masks the fact that a portion of the nominal spread is compensation for accepting prepayment risk. For instance, support tranches in a CMO structure are typically offered at large nominal spreads. However, the nominal spread does not account for the substantial prepayment risk associated with support tranches. Investors who evaluate MBS solely on the basis of nominal spread have no basis to determine whether that nominal spread offers adequate compensation given the substantial prepayment risk faced by the holder of a support tranche. This calculation requires the use of more sophisticated techniques that is described later in this chapter.

Z-SPREAD

The nominal spread has an additional weakness in that it compares the yield on assets with varying patterns of monthly principal and interest cash flows (i.e., MBS) to the yields on a Treasury security (or securities, if the interpolated yield is used) paying semiannual interest with a bullet payment at maturity. A more accurate measure of spread is to compare an MBS to a portfolio of Treasury securities having the same cash flows. This spread is called the ***Z-spread***. While it does not take prepayment risk into account, it does account for the various patterns that principal payments on an MBS or CMO can take at a given prepayment speed.

The Z-spread is a measure of the spread that the investor would realize over the entire Treasury spot rate curve if the mortgage security were held to maturity. It is not a spread off one point on the Treasury yield curve, as is the nominal spread. Rather, it is the spread that makes the present value of the cash flows from the MBS equal to the price of the MBS when discounted at the Treasury spot rate plus the spread. However, it is similar to the nominal spread in that the security’s cash flows are generated using a single prepayment path or vector for the life of the security. An iterative process is used to determine the zero-volatility spread.

In general, the shorter the average life of the MBS, the less the zero-volatility spread will differ from the nominal spread. The magnitude of the difference between the nominal spread and the zero-volatility spread also depends on the shape of the yield curve—that is, the steeper the yield curve, the greater the difference.

VALUATION USING MONTE CARLO SIMULATION AND OAS ANALYSIS

While the Z-spread is a more realistic measure of relative value than the nominal spread measure, it also does not account for the impact of prepayments, and changing prepayment rates, on the value of the MBS. While the borrowers' ability to prepay is an option, it cannot be valued directly using traditional option valuation techniques. Rather, the value of this option, and the value of securities containing this type of embedded option, must be derived using complex alternative methodologies. This section is not intended as an in-depth technical description of the processes. It should rather serve as an introduction to the techniques, allowing the user to understand and interpret the output of the models, as well as the assumptions underlying the methodologies.

In fixed income valuation modeling, there are two methodologies commonly used to value securities with embedded options—the binomial model and the Monte Carlo model. The latter model involves simulating a sufficiently large number of potential interest rate paths in order to assess the value of a security along these different paths. This model is the most flexible of the two valuation methodologies for valuing interest rate sensitive instruments where the history of interest rates is important. MBS are commonly valued using this model. As explained below, a by-product of this valuation model is the OAS.

The binomial model is commonly used to value callable agency debentures and corporate bonds. This valuation model accommodates securities in which the decision to exercise a call option is not dependent on how interest rates evolved over time. That is, the decision of an issuer to call a bond will depend on the level of the rate at which the issue can be refunded relative to the issue's coupon rate, and not the path interest rates took to get to that rate. In contrast, there are fixed income securities and derivative instruments for which the periodic cash flows are interest rate path dependent. This means that the cash flow received in one period is determined not only by the current interest rate level, but also by the path that interest rates took to get to the current level.

In the case of mortgage pass-through securities, prepayments are interest rate path dependent because this month's prepayment rate depends in part on whether there have been prior opportunities to refinance since the underlying mortgages were originated. This phenomenon, referred to as *prepayment burnout*, implies that borrowers who have eschewed previous refinancing opportunities are either unable to refinance, or unaware of such opportunities. In addition to burnout effects, the nature of structured securities such as CMOs gives them an additional form of path dependency. The cash flows to be received by a CMO tranche in any particular month often depend on the outstanding balances of other tranches in the deal, which were reduced (to a greater or lesser extent) by earlier principal payments. Thus, the history of prepayments is an important component to value, making the binomial model inappropriate for valuing MBS.

The valuation of pass-throughs using the Monte Carlo model is conceptually simple. In practice, however, it is very complex. The simulation involves generating a set of cash flows based on simulated future mortgage rates, which in turn required creating prepayment vectors for each interest rate path.

Valuation modeling for agency CMOs is similar to valuation modeling for pass-throughs. However, the difficulties in valuing structured bonds are amplified because the issuer has carved up the collateral cashflows, effectively redistributing both the prepayment and interest rate risk. The sensitivity of the pass-throughs comprising the collateral to these two risks is not transmitted equally to every tranche. Some of the tranches may wind up being more sensitive to prepayment risk and interest rate risk than the collateral, while some of them may be much less sensitive. Using a sophisticated valuation model allows for a fair comparison of bonds with differing degrees of cash flow priority, and facilitates investors' search for bonds with favorable trade-offs between expected returns and risk.

Overview of Monte Carlo Simulation

The valuation of MBS depends on the outcome of many variables. These variables include future interest rates, the shape of the yield curve, projected interest rate volatility, prepayment rates, default rates and their timing, and recovery rates. Suppose that for each of these six variables, there are nine possible values that can be realized by each. Then the value of a mortgage security would depend on the six variables and the nine potential outcomes for each. One way to get a feel for the possible value is to calculate all possible outcomes. There would then be 10,077,696 (6^9) possible values for the mortgage security representing all possible combinations of the six variables.

Furthermore, each of the 10,077,696 values for the mortgage security will not have the same probability of occurrence.

At the other extreme, an investor can take the "best guess" for the value of each variable and determine an estimated value for the mortgage security. The best-guess value of each variable is usually the expected value of the variable. However, there are serious problems with this shortcut approach. To understand the shortcomings, suppose the probability associated with the best guess for each variable is 75%. If the probability distribution for each variable is independently distributed, then the probability of occurrence for the best-guess value for the mortgage security would be only 18% (0.75^6). Consequently, an investor should not place a great deal of confidence in this best-guess estimate of the value of the mortgage security.

Between the extremes of enumerating and evaluating all possible combinations and the best-guess approach is the simulation approach. Simulation is more of a procedure than a model. It provides information about the range of outcomes, or more specifically, an estimated probability distribution of the outcomes. When used to value MBS, it provides a probability distribution for the value of a mortgage security. While the purpose is to describe the entire range of outcomes, only one parameter from the distribution is used in valuing mortgage-backed securities: the mean or average value. It is typically this value that is taken as the value of the mortgage security. While the rest of the information that is available from the probability distribution for the value of the mortgage security is generally ignored, it possesses information that can be useful in gauging the value of a security.

Steps in the Monte Carlo Methodology for Valuing a Mortgage Security

Monte Carlo simulations involve a series of interrelated steps. As noted previously, it is critical to understand the assumptions at each step. Not only do these assumptions having varying degrees of influence on the value of a mortgage security, but they will affect the measures of some of the interest rate risk measures described in the next chapter.

The steps in the methodology:

Step 1: Simulate short-term interest rate and refinancing rate paths.

Step 2: Project the cash flow on each interest rate path.

Step 3: Determine the present value of the cash flows on each interest rate path.

Step 4: Compute the theoretical value of the mortgage security.

We discuss each step next.

Step 1: Simulate Short-Term Interest Rate and Refinancing Rate Paths

An interest rate path is first simulated for interest rates over the life of the mortgage security. If, for example, the mortgage security has a remaining life of 29 years, then interest rates will be simulated for 248 months. The number of months on an interest path will be denoted by *T*. The simulation requires the generation of multiple interest rate paths. The number of paths utilized depends on the model; at this time, assume that there are *N* paths. In the terminology of the Monte Carlo model, each interest rate path is called a "trial." Ultimately, the monthly interest rates are used to discount the projected cash flows that are obtained at Step 3.

The typical model uses the term structure of interest rates, as well as a volatility assumption, to generate a series of random interest rate paths. The term structure of interest rates is the theoretical spot rate (or zero coupon) curve for the market on the pricing date. The simulations should be calibrated so that the average simulated price of a zero-coupon Treasury bond equals today's actual price. Some dealers and vendors of analytical systems use the LIBOR curve instead of the Treasury curve, or give the user a choice of using the LIBOR curve. This choice may be due to either the investor's performance objectives, or the functionality of the investor's prepayment model. Some portfolio managers, for example, are interested in the spreads that they can earn relative to their funding costs, and LIBOR is a better proxy for that than the Treasury curve. (This measure is referenced as a LIBOR OAS or LOAS.) In addition, some prepayment models use LIBOR or swap rates as the refinancing rate, rather than outstanding Treasury rates.

Each model has its own method for projecting the evolution of future interest rates and its own volatility assumptions. Typically, there are few significant differences in the interest rate models of dealer firms and vendors, although their volatility assumptions, and how volatility is incorporated in the model, can differ greatly. The volatility assumption determines the dispersion of future interest rates in the simulation. Today, many vendors do not use one volatility number to generate the yield curve simulations. Instead, they use either a short/long yield volatility or a term structure of yield volatility. A short/long yield volatility means that volatility is specified for maturities up to a certain number of years (short yield volatility) and a different yield volatility for greater maturities (long yield volatility). The short yield volatility is assumed to be greater than the long yield volatility. A term structure of yield volatilities means that a yield volatility is assumed for each maturity.

The random paths of interest rates should be generated from an arbitrage-free model of the future term structure of interest rates, using values obtained from the derivatives markets. 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.

While the short-term interest rate paths are eventually used to discount the mortgage security's cash flows, they are also used to generate the prepayment path or "vector," and thus the cash flows, for each interest rate path. What determines the prepayment vector is the refinancing rate available at each point in time, relative to the note rate of the mortgages in question. The refinancing rate represents the opportunity cost the mortgagor is facing each month. If the refinancing rates are high relative to the mortgagor's original coupon rate (i.e., the rate on the mortgagor's loan), the mortgagor will have less incentive to refinance, or even a positive 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.

An assumption must be made about the relationship between refinancing rates and short-term interest rates. This is an important assumption and how it is handled varies from model to model.

Step 2: Project the Cash Flow on Each Interest Rate Path

The cash flow for any given month on any given interest rate path is equal to the scheduled principal for the mortgage pool, the net interest, and prepayments. Calculation of the scheduled principal is straightforward, based on the projected mortgage balance in the prior month. A prepayment model determines the unscheduled principal (i.e., prepayments) to be assumed for that month. Therefore, the functionality of the prepayment model employed is critical to the valuation process. Note that a prepayment model is used, not a predetermined prepayment rate. One often hears about the valuation of MBS using Monte Carlo simulation based on a constant prepayment rate such as a single PSA speed. This is incorrect. There is a prepayment rate for each month on a given interest rate path and the rate for a given month across all interest rate paths is not necessarily the same. In theory, there can be $T \times N$ prepayment rates.

The process of calculating the cash flow for a given month on an interest rate path begins with calculating the scheduled principal, net interest, and prepayments for the security being analyzed. Analyzing CMOs has an extra layer of complexity, since each deal has its own unique set of payment rules that dictate how cash flows are to be allocated. After the cash flow paths are generated for a deal's collateral, a tranche's cash flows can be determined for each path by subjecting the collateral cash flows to the structure's payment rules. (Note that this requires that the cash flows be run through a separate model in which the individual transaction is "reverse engineered.")

Step 3: Determine the Present Value of the Cash Flows on Each Interest Rate Path

Given the cash flows on an interest rate path, the path's 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 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

$$z_T(n) = \{[1 + f_1(n)][1 + f_2(n)]\ldots[1 + f_T(n)]\}^{1/T} - 1$$

where

$z_T(n)$ = simulated spot rate for month T on path n
$f_j(n)$ = simulated future 1-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. Therefore, the present value of the cash flows for month T on interest rate path n discounted at the simulated spot rate for month T plus some spread is

$$PV[C_T(n)] = \frac{C_T(n)}{[1 + z_T(n) + K]^T}$$

where

$PV[C_T(n)]$ = present value of cash flows 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 flows for each month on path n. That is,

$$PV[\text{Path}(n)] = PV[C_1(n)] + PV[C_2(n)] + \ldots + PV[C_{360}(n)]$$

where $PV[\text{Path}(n)]$ is the present value of interest rate path n.

Step 4: Compute the Theoretical Value of the Mortgage Security

The present value of a given interest rate path can be thought of as the theoretical value of a cash flow if that path was actually realized. The theoretical value of the pass-through can be determined by calculating the average of the theoretical values of all the interest rate paths. That is, the theoretical value is equal to

$$\text{Theoretical value} = \frac{PV[\text{Path}(1)] + PV[\text{Path}(2)] + \ldots + PV[\text{Path}(N)]}{N}$$

where N is the number of interest rate paths.

Distribution of Path Present Values

The Monte Carlo model is a commonly used management science tool in business. It is employed when the outcome of a business decision depends on the outcome of several random variables. The product of the simulation is the average value and the probability distribution of the possible outcomes.

Unfortunately, the use of Monte Carlo simulation to value MBS has been limited to just the reporting of the average value, which is referred to as the theoretical value of the security. This means that the information about the distribution of the path present values is typically ignored. Yet this information is quite valuable.

For example, consider a well-protected PAC bond. The distribution of the present value for the paths should be concentrated around the theoretical value; that is, the standard deviation should be small. In contrast, for a support tranche, the distribution of the present value for the paths could be wide or, equivalently, the standard deviation could be large.

Therefore, information about the distribution of the path present values should be obtained, and used in conjunction with either the bond's theoretical value or its option-adjusted spread.

Exhibit 10.1 shows schematic representations of these processes. The exhibit has no economic accuracy. It is simply an attempt to illustrate how the simulation process works and the interrelationship between the different steps. Exhibit 10.1(D) also shows the distribution of the present values which, as we noted, often contains information useful in valuing and analyzing different securities.

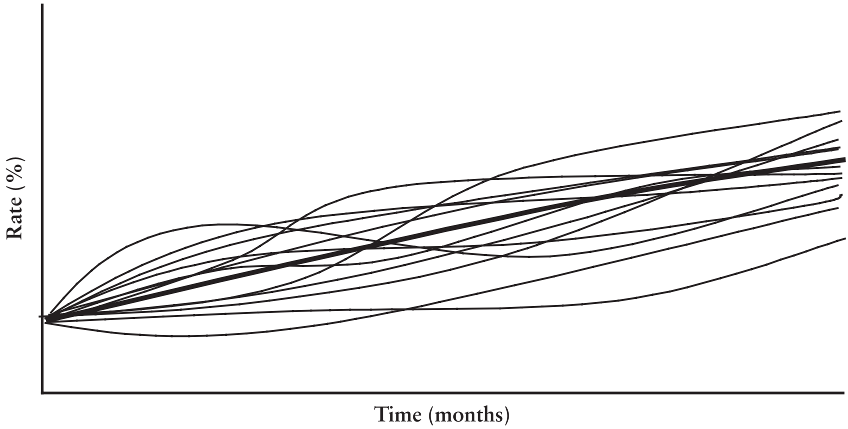
Option-Adjusted Spread

In the Monte Carlo model, the ***option-adjusted spread*** (OAS) is the spread K that, when added to all the spot rates of 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 that will satisfy the following condition:

$$\text{Market price} = \frac{PV[\text{Path}(1)] + PV[\text{Path}(2)] + \ldots + PV[\text{Path}(N)]}{N}$$

where N is the number of interest rate paths.

EXHIBIT 10.1 Schematic of Hypothetical Monte Carlo Process
A. Generation of Rate Paths by Interest Rate Model[a]



[a]The bold line represents the base-case interest rate path.

B. Prepayment Vectors (in SMM) for Each Rate Path from (A) Generated by Prepayment Model

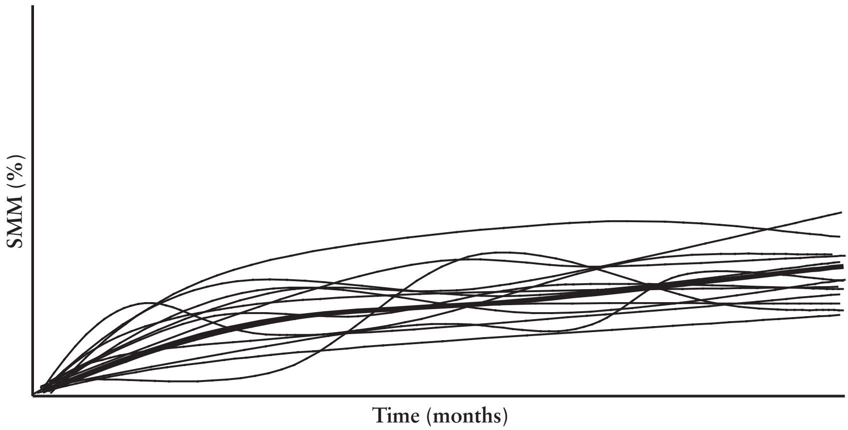
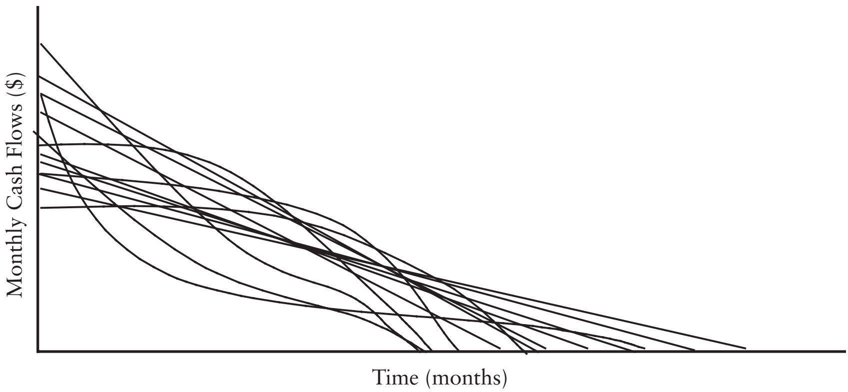
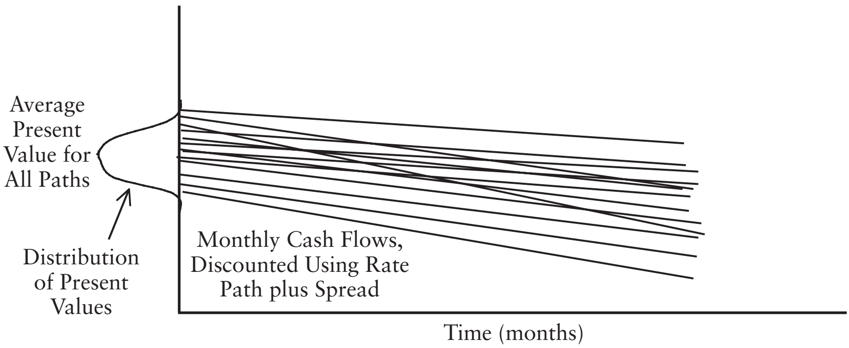


EXHIBIT 10.1 (Continued)
C. Monthly Cash Flows of Security Generated by Cash Flow Calculator and Prepayment Model from (B) for Each Rate Path



D. Discounting Monthly Cash Flows from (C) Using Rate Paths from (A) Plus Spread



The procedure for determining the OAS is straightforward, although time consuming. Basically, the OAS is used to reconcile value with market price. On the left-hand side of the previous equation is the market's statement: the price of an MBS. 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 its value. Calculating the OAS is an iterative process. The value (i.e., the right-hand side of the equation) is calculated and compared to the security's market price. If the value is higher than the market price, the spread is increased; if it is lower, the spread is decreased. The value is then recalculated and compared again to the market price. The process is repeated until the value equals the market price; under this condition, the spread is the security's OAS.

The next question is how the OAS should be interpreted, and how it can be used by investors. What a portfolio manager seeks to do is to buy securities which have value greater than their price. By using a valuation model such as the Monte Carlo model, and the OAS observed for comparable bonds, an investor could estimate the value of a security, which at this point would be sufficient in determining whether to buy a security. Put differently, the OAS of a similar security can be used to generate the bond's theoretical value; the investor can judge richness or cheapness by comparing the theoretical value to the bond's market price. Alternatively, the investor can compare the OAS generated at the market price to that available for either similar securities or an investment benchmark (such as a cost of funds). This allows the investor to judge whether the bond offers value relative to other securities, as well as whether the bond's purchase would help meet investment objectives.

In describing the model above, it is important to understand that the OAS is measuring the average spread over the Treasury forward rate curve, not the Treasury yield curve. It is an average spread since the OAS is found by averaging over the interest rate paths for the possible Treasury spot rate curves. (Of course, if the LIBOR curve is used, the OAS is the spread over that curve.)

This spread measure is superior to both the nominal spread and Z-spread, which give no recognition to the prepayment risk. The OAS is "option adjusted" because the cash flows on the interest rate paths take account of the option of the borrowers to prepay.

Option Cost

The implied cost of the option embedded in an MBS can be obtained by calculating the difference between the OAS at the assumed volatility of interest rates and the ***zero-volatility OAS***. This measure, commonly called *Z-vol OAS*, is calculated in the same fashion as the OAS, except that only the base-case interest rate path is utilized. (The effect is that same as if interest rate volatility is assumed to be zero.) The option cost is therefore calculated as:

$$\text{Option cost} = \text{Zero-volatility OAS} - \text{OAS}$$

The option cost measures the prepayment (or option) risk embedded in the MBS. Note that the cost of the option is a by-product of the option-adjusted spread analysis, not valued explicitly with an option-pricing model. It is sometimes used as a proxy for the annual cost of hedging the bond's optionality. The correct interpretation is the cost, in terms of option-adjusted spread, of volatility. Note that this cost is reduced as volatility declines; in this context, the relationship in the above equation indicates that OAS increases as volatility declines, all other things equal.

Selecting the Number of Interest Rate Paths

An interesting question raised in the prior discussion relates to the question of the number of scenario paths, N, needed to value a mortgage related security. A typical analysis might be for 256 to 1,024 interest rate paths. The scenarios generated using the Monte Carlo model reproduce today's Treasury curve (or whatever the benchmark securities or curve used in the valuation analysis). By employing this technique, one is effectively saying that Treasuries are fairly priced today and that the objective is to determine the returns of the security being evaluated relative to those of the benchmark.

The number of ***interest rate paths*** determines how "good" the estimate is. The more paths, the more average spread tends to settle down. It is a statistical sampling problem.

Most models employ some form of *variance reduction* to cut down on the number of sample paths necessary to get a good statistical sample.[1] A variance reduction technique allows one to obtain price estimates within a tick (i.e., 1/32nd of a point). By this we mean that if the model is used to generate more scenarios, price estimates from the model will not change by more than a tick. So, for example, if 1,024 paths are used to obtain the

[1]The *mean standard errror* (MSE) is a commonly used measure of how good the estimate is from a Monte Carlo simulation model and is defined as

$$\text{MSE} = \sqrt{\frac{\text{Variance of the trial values}}{\text{Number of trials}}}$$

A confidence interval for the estimate of the value sought can be construct using the MSE. The smaller the MSE, the greater the precision of the estimated value. As can be seen from the definition of the MSE, one approach to reducing the MSE to a satisfactory level is to increase the number of trials. However, this approach can be costly. An alternative approach is the variance reduction approach and involves reducing the variance of the trial values. In the Monte Carlo simulation literature, several variance reduction methods have been suggested. For a discussion of two variance reduction methods used in pricing derivative instruments, the antithetic variates method and the control variates method, see John M. Charnes, "Sharper Estimates of Derivative Values," *Financial Engineering News,* no. 26 (June–July 2002): 6–7. For a discussion of other variance reduction methods, see Chapter 11 in Averill M. Law and W. David Kelton, *Simulation Modeling and Analysis*, 3rd ed. (New York: McGraw-Hill, 2000).

estimated price for a tranche, there is little additional information to be had from the 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.)

Several vendor firms have developed computational procedures that reduce the number of paths required but still provide the accuracy of a full Monte Carlo analysis. The procedure is to use statistical techniques to reduce the number of interest rate paths to similar sets of paths. These paths are called ***representative paths***. For example, suppose that 2,000 sample paths are generated. Using a statistical technique known as *principal component analysis*, these 2,000 sample paths can be collapsed to, say, 16 representative paths. The security is then valued on each of these 16 representative paths. The theoretical value of the security is then the weighted average of the 16 representative paths. The weight for a path is the percentage of that representative path relative to the total sample paths.

Mathematically this is expressed as follows:

N = number of sample interest rate paths
J = number of representative paths
W_j = number of sample interest rate paths represented by representative path j divided by the total number of sample interest rate paths
$R\text{Path}(j)$ = representative path j

Then the theoretical value is

$$\text{Theoretical value} = W_1\, PV[R\text{Path}(1)] + W_2\, PV[R\text{Path}(2)] + \ldots + W_J\, PV[R\text{Path}(J)]$$

Pitfalls with the OAS Measure

As a measure of relative value, OAS is clearly superior to the static cash flow yield measures discussed in the first part of this chapter. Despite this, an investor must be aware of the pitfalls of this measure.[2] As the OAS is a product of a Monte Carlo simulation, the modeling risk associated with the simulation will also be present in the OAS. In addition, the Monte Carlo method requires that the interest rate paths be adjusted so that the securities or rates comprising the benchmark curve are valued properly. If the on-the-run Treasury curve is used, for example, the modeled value of each Treasury

[2]These pitfalls have been described and documented in David F. Babbel and Stavros A. Zenios, "Pitfalls in the Analysis of Option-Adjusted Spreads," *Financial Analysts Journal* 48, no. 4 (1992): 65–69.

is equal to its market price or, equivalently, its OAS is zero. The process of adjusting the interest rate paths to achieve that result is itself subject to modeling error. Another pitfall with the OAS methodology is that it assumes a constant OAS for each interest rate path and over time for a given interest rate path. If there is a term structure to the OAS, this is not captured by having a single OAS number.

Arguably the greatest weakness of the Monte Carlo simulation, as well as the OAS values it produces, is its dependence on a prepayment model. Modeling prepayments is a highly complex endeavor in itself; in addition, the behavior of both borrowers and lenders changes over time, which in turn changes how borrowers prepay their loans both with and without refinancing incentives. As we discuss in Chapter 12, utilizing OAS as a valuation tool requires the user to be aware of the potential biases of the prepayment model, as well as the sensitivity of the securities being analyzed to different prepayments in a variety of scenarios.

TOTAL RETURN ANALYSIS

Despite their shortcomings, Monte Carlo simulations and option-adjusted spreads are greatly superior to the earlier methods of projecting return. As with the other measures discussed previously in this chapter, a major drawback is that they also implicitly assume that the securities being analyzed are held to maturity. While some conservative investors operate in this fashion, many investors will invest in securities to be held over finite horizons. In order for them to analyze bonds in a fashion consistent with their investment management style, they must incorporate different analytical techniques. A commonly used technique, called ***total return analysis***, allows the investor to evaluate returns over different horizons and interest rate scenarios. It has the additional advantage of allowing the investor to specify reinvestment returns, which is quite helpful in analyzing securities such as inverse floaters and inverse IOs.

The total return from an MBS is defined by the following parameters:

- The cost of the security at the time of purchase.
- The security's projected cash flows, which include scheduled and unscheduled principal payments, interest, and reinvestment income (interest-on-interest and interest-on-principal).
- The security's projected value at the horizon date.

The total percentage return (i.e., the returns over the time horizon) for a six-month horizon can be calculated as follows:

$$\text{Periodic total return} = \frac{\text{Total horizon proceeds}}{\text{Total cost}} - 1$$

The return can be annualized, in this case, by multiplying them by 2; the generalized calculation is

$$\text{Annualized total return} = [\text{Periodic total return}]^{\frac{12}{\text{Number of months in period}}}$$

assuming that the period in question is less than 12 months.

Exhibit 10.2 shows the total return calculation for a Fannie Mae 6.0% pass-through over a six-month horizon. The total cost of the security is the dollar price plus accrued interest; the proceeds are the interest paid to the investor on the declining monthly balance, the principal paid back to the investor (valued at par), and reinvestment income (at the specified reinvestment rate).

The analyses performed by total return models are typically much more sophisticated than the calculations shown in the exhibit. The models typically allow returns to be generated in multiple interest rate scenarios, assuming parallel and nonparallel interest rate shifts. They will also typically generate scenario returns under variable assumptions, e.g., if implied volatilities were to change.

In addition, the models normally allow for much greater flexibility in generating the inputs than implied by the exhibit. In Exhibit 10.2, for example, the security's horizon price and the projected prepayment speed are simply inputs into the calculations. Total return models typically utilize valuation and prepayment models to generate the horizon prices and prepayment assumptions in both the base case and chosen scenarios. A number of different metrics can be used to calculate the horizon price, and can be divided into either "constant" inputs (i.e., OAS, nominal spread, price, etc.) or "user-generated" measures. As an example, variable spreads could be used to generate returns under different rate scenarios. Historical data could be used to calculate spreads for a security at different interest rate levels; these spreads could be used to generate horizon prices and returns for various rate scenarios.

For MBS, a number of other factors are important to the return calculations. As mentioned, reinvestment assumptions can have a major impact on returns for certain types of securities. In addition, the path-dependency of mortgages and MBS cash flows suggests that changes in the timing of rate shifts will impact total returns under varying rate scenarios. Most models allow the user to specify whether the rate shift should occur immediately, at the horizon, or gradually over the horizon. The latter is typically more realistic than an instantaneous shift; however, it is more difficult to specify

EXHIBIT 10.2 Example of Total Return Calculation for 30-year Fannie 6.0s Held Over Six-Month Horizon

	Assumptions	
	Current balance invested at settlement	10,000,000
	Initial price	100 10/32
	Horizon price	100 20/32
	Reinvestment rate (%)	5.00%
	Prepayment speed	20% CPR
	Settlement date at purchase	10/12/06
	Settlement date at horizon	4/12/07
	Original cost	
	Face value × Price	10,031,250
	Accrued interest	18,333
(1)	Total cost	10,049,583
	Interim cash flows	
	Principal received (par value)	1,104,904
	Interest received from security	285,879
	Reinvestment income	12,239
(2)	Total interim cash flows	1,403,022
	Value at horizon	
	Remaining principal	8,895,096
	Dollar value of remaining principal	8,950,690
	Accrued interest	16,308
(3)	Total value at horizon	8,966,998
(4)	Interim cash flows + Horizon value (lines 2 and 3)	10,370,020
(5)	Periodic return (line 4/line 1)	3.189%
	Annualized total return (line 5 × 2)	6.377%

the terms of the shifts, so that the analysis can be replicated over time for other securities. Finally, total return models also typically calculate other return metrics, such as cash profit and loss (P&L), return on equity (ROE), and financing-adjusted returns.

While the additional flexibility of total return analysis is a key attribute of the methodology, it is also a disadvantage because these models are highly dependent on inputs such as the horizon price. The need to project prices at the horizon (in addition to prepayment speeds) adds an additional element of uncertainty to the analysis. Another drawback is that the models typically do not incorporate dynamic rates scenarios in the analysis. As we will subsequently discuss, many types of structured securities have attributes that can only be assessed under variable interest rate conditions, where rates undergo multiple changes or "whipsaw" scenarios.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Cash Flow Yield
Bond Equivalent (mortgage) Yield (BEY)
Reinvestment Risk
Nominal Spread
Z-Spread
Monte Carlo Simulation
Option-Adjusted Spread (OAS)
Zero-Volatility (Z-Vol) OAS
Interest Rate Paths
Representative Paths
Total Return Analysis

CHAPTER 11

Measuring MBS Interest Rate Risk

With the exception of cash equivalents, all fixed income investors are exposed to ***interest rate risk***. Interest rate risk is defined as the risk of principal losses due to changes in the level of interest rates. This exposure is more difficult to measure for MBS than other securities, however, because of the additional risk associated with predicting and measuring prepayment speeds in different interest rate regimes. The two measures of interest rate risk most commonly used by managers are *duration* and *convexity*. Duration is a first approximation as to how the value of an individual security or the value of a portfolio will change as interest rates change. Convexity attempts to measure the change in the value of a security or portfolio that is not explained by duration; it is a second approximation of the relationship between a bond's price and the level of interest rates.

This chapter discusses some of the ways the interest rate risks associated with MBS are measured. The above-mentioned difficulties in measuring risk manifest themselves in a variety of techniques used to calculate duration, as well as additional measures used to gauge the different risks that impact MBS pricing. The chapter also addresses the exposure of MBS to changes in the configuration of the yield curve, as well as other factors that impact the value of a security or portfolio

DURATION

The risk measure most commonly utilized by fixed income traders and investors is ***duration***. In its basic form, duration calculated in any fashion estimates the percentage change in the price of a fixed income security, given a 100 basis point change in the yield curve. Basic duration measures make the following assumptions:

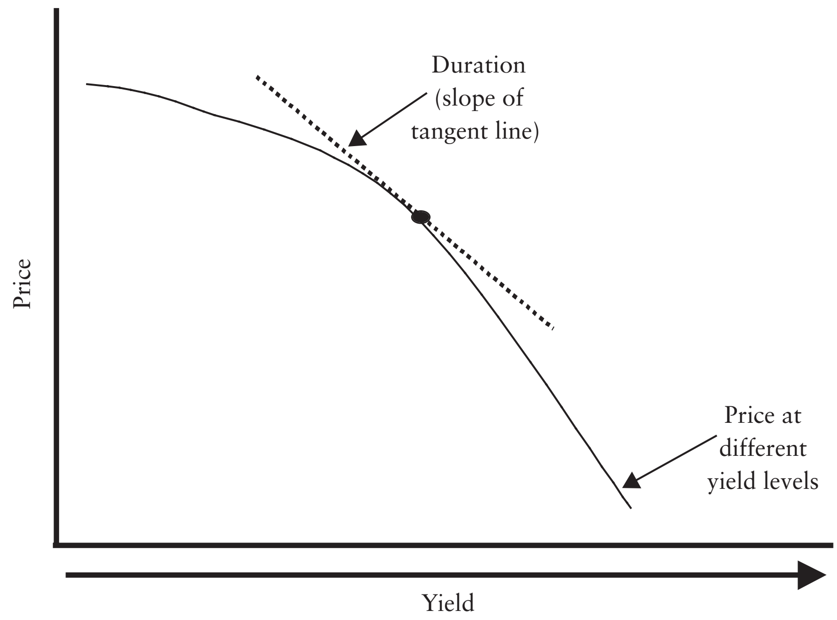
- The spread of the security relative to its pricing benchmarks remains unchanged.

- The yield curve shifts in a parallel fashion.
- The spread of current coupon mortgages to Treasuries remains unchanged.
- The level of volatility remains constant.

(In some instances, duration is defined by a change in the security's yield, rather than in the interest rate environment. However, the constant-spread assumption means that these definitions are identical.)

Exhibit 11.1 shows an interpretation of duration in an economic context. Duration measures the rate of change in a bond's price, given a change in yield. As such, it is a first-order rate of change (akin to speed when measuring movement), and can therefore be conceptualized as the first derivative of the bond's price–yield function, if such a function existed in reality. As illustrated in the exhibit, it can be graphically represented as the slope of the tangent line at a single point in a line representing the bond's price–yield function. (If the bond's profile were linear, duration would be the line's slope; in actuality, the price–yield function for virtually all bonds, even those with no embedded options, has some degree of curvature.)

EXHIBIT 11.1 Illustration of Duration as Risk Measure



As noted above, duration is defined as the percentage change in a security's price, given a change in yield. However, the dollar price change will not be the same for two bonds with the same duration, if their prices are different. For example, consider two bonds, W and X. Suppose that both bonds have a duration of 5, but that W is trading at par while X is trading at 90. A 100 basis point change in yield for both bonds will change their prices by approximately 5%. This means a price change of 5 points (5% times \$100) for W and a price change of 4.5 points (5% times \$90) for X. The dollar price change of a bond can be measured by multiplying its duration by the full dollar price and the rate change in basis points (in decimal form). The price sensitivity of a bond is often called its ***dollar duration***, and is calculated as follows:

$$\text{Dollar duration} = \text{Duration} \times \left(\frac{\text{Dollar price}}{100} \right)$$

Analytical systems will often calculate dollar duration directly, using various terms for the measure. A metric called the *DV01* is a short-hand term for the ***dollar value of a basis point***. This is different from dollar duration in that it indicates the dollar value of one basis point, rather than 100 basis points; as such, it is typically a very small number. Another term often used for dollar duration is *DP/DY*, a term that comes from calculus, defined as delta *P* given a delta *Y*. Because this represents the price change for a 100 basis point change in yield, it is more directly comparable to duration than the DV01 term.

Calculating Duration—Macaulay and Modified Duration

There are several general approaches to calculating duration. One popular approach is to calculate duration from the security's cash flows. This metric is called ***modified duration***, which adjusts ***Macaulay duration***, a metric formulated in 1938 by Frederick Macaulay.[1] The Macaulay duration is specified as follows:

$$\text{Macaulay duration} = \left[\frac{1\text{PVCF}_1 + 2\text{PVCF}_2 + 3\text{PVCF}_3 + \ldots + n\text{PVCF}_n}{k \times \text{Price}} \right] \quad (11.1)$$

where

k = number of periods, or payments, per year (e.g., $k = 2$ for semiannual pay bonds and $k = 12$ for monthly pay bonds)

[1]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 Economic Research, 1938.)

n = number of periods until maturity (i.e., number of years to maturity times k)

$PVCF_t$ = present value of the cash flow in period t discounted at the yield to maturity

The "modification" in modified duration adjusts for the frequency of payment, and is made as follows:

$$\text{Modified duration} = \frac{\text{Macaulay duration}}{(1 + \text{Yield} / k)} \tag{11.2}$$

To accommodate the unique nature of MBS, the cash flows used to calculate modified duration are generated using a static prepayment speed or vector. (As a result, MBS investors sometimes refer to this measure as the *cash flow duration*.) Typically, yield matrices (a method of viewing MBS attributes discussed in Chapter 12) show a bond's modified duration, as well as the yield and weighted average life, for a number of prepayment speeds.

As defined above, the change in the price of a bond when yields change is solely due to discounting the bond's cash flows at the new yield. The measure thus implicitly assumes that the bond's cash flows are constant. This makes sense for option-free bonds such as noncallable Treasury securities, as the payments made by the U.S. Treasury to holders of its obligations do not change when the yield curve changes. However, the same cannot be said for MBS. For these securities, a change in yield will alter the expected cash flows because it will change expected prepayments speeds. This makes the calculation of duration at a static prepayment assumption unrealistic, and the modified duration a flawed (or at least an incomplete) measure for estimating the interest rate risk of an MBS.

Effective Duration

A more realistic method to measure a mortgage-backed security's price sensitivity is to change interest rates by a small amount and estimate how its price will change. This measure is generally called ***effective duration***. The projected price changes can be calculated by a variety of methods. When an option-adjusted spread model is used to estimate the price changes, the metric is known as ***option-adjusted duration*** (OAD). Note that for a noncallable bond such as a U.S. Treasury, the estimates for modified and effective duration are equivalent. Effective duration is greatly superior for measuring the riskiness of MBS and securities with embedded options, however, since it accounts for changes in the cash flows of the bond in question due to rate changes.

Effective duration is calculated as follows:

$$\text{Effective duration} = \left[\frac{V_- - V_+}{\Delta y \times \left(\frac{V_0}{100} \right) \times 2} \right] \times 100 \qquad (11.3)$$

where

Δy = change in interest rates
V_0 = initial security price
V_- = the estimated value of the security if rates are decreased by Δy
V_+ = the estimated value of the security if rates are increased by Δy[2]

The change in yield referred to above is the same change for all points in the yield curve. Put differently, the methodology is based on parallel shifts in the yield curve. (Metrics for determining a bond's price volatility when the yield curve undergoes nonparallel shifts will be addressed later in this chapter.) The 2 appears in the denominator in order to compute the average percentage price change resulting from an increase *and* decrease in yields.

To illustrate the above formula, assume a bond priced at par where its price is projected to rise to 100-24 if rates decline by 25 basis points, and the price declines to 99-00 if rates increase by the same amount. The effective duration is calculated as follows:

$$\text{Effective duration} = \left[\frac{100.75 - 99}{25 \times 1.00 \times 2} \right] \times 100 = 3.5$$

Option-Adjusted Duration

As mentioned, OAD is a subset of effective duration, although the terms are sometimes used interchangeably. A critical issue that arises in calculating effective duration is how to generate projected prices in the different rate scenarios. Option-adjusted spread models are the most commonly used methodology for generating the estimated values of V_- and V_+. The process for calculating OAD is as follows:

Step 1: Calculate the bond's OAS at its current market price, as described in Chapter 10.

[2]Since V_- and V_+ are present values, the calculation of effective duration (as well as convexity discussed later in this chapter) takes accrued interest into account.

Step 2: Shift the entire set of interest rate paths (i.e., the "rate tree") up and down by the same number of basis points (i.e., Δy in the the effective duration calculation).
Step 3: Generate cash flows for the interest rate paths in each tree.
Step 4: Calculate V_- and V_+ by discounting the cash flows to the new trees, using the OAS calculated in step 1.
Step 5: Calculate the effective duration, as described in the previous subsection.

A key choice to be made with the models relates to the size of the rate shift. A shift that is too large may not provide much useful information; a shift that is too small will not generate a significant change in the prepayment model and thus will not materially change the bond's cash flows. Most models default to a 25 basis point shift of the yield curve in each direction.

Empirical Duration

Durations can also be calculated from market data. The most widely used of these measures, calculated using historical price and yield data, is *empirical duration*. Empirical duration is the sensitivity of a MBS to changes in Treasury or swap yields estimated empirically from historical prices and yields. Once the benchmark yield (e.g., the 10-year Treasury) is chosen and a series of daily prices and yields are assembled, regression analysis is used to estimate the relationship between the price of the MBS and the yield of the benchmark. The regression coefficients are calculated using the following form:

$$\Delta\%\,\text{MBS price} = a + b(\Delta\text{Benchmark yield})$$

The empirical duration is then represented by the *b* coefficient. Note that *b* calculated in this way for almost all bonds will have a negative sign; in order to maintain consistency with other measures, the inverse of *b* is typically quoted.

For 30-year MBS pass-throughs, empirical durations using 10-year Treasuries and swaps are most commonly used, although calculations versus other sectors of the curve are also useful.

There are advantages and disadvantages to the empirical duration methodology. The advantages are:

- The duration estimate does not rely on any theoretical formulas or analytical assumptions.
- The estimation of the required parameters is fairly easy to compute using regression analysis.

- The only inputs that are needed are reliable time series for MBS prices and Treasury yields.

However, there are significant disadvantages to the empirical duration metric that limits its usefulness. Empirical duration is, by definition, a backward-looking measure. The metric shows how mortgages have behaved vis-à-vis the benchmark in the past, but is not as reliable as a forward-looking measure. This is particularly the case during periods when the price history may lag current conditions such as during a period of sudden interest rate volatility. In addition, the question arises with respect to how long a data series should be used. A longer time series (utilizing, for example, data from the last 120 trading sessions) typically gives the most robust and stable output. However, because the technique equally weights relatively old and recent observations, the resulting sensitivity could be very different than may be expected under more current conditions. A short data series, on the other hand (using, for example, 20 days of data) will account for current market conditions and behavior, but will provide volatile and relatively unreliable durations.

The most serious shortcoming of the empirical duration measure is its lack of applicability across all products. Since the availability of a reliable price series is an essential element of the methodology, it is not typically useful for calculating durations of structured products, where robust and reliable time series of prices do not exist. (While it is possible to track the pricing of 10-year PACs, for example, the illiquidity of the sector relative to pass-throughs, as well as differences across various securities, makes such a data series of questionable value.) The ability to make reliable comparisons of risk across products is therefore limited.

Hedge Ratios and Treasury Equivalents

A simple and convenient tool used by traders and investors to quote durations is through a ***hedge ratio***. The hedge ratio is simply the ratio of the dollar duration of the MBS in question to that of a convenient benchmark. Hedge ratios are normally quoted versus Treasury securities (typically using 5- and 10-year Treasury notes). They allow the trader to quickly calculate how they will hedge the purchase or sale of a security. For example, if Fannie 6.0s have a hedge ratio of 0.5 versus 10-year Treasuries, a purchase of \$100 million Fannie 6.0s would be hedged with a sale of \$50 million 10-year Treasuries.

Another simple quotation device used is ***Treasury equivalents***. It uses the hedge ratio of an MBS to quickly calculate how many Treasuries must be bought or sold to quickly neutralize (or “flatten”) the position after a trade.

For example, 10-year equivalents would be calculated, using the hedge ratio of the MBS versus 10-year Treasuries, as follows:

$$10 - \text{Year equivalents} = \text{Hedge ratio} \times \text{MBS position}$$

In the above example, since the hedge ratio of Fannie 6.0s to the 10-year Treasury is 0.5, every $10 million purchase of Fannie 6.0s must be hedged with a $5 million sale of 10-year Treasuries, and vice versa.

These measures are convenient devices for quickly executing trades, and quoting the amount of securities necessary to hedge those trades. The measures, however, are only as accurate as the duration being used to generate the quoted value.

CONVEXITY

As discussed, duration is a first approximation of the expected price change for a small change in yield. As the yield changes grow large, the estimation error grows larger; this is particularly true for MBS, where the prepayment option introduces significant curvature into the bond's price–yield function. ***Convexity*** is a second approximation of the expected price change. It is a parameter which can be used in conjunction with duration to estimate the expected change in a bond's price, given a change in market yields. It also represents how much the bond's duration is expected to change, given changes in yields. An illustration of convexity is shown in Exhibit 11.2. The exhibit highlights the change in the slope of the tangent lines at different points in the bond's price–yield relationship.

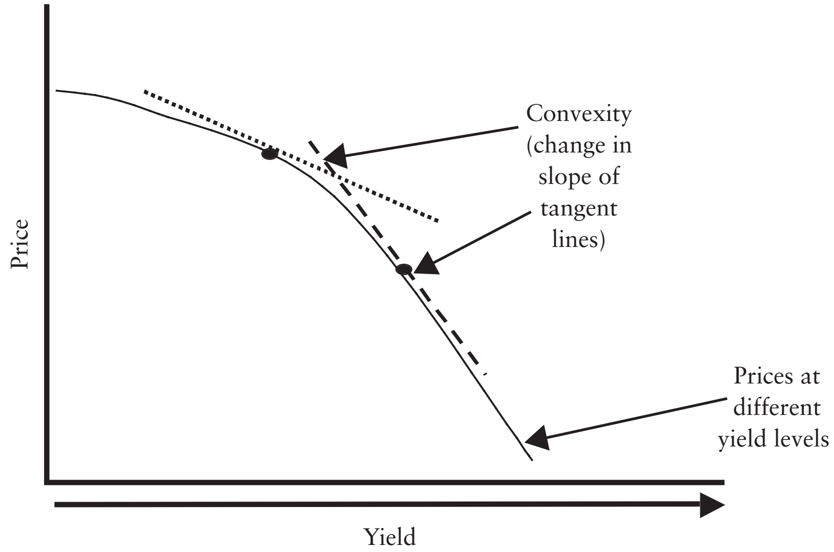
Duration can be viewed as the equivalent of speed, that is, the rate of change, such as feet per second. Thus, using the previous example from physical science, convexity is the equivalent of acceleration. It measures the rate of change of the rate of change such as, in feet per second per second.

Convexity is measured in a fashion similar to the effective duration calculation. (There is no meaningful convexity calculation that can be generated from a bond's modified duration.) Using the term V_0 to indicate the security's current value, convexity is calculated as follows:

$$\text{Convexity} = \frac{(V_- + V_+) - 2V_0}{V_0 \times \left(\frac{\Delta y}{1{,}000}\right)^2} \tag{11.4}$$

where Δy is, as before, the change in yield in basis points. To illustrate the calculation, we return to the earlier example of a bond with a base-case

EXHIBIT 11.2 Illustration of Convexity as Risk Measure



price of par, and prices when rates fell and rose by 25 basis points of 100-24 and 99, respectively. Recall that the bond had a duration of 3.5. The convexity of a bond with this profile is calculated as follows:

$$\text{Convexity} = \frac{(100.75 + 99) - (2 \times 100)}{100 \times \left(\dfrac{25}{1{,}000}\right)^2} = \frac{199.75 - 200}{0.0625} = -4$$

It is possible to approximate the convexity price adjustment (i.e., the percentage price change due to convexity) as follows:

$$\text{Convexity price adjustment} = \text{Convexity} \times (\Delta y)2 \times 100$$

where Δy is the change in yield in percentage terms (i.e., 100 basis points is quoted as 0.01). Using the previous example, the convexity adjustment for a 100-basis-point change in the bond's yield can be estimated as follows:

$$\text{Convexity price adjustment} = -4 \times (0.01)^2 \times 100 = -0.04\%$$

The approximate price change attributable to *both* duration and convexity can be found by simply adding the two estimates. In the above example, the price change approximated from the duration of 3.5% and the convexity adjustment of –0.04% are added to give the total estimated price change, for a 100 basis point move in yields, of 3.46%.

Note that when a bond's convexity is negative, the bond's gain in a rally scenario is less than its loss when rates rise. (The opposite, of course, is true for bonds with positive convexity.) This can be demonstrated through an exaggerated example. Imagine a security with a duration of 4 and a convexity of –30. The convexity adjustment for a 200 basis point change in rates would be estimated as follows:

$$\text{Convexity price adjustment} = -30 \times (0.02)^2 \times 100 = -1.2\%$$

The approximate price change for a rate increase of 200 basis points would be:

Estimated price change due to duration	= –8.0%
Convexity adjustment	= –1.2%
Total estimated price change	= –9.2%

For a rate decrease of 200 basis points, the estimate price change would be:

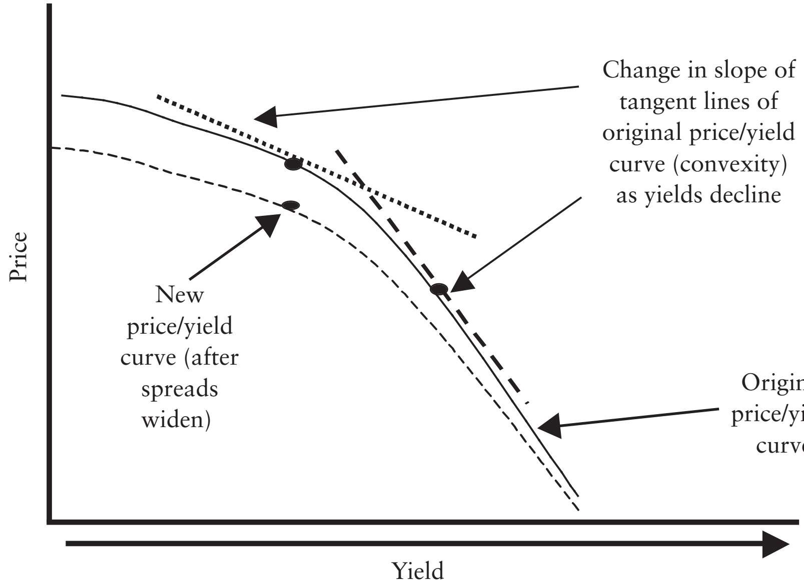
Estimated price change due to duration	= +8.0%
Convexity adjustment	= –1.2%
Total estimated price change	= +6.8%

The gain in the rally scenario of 6.8% is less than the loss of 9.2% if rates rise. This phenomenon is attributable to the fact that the sign of the convexity adjustment is unchanged if rates either rise or decline because of the squared term; the sign of the price change attributable to duration, however, is different depending on the direction of the rate change.

However, the most common use of convexity is as a comparative measure. If two bonds with similar durations and spreads have significantly different convexity measures, the bond with the "better" (i.e., less negative) convexity is considered to offer better value, all other factors constant. Using the duration and convexity numbers generated by the different models to gauge relative value will be discussed in Chapter 12.

One common mistake in the MBS market is to confuse the effects of convexity and spread widening. For example, it is common to hear about a bond's *price compression,* which is the "stickiness" in a bond's price at a certain point above par value, being attributable to its "negative convexity." Rather than being a function of convexity, this represents spread widening; spreads typically widen when prices reach a certain price level because fewer investors will purchase bonds at prices substantially over

EXHIBIT 11.3 Illustration of Price Effects: Convexity versus Spread Widening



par. Spreads also widen to compensate investors for accepting increased model risk, that is, the possibility that valuation models may underestimate prepayment speeds.

This phenomenon is illustrated in Exhibit 11.3. The exhibit contrasts two situations associated with price changes of a hypothetical bond due to declining yields. In one case, the bond's price is moving along the original price–yield curve; the change in the bond's price can be approximated using duration and convexity. The other scenario occurs when the price–yield curve shifts, due to changes in the bond's spread. This type of exogenous change is the result of a shift in the price–yield curve, and cannot be estimated using standard duration and convexity measures.

YIELD CURVE RISK

As discussed previously, duration and convexity are measures of what is called *level risk* if the yield curve shifts in a parallel fashion. That is, if all Treasury rates shifted up or down by the same number of basis points, these measures do a good job of approximating the exposure of a security or portfolio to a change in the level of rates. However, yield curves cannot be expected to change in a parallel fashion. Consequently, two MBS portfolios with the same duration can perform quite differently when the yield curve shifts in a nonparallel fashion.

Several approaches have been suggested for measuring the exposure to a shift in the yield curve. A popular approach for measuring yield curve risk is to change the yield for a particular sector of the yield curve and determine the sensitivity of an MBS or portfolio to this change, holding all other yields constant. The sensitivity of the change in value to a particular change in the yield is called ***rate duration***. There is a rate duration associated with every point on the yield curve. Consequently, every bond has a profile of rate durations representing each maturity on the yield curve.

The most commonly used approach, first proposed by Thomas Ho,[3] focuses on a series of key maturities on the spot rate curve. The durations for each maturity "bucket" are called ***key rate durations***. The specific maturities on the spot rate curve for which key rate durations are measured can vary, but typical maturity buckets used are 6 and 12 months, and 2 through 30 years. The spot rate in each bucket is changed by a predetermined amount, holding the rest of the spot rate curve constant, and the percentage price change for the security is calculated for each bucket. (Changes in spot rates between any two key rates are calculated using interpolation.)

As we discuss in Chapter 12, key rate durations (or *partial durations*, as they are sometimes called) offer a useful way to observe how a bond or portfolio can be expected to perform under nonparallel yield curve shifts. It must be considered, however, that since key rate durations are a form of effective duration (in that they are calculated from projected price changes, given changes in yields), they will be subject to the same biases and weaknesses. For example, a key driver of these calculations is the prepayment model utilized. Depending on how the functionality of the model is specified, different models may generate inconsistent values.

OTHER RISK MEASURES

In addition to the duration and convexity measures discussed in this chapter, there are other measures that aid in assessing the relative riskiness of different securities, as well as how they will impact the duration of portfolios into which they may be included. In calculating the different measures, the parameter in question is shifted, holding the remaining factors constant. This allows for the measurement of risks external to effective duration and convexity.

Commonly used measures include prepayment duration, volatility duration, and spread duration.

[3]Thomas S.Y. Ho, "Key Rate Durations: Measures of Interest Rate Risks," *Journal of Fixed Income* 2, no. 2 (1992): 29–44.

Prepayment Duration

Prepayment duration is a metric that measures how much the bond's price can be expected to change given a change in the multiple of the prepayment model. An example would be to generate values at 80% and 120% of the prepayment model. This measure helps in assessing the exposure of a bond to changes in overall prepayment speeds. Its weakness, however, is that by taking a multiple of the model, it does not account for changes in the prepayment model's functionality. As an example, the market may expect slower turnover during periods of housing market weakness, even as the refinancing propensity may be heightened. A simple multiple of the prepayment model cannot accurately account for this difference.

Prepayment duration is typically quoted as the inverse of the price change resulting from an increase in the prepayment model; a value of 1.0, for example, indicates that the bond's price will decline by 1%.

Volatility Duration

Volatility duration is a measure that estimates how much the bond's price can be expected to change given a change in the level of volatility. The issue of scale arises with volatility duration, as with returns generated using different volatility assumptions (discussed in Chapter 12) in that there are a number of ways to quote volatility. For example, a 10% change in percentage or Black volatility can mean either a 10% change in the level of volatility, or a change of 1,000 basis points in volatility. It is clearly important to specify the changes correctly and consistently.

Spread Duration

Spread duration measures how sensitive a security's expected price is to changes in the bond's spread, typically its OAS. Spread duration is different from effective duration in that the incremental change in the bond's yield associated with the spread change does not impact the prepayment model. Thus, the impact of changes in spread can be isolated from the overall change in the bond's yield. This is useful for assessing the riskiness of bonds that are highly sensitive to small changes in projected prepayment speeds.

Spread duration is especially useful for measuring the risk associated with IOs. Because of their unique structure, these bonds typically have negative durations, i.e., their prices increase as interest rates *rise*. This is because rising rates are associated with slower prepayment speeds, which increase the amount of cash flowing to the IO. However, wider spreads would lower the price of the IO, all things equal. Therefore, some of the risks associated with IOs cannot be fully gauged without using spread duration.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Interest Rate Risk
Duration
Dollar Duration
Dollar Value of a Basis Point
Modified Duration
Effective Duration
Option-Adjusted Duration
Hedge Ratio
Treasury Equivalents
Convexity
Yield Curve Risk
Rate Duration
Key Rate Durations
Prepayment Duration
Volatility Duration
Spread Duration

CHAPTER 12

Evaluating Senior MBS and CMOs

The process of evaluating and analyzing agency MBS is unique, particularly for structured securities. Because of the external backing provided by the government (either explicit or implicit), investors assume that principal will be returned with 100% certainty. The driver of performance of these securities is thus not *if*, but *when* principal is paid to the bondholder. While sophisticated techniques such as Monte Carlo simulation and total return analysis (described in Chapter 10) are quite useful, they are best utilized as tools comprising one component of extensive comparative analysis. Simple and straightforward tools, such as yield matrices and vector analysis, are also quite useful in understanding the fundamental attributes of different securities, as well as making comparisons between securities and across sectors. While such techniques are "quantitative" in the sense that they generate a series of numbers, it is more productive to view them as qualitative devices for evaluating tranches and contrasting different securities. A thorough analysis of agency MBS (in the form of both passthroughs and CMO tranches) utilizes both qualitative and quantitative techniques to understand, value, and compare different securities.

In this chapter, we discuss techniques and metrics that investors and traders commonly utilize to evaluate agency MBS. We demonstrate how basic tools, such as yield tables and prepayment vectors, can be used in conjunction with the results obtained from higher-level analytical models to make relative value judgments. It will also discuss how the assumptions associated with metrics such as option-adjusted spreads (OAS) and total rate of return (TR) discussed in Chapter 10 should be considered when attempting to use model outputs in a framework of analysis. As opposed to an all-encompassing list of MBS analysis techniques, this chapter should serve as a framework for how investors can evaluate agency MBS using techniques and models of varying degrees of sophistication.

In the past, investors have treated the senior tranches of private-label transactions as virtually the equivalent of agency-backed MBS from the perspective of credit quality. One of the changes in investor outlook stemming from the mortgage crisis was the decline in confidence in the rating agencies' ability to both gauge future losses for private-label securities and assign proper credit support levels. A significant manifestation of this change is that *all* securities that do not carry agency backing must be evaluated as credit-sensitive tranches; even triple-A senior and super-senior tranches can no longer be automatically assumed to be "money-good." We discuss techniques for this type of evaluation in Chapter 13.

YIELD AND SPREAD MATRICES

The most basic analysis used in evaluating structured MBS is the ***yield matrix*** and ***yield table***. While limited in its scope and flexibility, it is quite useful in allowing traders and investors to observe the basic attributes of the security in question, as well as measure and quote its spread over market benchmarks. In the context of MBS analysis, a yield matrix is a format that allows the user to observe changes in average lives, durations, and yields under different prepayment scenarios, offering a simple but robust means of evaluating securities.

While there are many variations on yield matrices, they all typically designed to show the attributes and parameters of MBS under different prepayment assumptions. The tables are commonly constructed to show a range of prepayment assumptions on the horizontal axis. Prepayment speeds can be quoted using a variety of conventions (i.e., as CPRs, PSAs, or PPCs) as well as user-defined prepayment vectors discussed in Chapter 4. (In this context, a prepayment vector is a series of monthly CPRs that encompass a single prepayment scenario that unfolds over time. We discuss vectors in more depth later in this chapter.) The vertical axis can show a number of different parameters, including prices (giving a ***yield-to-price table*** or, in some cases, *spread-to-price tables*), yields (creating a ***price-to-yield matrix***), and index levels. The table also typically shows the bonds' average lives, modified durations, spreads over various benchmarks, and principal payment "windows" under the different prepayment scenarios. An example of a ***yield-to-price table*** for a sequential CMO, run at prices around par value, is shown in Exhibit 12.1.

For the user's convenience, yield matrices also typically show the bond's basic parameters. For example, Bloomberg tables show the following data on structured bonds:

- Deal and tranche name.
- CUSIP number.
- The bond's coupon rate and maturity date.

EXHIBIT 12.1 Yield-to-Price Table for a Hypothetical Sequential Agency CMO

		PSA							
		115	**125**	**145**	**175**	**225**	**450**	**850**	**1250**
	99 28/32	5.54	5.54	5.54	5.53	5.53	5.51	5.49	5.47
	99 28/32	5.51	5.50	5.50	5.49	5.48	5.44	5.39	5.34
	100	5.47	5.47	5.46	5.45	5.43	5.37	5.28	5.22
	100 4/32	5.44	5.43	5.42	5.40	5.38	5.29	5.18	5.09
	100 8/32	5.40	5.40	5.38	5.36	5.33	5.22	5.08	4.96
	Avg. life	4.3	4.1	3.7	3.3	2.8	1.8	1.3	1.0
	Mod. dur.	3.6	3.5	3.2	2.9	2.5	1.7	1.2	1.0
	Sprd/Tsys	70	69	67	65	62	47	28	17
Principal	First pay	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Window	Last pay	8.42	8.04	7.17	6.08	5.17	3.17	2.08	1.67

- The tranche type.
- Information on the deal's collateral (including issuer, coupon, WAC, WAM, and WALA).
- The bond's effective PAC band (in the case of a PAC).
- Recent historical prepayment speeds.

In the agency CMO market, yield tables are often constructed using Bloomberg's median PSAs.[1] Since most market participants utilize these speeds, the market treats them as a consensus estimate for prepayment speeds both in the current rate regime as well as parallel-shift rate scenarios. (In fact, a Bloomberg user's default settings can be set to call up the median speeds.)

However, the use of Bloomberg medians as prepayment consensus speeds, as is typically done in the agency CMO market, arguably obscures the prepayment performance of a bond based on its actual collateral attributes. Interestingly, this runs contrary to the practice of using loan- and borrower-level attributes to better estimate prepayment performance. This is why intelligent use of yield tables requires more than rote usage of consensus speeds and market spreads. A well-constructed yield table gives the user a good snapshot of a bond's profile at that point in time, and facilitates an analysis of the bond's attributes. In this context, we compare different bonds that have similar average lives in the base case in order to illustrate how yield tables can best be utilized.

Aside from the yields and spreads themselves, the most important and commonly used attributes in a yield matrix are the subject bond's average lives and duration at different prepayment speeds. These metrics give the investor a sense of the bond's "profile," which in turn will influence its performance under different interest rate and prepayment scenarios. A bond's profile serves as an indicator of both its riskiness and the costs associated with hedging it. Greater average life and duration variability is typically associated with wider spreads, as investors collectively demand greater expected returns to compensate for the incremental increases in risk.

The timing of a bond's principal payments—its ***principal window***—is also an important attribute. Quoted as either elapsed time or actual dates, a bond's principal window indicates when the bond's principal cash flows begin and end under different prepayment scenarios. (Note that the principal window in all matrices shown in this chapter are quoted as time, in years, after settlement.) The window can have a significant impact on a bond's performance; it also influences the bond's accounting treatment. Some implications of the principal window include:

[1]These are the median of the prepayment projections reported to Bloomberg by a number of Wall Street dealers on a periodic basis.

- Bonds with tight principal windows and delayed principal payments, or a principal "lockout," are easier and more convenient to hold for the investor's accountants. This is especially true for investors that have accounting systems created to manage Treasury securities and corporate bonds, which have one bullet principal payment at maturity.
- Bonds with short principal windows will typically outperform wide-window bonds in regimes when the yield curve is steep, because the shortening of the bond's life and duration as the bond ages puts upward pressure on its price, all else equal. This so-called "rolldown" impacts the returns generated through total return analysis. We discuss this phenomenon later in this chapter.
- Bonds with a principal lockout will often perform better under scenarios where interest rates experience a sharp short-term decline. Since they do not receive unscheduled prepayments immediately, their cash flows are not immediately affected by the resulting spike in prepayment speeds. By contrast, a bond that receives principal payments immediately will have its yield and returns impacted by early fast prepayment speeds, particularly if the bond is trading at a sizeable premium or discount.
- The principal window is a good indicator of how a bond's structure might behave. For example, the presence of so-called "cash flow breaks" in some PAC2s and support bonds (caused by the barbelling of cash flows discussed in Chapter 6) is also typically shown in yield tables, and is often indicated (as it is in Bloomberg) by a tilde (~) in the cash flow window field.

To illustrate how yield matrices can be used, we compare yield tables for different types of CMO tranches backed by the same collateral, using the same prepayment assumptions. Exhibit 12.2 shows a yield table for a hypothetical support CMO with an average life at pricing that is comparable to the sequential shown in Exhibit 12.1. Both bonds were structured using the same assumptions for the collateral, and the tables show the same PSA assumptions in instantaneous parallel shifts of the yield curve. Most notably, the median prepayment speed in the scenario when rates are assumed to increase 300 basis points is 115% PSA for both bonds. In comparing the two bonds, the following similarities and differences are noteworthy:

- In the base-case assumption of 175% PSA, the two bonds have similar average lives, modified durations, and yields.
- The sequential bond's average life only extends one year from the base case in the +300 basis point scenario (which equates to extending by 30%). By contrast, the support bond's average life almost quadruples, extending from 3.0 years in the base case to 11.5 years in the +300 basis

point scenario; the support's principal window also extends much more than that of the sequential.

- In rates-down scenarios, both bonds lose yield, as they are shown at prices above their parity price.[2] In the scenario where rates decline 300 basis points (which generates an assumed median prepayment speed of 1,250% PSA), the sequential loses 23 basis points of yield; the support bond loses 54 basis points of yield, as its cash flows (reflected by its average life and duration) shorten more than that of the sequential.

For ease of comparison, Exhibit 12.2 shows the support bond at the same price (and approximately the same yield and spread) as the sequential in Exhibit 12.1. In reality, the greater volatility of the support bond's profile and yields means that it should trade at a significant concession to the sequential bond. The tricky part of analyzing MBS (where more sophisticated analysis is required) is in deciding how much of a concession is fair, especially in more complex cases where the major components of value are not held constant.

The yield matrix for a PAC bond is fairly straightforward, in that its cash flows (i.e., its yield, average life, modified duration, and principal windows) are constant within the effective PAC band. A yield matrix for a representative intermediate PAC, run at a variety of prepayment speeds, is shown in Exhibit 12.3. Traders and investors typically compare PACs with similar coupons and collateral attributes based on a number of factors shown in the yield table, including the effective band, principal window, average life, and the dollar price at a given spread.

Exhibit 12.4 shows the yield table of a PAC2, structured with a 135% to 175% PSA band. The profile of the bond, on its face, is somewhere in between that of the sequential and support bonds shown in the earlier exhibits; for example, the PAC2's average life extends roughly four years in the +300 scenario (which equates to roughly 120% over the base case), as compared to the 30% extension of the sequential. However, the average life of the PAC2 at 100% PSA is 13.1 years, significantly longer than the 4.7 years of the sequential structure. Since the bond is a PAC2, by definition it is subordinate in principal priority to other bonds in the structure (i.e, the PAC1s); scrutiny of its performance at speeds other than the Bloomberg medians is important for evaluating this type of structure.

This is not to say that 100% PSA is necessarily correct or reasonable as a measure of prepayment speeds in high-interest rate regimes. However,

[2]Parity is the level where the bond's yield equals its coupon. For a bond that pays semiannually with no payment delay, the parity price is the bond's par value (i.e., 100% of face value). For fixed rate MBS, parity prices are typically below par, due largely to the effects of the payment delay on the bond's yield.

EXHIBIT 12.2 Yield-to-Price Table for a Hypothetical Agency Support CMO

		PSA							
		115	**125**	**145**	**175**	**225**	**450**	**850**	**1250**
	99 24/32	5.55	5.55	5.54	5.53	5.52	5.48	5.43	5.39
	99 28/32	5.54	5.53	5.52	5.48	5.45	5.36	5.24	5.15
	100	5.52	5.51	5.49	5.44	5.38	5.24	5.05	4.90
	100 4/32	5.51	5.49	5.46	5.39	5.32	5.12	4.86	4.65
	100 8/32	5.49	5.48	5.43	5.34	5.25	5.00	4.68	4.41
	Avg. life	11.5	9.3	5.7	3.0	2.0	1.1	0.7	0.5
	Mod. dur.	7.9	6.6	4.5	2.7	1.9	1.0	0.7	0.5
	Sprd/Tsys	74	74	73	64	51	20	–6	–24
Principal	First pay	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Window	Last pay	18.00	16.58	13.42	6.00	3.42	1.75	1.08	0.83

EXHIBIT 12.3 Yield-to-Price Table for a Hypothetical Agency PAC

		PSA							
		85	100	175	250	300	500	800	1200
	99 24/32	5.547	5.545	5.545	5.545	5.543	5.534	5.522	5.508
	99 28/32	5.522	5.518	5.518	5.518	5.515	5.492	5.461	5.429
	100	5.498	5.491	5.491	5.491	5.486	5.449	5.401	5.349
	100 4/32	5.473	5.465	5.465	5.465	5.457	5.407	5.340	5.270
	100 8/32	5.449	5.438	5.438	5.438	5.428	5.365	5.280	5.190
	Avg. life	6.2	5.5	5.5	5.5	5.1	3.3	2.3	1.7
	Mod. dur.	5.1	4.7	4.7	4.7	4.3	2.9	2.1	1.6
Principal	First pay	5.67	5.08	5.08	5.08	4.75	3.08	2.17	1.58
Window	Last pay	6.75	6.08	6.08	6.08	5.42	3.50	2.42	1.75

EXHIBIT 12.4 Yield-to-Price Table for a Hypothetical Agency PAC2 CMO

		PSA								
		100	**115**	**125**	**135**	**175**	**225**	**450**	**850**	**1250**
	99 24/32	5.55	5.55	5.54	5.54	5.54	5.54	5.52	5.50	5.48
	99 28/32	5.54	5.53	5.51	5.49	5.49	5.49	5.46	5.41	5.37
	100	5.53	5.50	5.48	5.45	5.45	5.45	5.40	5.32	5.26
	100 4/32	5.51	5.48	5.45	5.41	5.41	5.41	5.34	5.23	5.14
	100 8/32	5.50	5.46	5.41	5.37	5.37	5.37	5.28	5.14	5.03
	Avg. life	13.1	7.5	4.8	3.5	3.5	3.5	2.2	1.5	1.2
	Mod. dur.	9.1	5.7	3.9	3.0	3.0	3.0	2.0	1.4	1.1
	Sprd/Tsys	73.8	73.0	69.6	63.6	63.6	63.6	50.6	32.3	20.3
Principal	First pay	0.17	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Window	Last pay	15.67	13.08	10.83	7.42	7.42	7.42	2.75	1.67	1.33

it has traditionally been considered a benchmark of prepayment speeds for out-of-the-money MBS, at least before increased housing turnover and cash-out refinancings pushed base-case prepayment speeds higher after 2002. It therefore serves as a reasonable prepayment speed for evaluating a bond's performance in regimes of very slow prepayment speeds, particularly for tranches subject to complex cash flow allocation rules.

Prepayment Vectors and Dynamic Prepayment Scenarios

Based solely on its profile shown in the yield table, a case can be made that the relative riskiness of the PAC2 is not much greater than that of the sequential. However, such an assessment depends in part on which prepayment speeds are shown in the matrix. Moreover, this conclusion can be drawn only when the attributes of the bond (and its profile under a variety of assumptions) are understood. In this vein, standard yield tables can both illuminate and obfuscate the true attributes of a bond, depending on how they are used.

In order to further illuminate the structural attributes and expected performance of a bond, dynamic prepayment vectors are often utilized within the yield table. In this context, such a prepayment vector incorporates variable prepayment speeds over time. An example might be to run a bond at 200% PSA for 12 months, then at 1,200% PSA for 12 months, and then revert to 100% PSA for the remaining life of the deal. This type of analysis is useful in a number of ways. It is helpful to observe bond yields and average lives under prepayment assumptions that are different than those used in structuring the transactions. Variable or "dynamic" prepayment speeds, which presumably reflect multiple interest rate regimes, are also a more accurate representation of real-world conditions than the more static assumptions underlying the median speeds. In addition, the ability to run dynamic scenarios also helps to expose attributes of a bond that are not apparent under more standard prepayment assumptions. Vectors that utilize dynamic prepayment assumptions are particularly useful in evaluating structured bonds, such as PAC2s, that are subordinate in priority to other tranches in a structure. The nature of the cash flow rules, and the fact that the proportions within the structure change with every monthly cash flow, make dynamic prepayment vectors quite useful. Note that the vectors often don't need to be highly realistic in order to provide useful information on the bond in question.

An example of a scenario for utilizing vectors might be to view the yields and average lives of a bond under a faster prepayment "ramping" assumption. As discussed in Chapter 3, the PSA model assumes that loans season (or approach a predetermined prepayment plateau) over the course of 30 months.[3] An investor who believes that 30 months is too long of a seasoning ramp might construct vectors where the prepayment speeds ramp faster to the same terminal speed, that is, the CPRs increase more each month than assumed in the PSA convention. For example, 100% of an adjusted model might have a ramp that begins at 0.4% CPR in month 1 and increases 0.4% per month for 15 months, terminating at 6% CPR. Vectors are also utilized frequently for loan types where the prepayment behavior of the loans typically exhibits a large change over the life of the loan. As an example, prepayment speeds for hybrid ARMs typically spike when the loans approach their reset dates. As described in Chapter 4, risk-averse borrowers typically refinance into either a new hybrid ARM or a fixed rate loan at that point, depending on the yield curve and rates available for different products. No prepayment convention that exists at this writing accounts for this well-understood behavior.

The vectors typically used to evaluate CMOs and structured products are often constructed to "stress" the bond and the deal's structure. This is highly useful in examining a bond's profile under different dynamic scenarios, as well as assessing the scenarios that would cause the structure to break down. For example, consider the PAC2 bond shown in Exhibit 12.4. As discussed in Chapter 6, the bond is structured to take the support cash flows of a deal and, by assigning them a schedule, make them stable within a range of prepayments. Because the bonds are structured from support cash flows, however, the ability to support the structure of the PAC2s is compromised if prepayment speeds spike, even for a very short period. Exhibit 12.5 shows a yield table for the PAC2 tranche if prepayment speeds are run extremely fast (i.e., at 10,000% PSA) across all scenarios for the first two months after the deal is issued. Note that the profile of the bond changes considerably from that shown in Exhibit 12.4, even though the projected surge in prepayments is only assumed to last for two months. While this assumption may seem unreasonably onerous, keep in mind that 10,000% PSA in the first month after issuance is 20% CPR (10,000% × 0.2%). While this assumption is extremely fast, it is certainly conceivable; more importantly, the scenario shown in the exhibit is useful for evaluating the bond in question in terms of how it is structured, and what scenarios might cause its profile to change dramatically.

Another approach would involve using different initial CPRs and a variety of initiation periods in order to gauge the sensitivity of a bond's profile to prepayment spikes. Exhibit 12.6 shows the average lives and durations of the PAC2 used in the prior example under different stress scenarios. The terminal speed utilized across all scenarios is 10.5% CPR (which corresponds

[3]100% PSA assumes 0.2% CPR in month 1, increasing 0.2% CPR until reaching 6.0% CPR in month 30.

EXHIBIT 12.5 Yield-to-Price Table for a Hypothetical Agency PAC2 CMO: First Two Months Run at 10,000% PSA

		PSA (beginning in month 3)							
		115	**125**	**145**	**175**	**225**	**450**	**850**	**1250**
	99 24/32	5.56	5.56	5.56	5.55	5.53	5.49	5.45	5.42
	99 28/32	5.55	5.55	5.54	5.52	5.47	5.39	5.29	5.22
	100	5.54	5.54	5.53	5.49	5.42	5.28	5.13	5.02
	100 4/32	5.53	5.53	5.52	5.47	5.37	5.18	4.97	4.82
	100 8/32	5.52	5.52	5.51	5.44	5.32	5.08	4.81	4.61
	Avg. life	22.4	21.3	16.4	6.8	2.6	1.3	0.8	0.6
	Mod. dur.	12.5	12.2	9.9	4.8	2.4	1.2	0.8	0.6
Principal	First pay	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Window	Last pay	26.42	25.75	24.17	20.92	4.17	1.75	1.08	0.83

EXHIBIT 12.6 Average Lives and Modified Durations for a Hypothetical Agency: PAC2 CMO, Run at Variable Initial Speed, and then 10.5% CPR for Life

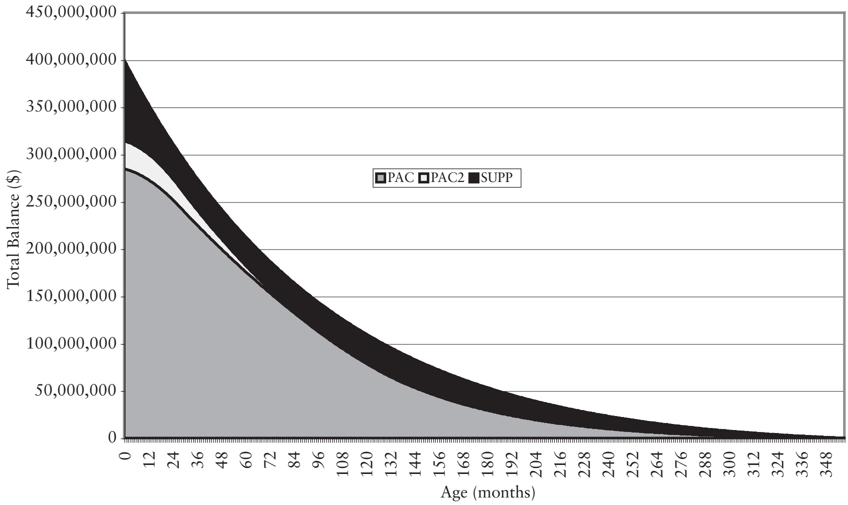
	Initial CPR	**10.5**	**15**	**20**	**25**	**30**	**35**	**40**	**45**
	Thereafter	**10.5**	**10.5**	**10.5**	**10.5**	**10.5**	**10.5**	**10.5**	**10.5**
2 months at initial speed	Avg. life	3.6	3.8	3.9	4.1	4.4	4.8	5.4	6.2
	Mod. dur.	3.1	3.2	3.3	3.4	3.6	3.8	4.1	4.5
3 months at initial speed	Avg. life	3.6	3.8	4.1	4.5	5.2	6.2	7.7	10.1
	Mod. dur.	3.1	3.2	3.4	3.6	4.0	4.4	5.1	6.1
4 months at initial speed	Avg. life	3.6	3.9	4.3	5.1	6.3	8.3	10.0	6.2
	Mod. dur.	3.1	3.3	3.5	3.9	4.5	5.4	6.0	3.8

to 175% PSA at month 30). In this case, a variety of CPRs are assumed for first few months of the bond after settlement. Note that as the early speeds increase, the average life and duration of the bond also *increases*; in addition, the bonds also extend in many scenarios when the "spike" speeds are assumed for a longer period.

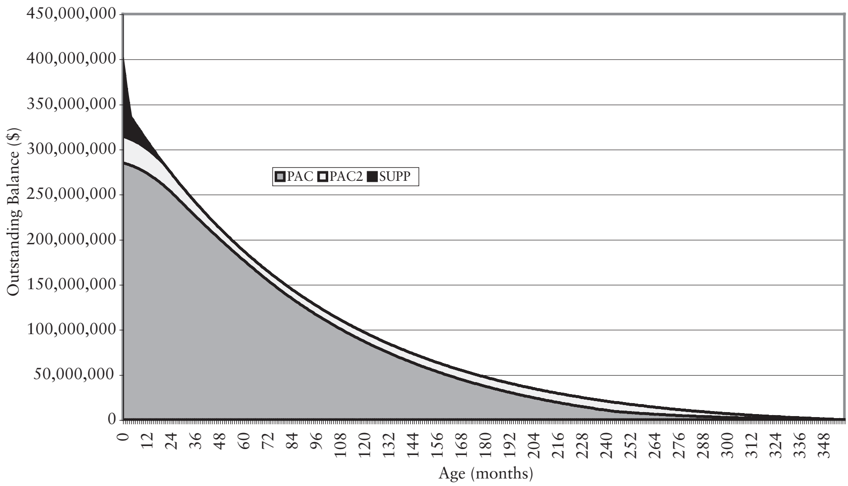
Both these results are counterintuitive because faster prepayment speeds typically shorten MBS average lives and durations. What is happening is that the spike in speeds resulting from a "whipsaw" rate scenario pays off the deal's support bonds very quickly. In the scenario of 40% CPR for four months, the support tranches are fully paid off by month 21. At that point, the PAC2 becomes the support for the high-priority PACs, that is, the PAC1s, in the structure. By month 68, the collateral no longer generates sufficient principal to meet the schedule of the PAC1s. At that point, all principal payments are directed to the PAC1s; as a result, the average life and duration of the PAC2 extends. This phenomenon is illustrated in Exhibit 12.7. The exhibits show the remaining tranche balances for the PAC1s, PAC2, and support bond over the life of the simple deal examined in this and the previous section. In Exhibit 12.7(A), the collateral is run at a constant 10.5% CPR for the life of the bond, and the PAC2 is almost entirely paid off after six years. Exhibit 12.7(B) shows the same deal when the collateral is run at 40% CPR for four months, and 10.5% CPR thereafter (i.e., the third scenario in Exhibit A.6 of the appendix). In this scenario, the support bond is paid off early in the life of the deal. By contrast, the PAC2's balance remains unchanged until after month 240, and is not completely paid off until the maturity of the entire deal.

This discussion highlights the fact that some CMO tranches can be less stable than implied by yield table analysis run at constant prepayment

EXHIBIT 12.7 Outstanding Balances for $400 Million PAC–Support Structure
A. Constant 10.5% CPR



B. 40% CPR for Four Months, 10.5% CPR Thereafter



speeds. This is because a yield table is similar in concept to a corporate balance sheet; it is a snapshot of the security's profile at a given point in time. Dynamic scenarios are a fairly straightforward way to uncover a bond's potential instability, particularly in more complex structures.

While PAC1s are typically quite stable, investors can stress-test them in a fashion similar to that used to evaluate PAC2s. For example, a vector might be created with a very fast speed in the first month (fast enough to prepay all the supports, typically in excess of 90% CPR), and then 6.0% CPR for life. While this does not represent a realistic scenario, it can expose structural weakness in a bond resulting from a priority shift written into the structure's cash flow rules, which is not typically evident from a static yield table. It also serves as a useful tool, in conjunction with a standard table, to compare ostensibly similar PACs from different deals.

Another type of dynamic prepayment analysis used to evaluate PACs addresses the issue of "PAC band drift." This technique attempts to analyze how much the "effective band" of a PAC changes if prepayment speeds are outside the range defined by the band for a period of time. In undertaking this analysis, a number of factors should be kept in mind. The definition of the effective band is the range of prepayments in which the bond's schedule can be met at a point in time. This means that the effective band on a PAC may shrink, even if the schedule falls short at a particular speed by a few cents. In addition, the intrinsic nature of the PAC structure discussed in Chapter 6 means that variable prepayment speeds will impact the effective bands of PACs differently, depending on their average lives. The effective band of long PACs, for example, are typically both more sensitive to fast speeds and more inclined to shrink than those of the short and intermediate PACs within the structure. (To review, the slow prepayment scenarios drive the PAC schedule early in the deal; at a certain point in time, however, the upper band takes over and dictates the schedule. Therefore, bonds created before the so-called "crossover point" will not be affected by fast speeds to the same extent as PAC tranches later in the structure.)

For example, the 5.5-year PAC shown in Exhibit 12.3 has a structuring band of 100% to 250% PSA. At issuance, however, the effective band of this bond was roughly 100% to 290% PSA, meaning that the schedule could be met at speeds faster than the upper band used to create the PAC schedule. However, prolonged faster speeds will eventually erode the bands of all the PACs in a deal; the fast speeds eventually pay off all of the support tranches, leaving the PACs to behave like sequential bonds.

Exhibit 12.8 shows the effective band of the 5.5-year PAC when run at fast speeds for a number of different initial periods. The length of time that the bond prepays faster than the upper band is clearly a key driver, and is at least as important as the level of early prepayments.

EXHIBIT 12.8 Effective Band for a Hypothetical PAC Run at Fast Prepayment: Speeds for Different Periods of Time Immediately after Issuance

		Early Prepayment Speed (% PSA)							
Months	**Band**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
6	Lower	102	103	104	105	106	108	109	110
	Upper	266	265	263	262	260	258	256	255
12	Lower	106	110	114	118	123	127	133	139
	Upper	265	260	255	249	243	237	231	224
18	Lower	114	122	132	143	155	170	n/a	n/a
	Upper	263	251	239	226	213	198	n/a	n/a
24	Lower	124	140	157	n/a	n/a	n/a	n/a	n/a
	Upper	260	237	213	n/a	n/a	n/a	n/a	n/a

Evaluating MBS with Variable Coupon Rates

A variety of matrices can be used to evaluate MBS that carry variable coupons, such as ARMs, floaters, and inverse floaters. As with fixed rate bonds, tables typically are run at a variety of prepayment assumptions in order to show a bond's principal profile. However, the analysis of yield and spread typically differs depending on how the securities are utilized by investors.

CMO floaters are most commonly purchased by depositories as a means of earning a spread over funding cost, and are typically quoted using a measure called ***discount margin*** (DM). A floater's DM is calculated as the security's monthly mortgage yield minus the level of the index. However, note that DM is not a perfect proxy for a spread over funding. For example, most CMO floaters are indexed to one-month LIBOR, while banks typically benchmark their funding to other measures, such as quarterly or annual LIBOR. In addition, DM is calculated using the normal mortgage convention of a 30/360 day count, while LIBOR itself is based on an actual/360 day count. The difference would reduce the bond's margin by 3 to 5 basis points, an adjustment often made by investors that purchase these bonds as a money-market alternative.[4]

By contrast, the techniques used by ARM investors depend on the attributes of the product being purchased. Short-reset ARMs (either new-issue one-year ARMs or seasoned hybrids) are often evaluated using ***bond equivalent***

[4]LIBOR-based floaters created off some types of deals, such as subprime ABS floaters, were normally structured to pay on an actual/360 basis.

effective margin (BEEM). While similar in concept to DM, BEEM is calculated as the difference between the security's semiannual (i.e., bond-equivalent) yield and the index. Longer hybrids are often evaluated using yield spreads over either Treasuries or swaps. Because of the uncertainty of the bond's principal and interest cash flows after the reset, however, investors often alter their prepayment assumptions to account for the expected spike in prepayments around the reset month by assuming a balloon payment at the reset. (Bloomberg accommodates this convention by allowing the user to run a metric it labels CPB, which stands for Constant Prepayment to Balloon, an alternative to a static CPR.)

Inverse floaters can be analyzed using traditional price–yield matrix. However, this framework (i.e., showing yields at different prices) can be highly misleading, since the analysis is performed by holding the reference index at a constant level. Given the addition of the index rate as a variable, the bond's ultimate returns can vary dramatically from those suggested by the yield table.

A more useful approach is run a ***yield-to-index matrix*** (or just an *index matrix*) such as one shown in Exhibit 12.9, which shows the index level on the vertical axis instead of prices. In addition to giving investors a better sense of risk as both the index and speeds change, it allows investors to gauge how the bond can be expected to perform under different yield curve scenarios. For example, a parallel shift in the yield curve means that

EXHIBIT 12.9 Yield-to-Index Matrix for a Hypothetical Agency Inverse Floater Priced at 92-16, 5.25% LIBOR

		PSA						
		115	**125**	**145**	**175**	**450**	**850**	**1250**
	2.25	18.06	18.10	18.18	18.30	19.38	20.52	21.41
	3.25	14.00	14.04	14.13	14.26	15.39	16.56	17.47
	4.25	10.00	10.05	10.14	10.29	11.45	12.65	13.58
LIBOR	5.25	6.07	6.12	6.22	6.37	7.57	8.79	9.74
	6.25	2.21	2.26	2.36	2.51	3.74	4.99	5.96
	7.25	0.87	0.92	1.03	1.18	2.41	3.67	4.64
	8.25	0.87	0.92	1.03	1.18	2.41	3.67	4.64
	Avg. Life	9.4	8.9	8.0	7.0	3.4	2.3	1.8
	Dur.	7.2	6.9	6.4	5.7	3.0	2.0	1.6
Principal Window	First Pay	8.42	8.00	7.17	6.25	3.17	2.08	1.67
	Last Pay	10.42	9.83	8.92	7.75	3.75	2.42	2.42

yields should perform roughly as shown in the "diagonal" highlighted in the exhibit. Using the 5.25% level for LIBOR and 175% PSA as the base-case prepayment speed (which results in a yield of 6.37%), an instantaneous 200 basis point parallel shift (which correspond to 3.25% LIBOR and an 850% PSA prepayment assumption) would cause the bond's yield to rise to 16.56%. By contrast, an inverting yield curve (with LIBOR rising sharply while long rates drop by roughly the same amount) would result in yields as shown in the lower right corner of the matrix. (A combination of 7.25% LIBOR and 850% PSA results in a yield of 3.67%.) As with all MBS analysis, yields must be treated with some caution; they incorporate future paths which are unknown and, at the time of the analysis, unknowable. Nevertheless, an index matrix is a useful starting point for exploring the relative value of inverse floaters. We discuss other aspects of inverse floater valuation later in this chapter.

MONTE CARLO AND OAS ANALYSIS

As explained in Chapter 10, option-adjusted spread (OAS) is a metric that attempts to show how much incremental spread is being earned over a benchmark forward curve, taking account of the cost of all options embedded in the security. The methodology involved in generating Monte Carlo simulations and calculating option-adjusted spreads and durations was outlined in Chapters 10 and 11. Our discussion here is focused more on using OAS as a method of gauging relative value, with the proviso that OAS can be utilized by investors in a variety of ways. While it is tempting to view the bond with the greatest OAS as the "best" bond, this is often not the case; as with other metrics, OAS and its related methodologies are tools to be used in evaluating bonds. The output generated by a model must be considered in light of both the model's biases and the limitations of the methodology itself. In this section, we highlight some ways that the methodology can be used, both on its own merit and as an input to other forms of analysis.

As noted previously, the calculation of OAS using Monte Carlo simulations is a highly complex process. The generation of the underlying yield curve, the first step in the process of generating the analysis, is a complex undertaking in its own right; the additional complexity of integrating the model's other components and inputs, such as volatility and prepayment functionality, suggests that the results obtained can be highly model-specific.[5]

[5]The appendix to this text describes a different and unique technique known as the Option-Theoretic Approach, which generates option-adjusted spreads independent of a prepayment model.

In this and the following section, we illustrate some analytical techniques by comparing the results obtained for three bonds. The bonds in question are all hypothetical bonds with a base-case average life of 4.0 years, structured from the same collateral. The three bonds utilized were (1) a 4.0-year sequential; (2) a 4.0-year PAC with a 100% to 250% PSA band and a 2-year principal payment window; and (3) a 4.0-year PAC2 with a 135% to 175% PSA band. All prices and spreads are hypothetical, constructed to illustrate analytical techniques rather than to conform to market levels at any point in time. We deliberately used bonds with the same base-case average life and collateral, in order to be able to conduct an apples-to-apples comparison and thus simplify the analysis.

Exhibit 12.10 contains a matrix that shows the profile of the three bonds used for the remainder of this chapter, along with the prices and spreads used in the analysis. Exhibit 12.11 contains a table showing the output of a standard OAS model for the three bonds. Included in the table are the most commonly used metrics, including:

EXHIBIT 12.10 Profile of the 4.0-year Sequential, PAC, and PAC2 Used in OAS and Total Return Analysis

		PSA						
		100	**115**	**150**	**175**	**250**	**400**	**600**
Sequential (+85/ curve, 99-16)	Yield	5.60	5.60	5.61	5.61	5.62	5.64	5.66
	Average life	5.8	5.3	4.4	4.0	3.1	2.3	1.8
	Mod. duration	4.6	4.3	3.7	3.4	2.8	2.1	1.7
	Principal window (months)	144	131	109	97	74	51	38
PAC (+65/ curve, 100-6)	Yield	5.41	5.41	5.41	5.41	5.41	5.39	5.35
	Average life	4.0	4.0	4.0	4.0	4.0	3.5	2.6
	Mod. duration	3.5	3.5	3.5	3.5	3.5	3.1	2.4
	Principal window (months)	25	25	25	25	25	12	7
PAC2 (+100/ curve, 99-00)	Yield	5.64	5.67	5.76	5.76	5.86	5.99	6.12
	Average life	13.6	8.6	4.0	4.0	2.5	1.7	1.3
	Mod. duration	9.3	6.3	3.4	3.4	2.3	1.6	1.2
	Principal window (months)	200	171	116	116	41	26	19

EXHIBIT 12.11 OAS Model Output for Three Hypothetical Securities

Bond	Price	Spread/ Treasury	Average Life	Modified Duration	OAS	Zero-Vol. OAS	Option Cost	OA Duration	OA Convexity	Projected Prepayment Speeds (CPR%)		
										12-month	36-month	Long-term
Sequential	99 16/32	85	4.0	3.4	10.8	43.9	33.0	2.5	–1.57			
PAC	100 6/32	65	4.0	3.5	11.9	26.2	14.3	2.6	–1.74	6.1	9.1	11.6
PAC2	99	100	4.0	3.4	0.2	65.3	65.1	2.2	–0.99			

- OAS
- Zero-volatility (Z-Vol) OAS
- Option Cost
- Option-adjusted duration (OAD)
- Option-adjust convexity (OAC)

(Note that since the three bonds were structured using the same collateral assumption, the projected speeds are the same for all three securities.)

A cursory viewing of Exhibit 12.11 shows that the PAC has the highest OAS of the three bonds; by contrast, the zero-volatility OAS (Z-Vol OAS) is highest for the PAC2, reflecting its wide static spread. The PAC2 also has the highest option cost. (As described in Chapter 10, option cost is the difference between the OAS and Z-Vol OAS, and can be interpreted as the cost of hedging the interest rate volatility implied by the model.) Interestingly, the PAC has the lowest option cost, but the most negative convexity of the three bonds. While often treated as equivalent measures, the two metrics measure related but different attributes of the bond. The option cost measures how much market volatility costs the bond in option-adjusted spread; the convexity measures the nonlinearity of the bond's price profile.

Depending on the interpretation, Exhibit 12.11 suggests that the 4.0-year PAC may either be the "best" bond (as it has the highest OAS and lowest option cost) or the "worst" bond (since it has the lowest Z-Vol OAS and the most negative convexity of the three securities in question). The temptation to use one metric or another as a sort of relative-value "magic bullet" is normally counterproductive. Rather than giving a simple summation of relative value, this type of analysis is most useful as a basis for further inquiry into the attributes of the different securities, and what conditions might cause one bond to offer better returns than another.

Given the complexities of the OAS methodology, the output generated by OAS models can vary greatly due to both biases within the model and changes in the level of inputs. One of the most important drivers of OAS functionality is the prepayment model, which generates prepayment vectors for each interest rate path. These in turn are used to generate the cash flow vectors central to the analysis. Therefore, the output of the prepayment model has a profound impact on the spreads and metrics ultimately displayed by the model; in turn, the functionality and biases implicitly contained in the prepayment model are one of the most important drivers of the OAS model's output.

Changes in the market levels used as inputs, as well as variations in how the inputs are handled, can also result in marked changes to the output of the model. For example, an important input is the level of implied volatility (*vol*). Higher implied volatility typically reduces option-adjusted spreads, although the response to rising vols is dependent on the attributes of the bond being analyzed.

Therefore, using OAS analysis effectively requires the user to be cognizant of both the potential biases of the model being utilized, as well as how the bonds being analyzed might be impacted by changes in the market environment. One way of accounting for these factors is to rerun the analysis using different model parameters. To illustrate this, we recalculated the OAS of the three bonds using multiples of the prepayment model (shown in Exhibit 12.12(A), using 80% and 120% of the model) and the level of volatility (running at 90% and 110% of the market levels, as shown in Exhibit 12.12(B)). With respect to the prepayment model, the PAC2 is clearly the most sensitive of the three bonds to changes in the prepayment functionality. In part, this is due to its lower dollar price; more importantly, changing the prepayment model increases (at a lower model multiple) or decreases (at a higher multiple) the probability that the collateral will prepay at speeds below the band, which would make it a much longer cash flow. The PAC2 is also the most sensitive to changes in volatility, although all three bonds are less responsive to this change than to changes in the prepayment model.

This output is useful in a number of ways. If, for example, the prepayment model is considered to be "fast" or "slow" relative to either historical experience or the market consensus, the output of the model should be interpreted in this context. If a relatively "fast" model generated a high OAS for a PAC2, the outsized spread might be largely attributable to the biases of the model, rather than the attractiveness of the bond. The same

EXHIBIT 12.12 OAS Output for Three Hypothetical Securities

A. Using Multiples of Prepayment Model

	OAS		OAS Change from Base Case	
	80%	120%	80%	120%
Sequential	7.5	13.4	–3.3	2.6
PAC	13.8	8.2	1.9	–3.7
PAC2	–33.7	23.6	–33.9	23.4

B. Using Multiples of Implied Volatilities

	OAS		OAS Change from Base Case	
	90%	110%	90%	110%
Sequential	15.5	6.0	15.5	6.0
PAC	14.8	8.7	14.8	8.7
PAC2	7.3	–6.8	7.3	–6.8

output from a "slow" model, by contrast, might well indicate a very cheap bond. In addition, the prepayment environment is not static; as discussed in Chapter 4, prepayment speeds reflect factors such as the state of the housing market, the shape of the yield curve, and the availability of alternative products. Therefore, even if the user is comfortable with the output of a model, changes in the prepayment environment may impact the relative attractiveness of a bond. The PAC2 in the example would be much less attractive if base-case prepayment speeds were to slow due to profound housing market weakness and resulting slower turnover (which was in fact experienced in the period following the beginning of the financial crisis in 2007).

In this light, the simple changes imposed on the prepayment model in Exhibit 12.12(A) are themselves somewhat biased. While using a simple multiple of the prepayment model is a fairly robust test in most cases, prepayment functionality is multidimensional. Model attributes such as base-case prepayment speeds, the ramping behavior, and the response to refinancing incentives all are important. Running the prepayment model at different percentages of the base model does not fully change the model's functionality. While this is an easy test that gives useful results for most bonds, certain cash flows (such as support POs and inverse IOs) require more robust stressing of the prepayment model in order to fully grasp the bond's prepayment sensitivities.

These considerations are also important in evaluating potential returns on securities that do not have fixed coupon rates. This includes the hybrid ARM product, which comprises a significant share of the mortgage universe. As discussed in Chapter 4, the prepayment behavior of a hybrid ARM varies based on how soon the bond resets, and whether it has already experienced its first reset and is subsequently experiencing periodic rate adjustments. The value of a hybrid ARM security is highly dependent on expected prepayment speeds. A major factor relates to what proportion of the bond will be outstanding when the underlying loans reset. This is because the bond's floating rate tail has great value in many scenarios; at the reset, it becomes a high-yielding security with a short duration. Therefore, OAS analysis of hybrid ARMs is highly dependent on the veracity of both the pre- and postreset prepayment model projections. A robust analysis of the hybrid ARM product involves running spreads and valuations at various multiples of the prepayment model both before and after the reset date.

Therefore, the output of OAS models should not be viewed as isolated indicators of relative value. OAS is much more useful when viewed as one of a variety of different techniques. Rather than signaling value in isolation, the results should be interpreted in the context of what the investor needs to believe in order to like one bond over another.

TOTAL RETURN ANALYSIS

As discussed in Chapter 10, the concept of total return (TR) methodology is a robust measure of expected returns over a defined horizon. This analysis is commonly used by investors that manage assets versus market benchmarks or indexes, as well as by investors looking to evaluate and compare projected performance under different interest rate scenarios. In the following section, we demonstrate some ways that TR analysis can be used, using the same three bonds evaluated in Exhibits 12.11 and 12.12.

Total return is arguably a more realistic and robust measure of performance than yield for a number of reasons. Most importantly, it relaxes some of the unrealistic assumptions underlying yield measures. For example, it allows for the assumption of different reinvestment rates; it recognizes the possibility that the bond will be held to a predefined horizon, rather than to maturity; and it also allows returns to be generated under a variety of different interest rate and prepayment scenarios. However, this increased flexibility means that some assumptions must be explicitly made prior to generating the analysis. These assumptions include:

- The method used to determine the terminal price of each security at the horizon. Often, an assumption of constant OAS is made, meaning that the bond's price is regenerated at a point forward in time, using the current level of OAS as the pricing benchmark. Other spreads, such as static spreads over swaps, can also be used, along with user-defined prices generated outside the TR model. Alternatively, the analyst can assume that spreads will change as time elapses; therefore, variable option-adjusted or static spreads can be used to calculate the terminal price.
- The time horizon to be evaluated (which often depends on the investor's typical holding period).
- When curve shifts would take place (i.e., instantaneous, at the horizon date, or gradually).[6]
- The nature of the yield curve shifts. (As discussed here, a thorough analysis involves both parallel shifts as well as changes in the configuration of the yield curve.)
- The reinvestment rate to be assumed. A commonly used method uses a *runoff strategy*, which assumes that all interest and principal proceeds are held in the form of cash. Under this assumption, a spread around

[6]While the impact of different rate shift timing is *de minimus* for most fixed income securities, the exposure to changing prepayment speeds makes MBS path-dependent, as noted in Chapter 10. Therefore, the returns will vary under the same rate-change scenario if the timing of the shift is changed.

LIBOR or some cash benchmark is typically assumed. Alternatively, the investor may assume that proceeds will be reinvested in similar securities, which means that the reinvestment rate should be the same as the yield of the bond being analyzed.

Total return analysis also has some biases that need to be taken into account. A significant issue is that the terminal price, arguably the most important determinant of return, is unknowable, and is normally generated using one or more simplifying assumptions. In addition is the issue of *rolldown*. If the yield curve is upward-sloping, the present value of a security will rise as time elapses, since the cash flows are being discounted at lower rates. The impact of rolldown, however, varies depending on the nature and timing of the instrument's cash flow. One interesting aspect of MBS is that the average lives and durations of bonds with tight principal windows shorten more than those with wide windows as time elapses. (At its extremes, the average life of a bond with a bullet maturity will shorten pro rata with the passage of time; a pass-through that amortizes over a 30-year schedule might only shorten 0.1 to 0.2 years in average life for every year that passes.) Depending on the shape of the yield curve, a tight-window bond's horizon price will rise as time elapses more than that of a wide-window bond. The value of the ***rolldown effect*** is greater when the yield curve for its class of securities is steeper, vis-à-vis when the product's yield curve is flat. (This "curve" is a function of both the benchmark yield curve and spreads for each point on the yield curve.) This means that the results of total return analysis will be impacted by the cash flow window; the magnitude of the effect is in turn a function of the shape of the product yield curve, as well as whether market spreads will widen as the bond ages and its price rises. This is especially important to keep in mind when using TR analysis to compare CMO tranches to passthroughs, as the methodology will often contain a subtle bias toward the structured product.

Exhibit 12.13 shows projected 12-month total returns for the three agency CMOs in various parallel-shift scenarios, using instantaneous changes to the spot curve, constant-OAS horizon pricing, and a LIBOR-flat reinvestment assumption. For the sake of comparison, we also show the returns for a par-priced noncallable agency debenture with a four-year maturity. While the returns of the debenture are virtually linear with respect to rate changes, all of the tranches exhibit returns that tail off in rally scenarios beyond a 50 basis point shift, reflecting the impact of faster prepayment speeds on returns.

Exhibit 12.14 shows the parallel-shift return data in Exhibit 12.13 as incremental returns versus the noncallable debenture. This framework is very useful in defining the scenarios where the different bonds can be

EXHIBIT 12.13 12-Month Total Returns for 4.0-Year Agency CMOs and Bullet Agency Debenture In Parallel-Shift Scenarios

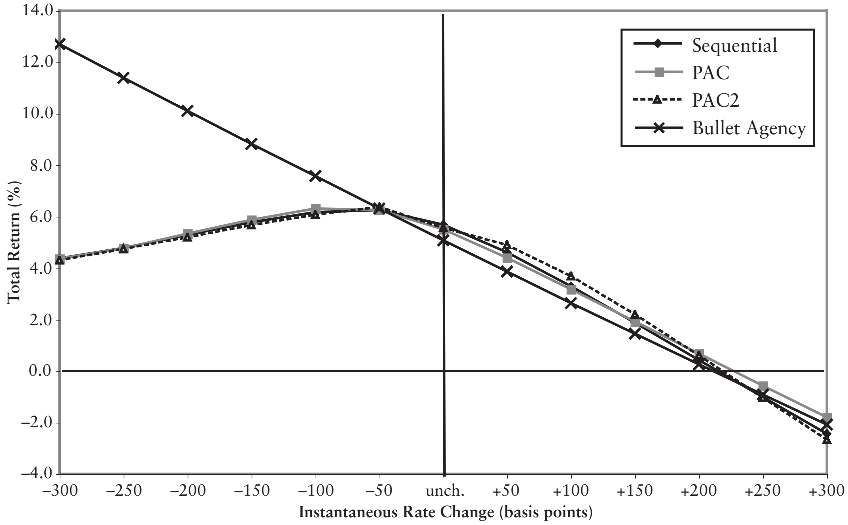
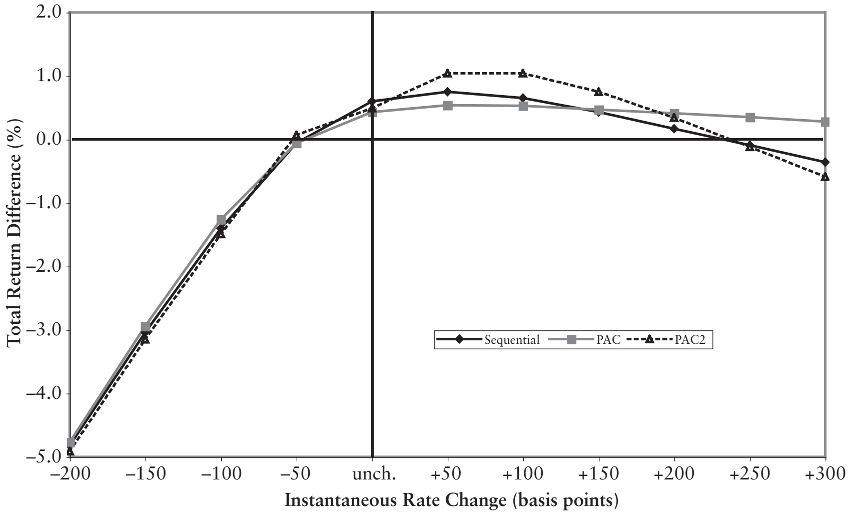


EXHIBIT 12.14 Difference in 12-Month Total Returns Between 4.0-Year Agency CMOs and Bullet Agency Debenture in Parallel-Shift Scenarios



expected to outperform or underperform each other. The returns of the three securities in "rally" (i.e., rate decline) scenarios are very similar. The PAC2 can be expected to outperform the other two MBS in cases of moderate rate increases; the PAC will outperform both bonds when rates rise more than 200 basis points.

As noted, the return analyses shown in Exhibits 12.13 and 12.14 are based on parallel shifts in the yield curve. However, nonparallel yield curve shifts can result in very different results, depending upon the characteristics of the bond in question and the nature of the nonparallel shifts being investigated. Exhibit 12.15 shows incremental returns for the three tranches versus the non-callable agency debenture in nonparallel shift scenarios. Exhibit 12.15(A) shows projected 12-month returns when the short end of the curve (i.e., 2-year and shorter rates) is varied, while the long end of the curve (10-year and longer rates) is held constant. Exhibit 12.15(B) shows the opposite scenario, where the short end is held constant while the long end is changed. (In both cases, the "belly" of the yield curve can be envisioned to pivot off the sector held constant.) Both exhibits are scaled to show yield curve "flattening" as the areas on the left of the horizontal axis, while yield curve "steepening" is illustrated at levels on the right side of the axis.

EXHIBIT 12.15 Difference in 12-Month Total Returns Between 4.0-Year Agency CMOs and Bullet Agency Debenture in Yield Curve Change Scenarios

A. Change in 2-Year Yield, 10-Year Yield Unchanged

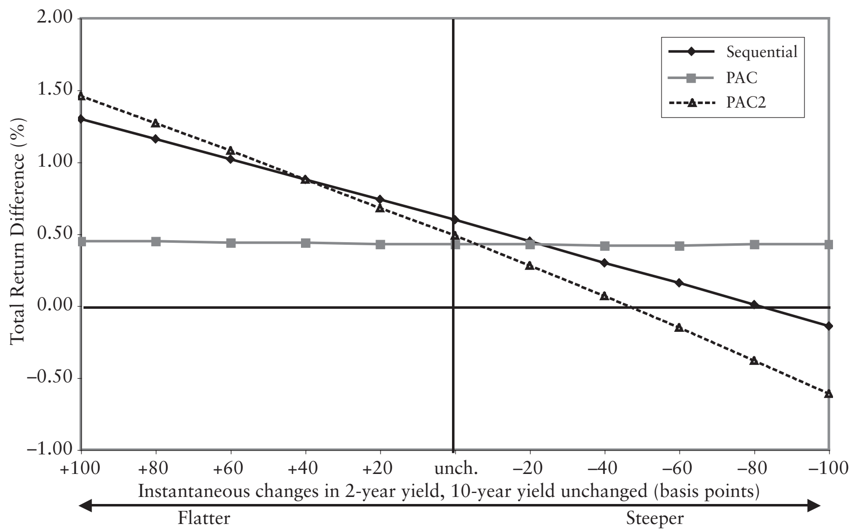
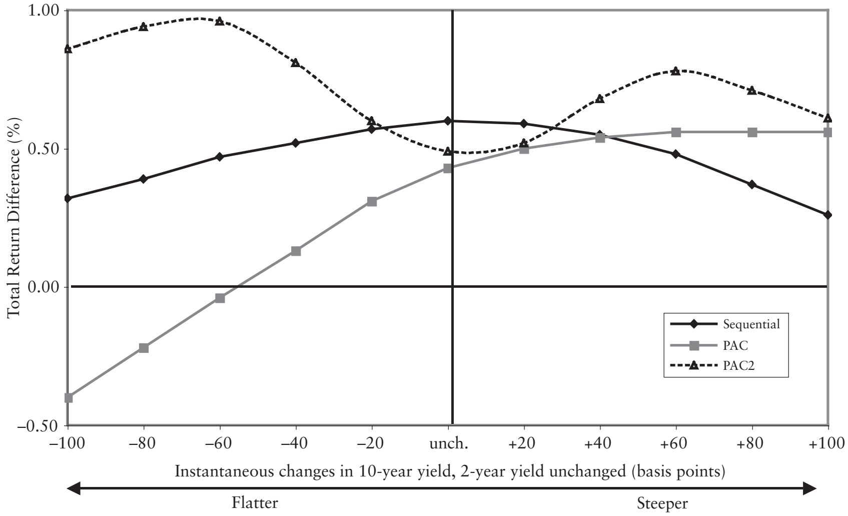


EXHIBIT 12.15 (Continued)

B. Change in 10-Year Yield, 2-Year Yield Unchanged



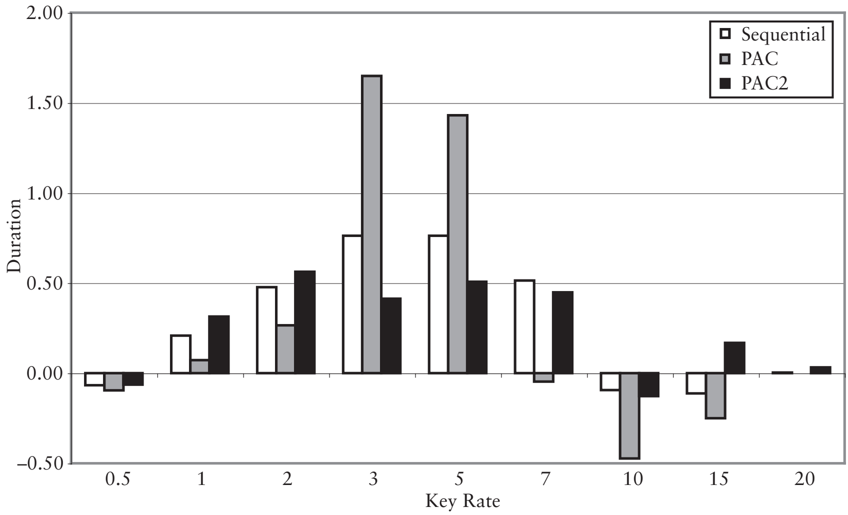
The striking aspect of these two exhibits is how much different the return profiles are for the three bonds under these scenarios, despite their identical base-case average lives and similar modified and option-adjusted durations. In Exhibit 12.15(A), the incremental returns of the PAC over the noncallable debenture are virtually insensitive to changes in the short end of the curve, while the sequential and PAC2 bonds both outperform the debenture in a flattening scenario, which in this case can be considered a ***bear flattener*** scenario, but lag the debenture as short rates decline and the curve steepens, that is, a ***bull steepener***.

In the case where the 10-year yield is changed, as shown in Exhibit 12.15(B), the results are quite different. The PAC's incremental returns lag those of the sequential when the curve flattens, a ***bull flattener*** scenario, but outpace them when the curve steepens, a ***bear steepener*** case. Interestingly, the PAC2 exhibits the best incremental performance in cases of moderate swings in either direction.

The differing incremental performance of the three bonds in the nonparallel curve shift scenarios reflects aspects of their structures related to those highlighted in the earlier discussion of yield curves and prepayment vectors. For example, bonds with schedules (such as PACs) will typically underperform sequentials (as well as unstructured securities such as pass-throughs) when the long end of the yield curve rallies. This is because of the impact of changing prepayment projections on the schedule. Lower long rates and a flatter yield curve cause the prepayment model to project faster future prepayment speeds. In turn, this causes the balances of the support bonds to pay down faster, resulting in less support for the PACs. The constant-OAS horizon pricing assumption therefore imputes wider static spreads and weaker price performance of the PACs in these scenarios, negatively impacting their total returns vis-à-vis bonds without schedules.

This effect is best illustrated by using key rate or partial durations. As discussed in Chapter 11, key rate durations attempt to measure the sensitivity of a bond's price when discrete segments of the yield curve are changed. Exhibit 12.16 shows the partial durations of the three structured MBS used in the analysis. Note that the PAC has a very uneven duration profile. It has relatively high positive exposure in the three- and five-year sectors; its durations in the longer rate buckets, however, are very negative, revealing the bond's vulnerability in the bull flattener scenario. This behavior results from the PAC band's sensitivity to prepayment speeds, which are primarily driven by the level of long interest rates. Its returns are not impacted by the bear flattener, however, as it has very little duration exposure to short rates. While the other two CMOs also have negative long durations, their magnitude is quite small in comparison to the PAC; this is consistent with their relative performance versus the PAC in curve-flattening scenarios.

EXHIBIT 12.16 Key Rate Durations for 4.0-Year Agency CMOs



While TR analysis is very useful, it has implicit weaknesses that should be taken into account. In the analysis shown in Exhibits 12.13, 12.4, and 12.15, we did not adjust for the different option-adjusted durations of the four securities utilized. A true duration-neutral analysis means that, to equalize the durations, some of the bonds in the structure will need to be evaluated as part of a portfolio that consists of CMOs and cash. (Lengthening a bond's duration can be accomplished by using a short position in cash, essentially leveraging the portfolio.) However, the CMO-and-cash portfolios are effectively portfolio barbells, with low-duration cash combined with securities exhibiting positive durations. Barbelled portfolios exhibit their own performance attributes with respect to changes in the yield curve configuration; typically, barbells will outperform as the yield curve flattens and lag when it steepens. Therefore, investors undertaking TR analysis need to take account of this potential bias; one potential solution would be to limit comparisons to securities with similar durations, in order to eliminate or minimize the biases imposed with barbelled portfolios.

Another important issue is a weakness addressed previously with respect to yield tables. The analysis is designed to project returns in either static or rate-change scenarios that move in one direction. However, the discussion on yield tables and vector analysis demonstrated that some bonds are more sensitive than others to yield curve shocks and dynamic changes in interest rates. Most TR models do not allow such scenarios to be taken into account. In addition, it is difficult to identify factors driving returns for MBS in different scenarios; the interaction between the cash flows within a deal is often unpredictable, and the returns can be quite model-specific.

This is highlighted by the incremental performance of the PAC2 shown in Exhibit 12.15(B). The incremental performance vis-à-vis the two other tranches in the bull flattener case is likely due to the PAC2's positive performance at faster prepayment speeds, as indicated previously. In the bear steepener case, the bond's schedule prevents the bond from extending as much, at least in scenarios of modest long-rate changes. However, these results would be different in a dynamic scenario where long rates first fell and then rose. Under these conditions, the PAC2's support would immediately erode, causing its incremental performance (particularly in bearish long rate scenarios) to suffer.

EVALUATING INVERSE FLOATERS

Evaluating complex securities such as inverse floaters and inverse IOs presents special challenges to investors. As discussed in Chapter 7, these bonds are created from either a collateral pool or, more commonly, from a collateral or "parent" tranche. In addition, their coupons are both variable and, especially for "payer" inverses, leveraged with respect to changes in the reference rate or index. In this section, we establish a framework for viewing these bonds in an economic context, and then outline some techniques for valuing these bonds.

Since both the inverse floater and floating rate tranche are created from a fixed rate parent tranche, the following relationship is true:

Long a fixed rate parent tranche
= Long a capped floater + Long an inverse floater

(As discussed in Chapter 7, the floater must be capped since the parent tranche has a fixed coupon rate and the coupon on the inverse cannot go below 0%.)

Recasting this relationship in terms of an inverse floater gives us:

Long an inverse floater
= Long a fixed rate parent tranche – Long a capped floater

Or, equivalently,

Long an inverse floater
= Long a fixed rate parent tranche + Short a capped floater

Thus, the owner of an inverse floater has effectively purchased a fixed rate tranche and shorted a capped floater. However, shorting a floater is equivalent to borrowing funds, where the interest cost of the funds is a floating rate and that rate is the reference rate plus the spread (subject to a cap). Consequently, the owner of an inverse floater has effectively purchased a fixed rate asset with borrowed funds, and thus owns a leveraged position in the parent tranche. This is consistent with the discussion in Chapter 7 of the leverage embedded in an inverse floater.

In this framework, the nature of inverse floaters is fairly straightforward. However, valuing and evaluating inverse floaters can be quite difficult, given the complexity of their cash flows and returns. As with other types of tranches, there are a number of techniques that can be utilized in evaluating and comparing different inverse floaters. However, there is no single guide to value, and the difficulty of valuing the bonds is magnified by both their complexity and the amplified impact of small modeling errors on the values generated.

As with other senior tranches, Monte Carlo simulations can be used to directly generate either OAS-based prices or an OAS at a given price, which can be compared to other comparable securities. However, for inverse floaters and bonds where the coupon is contingent on a reference rate, using this approach requires a special understanding of how the Monte Carlo process generates interest cash flows, based on the parent bond's coupon and the reference rate.

The model begins by simulating the path of short-term interest rates, as before. Then, from the path of short-term rates, two other paths are created. The first is the path of short rates used for both the generation of prepayment rates and discount rates for the cash flow vectors; the second is a path for the inverse floater's reference (i.e., index) rate. In constructing the simulated path for the reference rate, it is necessary to make an assumption about the relationship between the short-term rate and the reference rate. Thus, if the reference rate is one-month LIBOR, the model must make an assumption about the relationship between one-month LIBOR and the one-month risk-free rate. If one-month LIBOR is assumed to be X basis points over the one-month risk-free rate, then on the simulated path for the reference rate, the rates are assumed to be X basis points above the simulated short-term path of rates. Therefore, for a given month on a given interest rate path, there is a value for both the reference rate and the refinancing rate.

Given a prepayment model, the coupon reset formula for the inverse floater, and the structure of the deal, cash flows can be determined for each month on each interest rate path, subject to some relationship between the reference rate and the short-term rate. (Of course, the calculation is much simpler for LIBOR OAS values, as the short-term rate and the reference rate are similar, if not identical.)

If the required OAS is known, the value of an inverse floater is computed by generating cash flows for each interest rate path and then averaging the present values of all cash flows. Alternatively, the OAS can be computed given the market price of the inverse floater. In practice, it is difficult to use this methodology without a good idea of what the required OAS should be to generate a theoretical price (or, at a given price, what an acceptable OAS might be) for a bond in question. This method is most useful for those participants that are actively trading the sector during times when comparable bonds are trading. This allows the analyst to use the output of the models to value a variety of structures and leverages.

An alternative means of valuing the bonds is by computing its ***creation value***. In addition to inverses, many types of CMO tranches can be viewed in the context of where they can be created, and traders typically shape their valuations based on their knowledge of the levels that various tranches can be structured (assuming, of course, that they are createable at that point in time). Judging creation value on one bond, however, presupposes that the trader has a good idea of where the remaining tranches would trade at that point in time, along with the pricing of the appropriate collateral or parent bond. Given that knowledge, along with values for the yield curve, the structuring model would generate a break-even value and spread for the tranche in question. Under certain conditions, the generation of creation value is particularly helpful for inverse floaters and other tranches that are difficult to value in isolation. As we will discuss, however, this should not necessarily be viewed as a hard value, but rather as a guide in generating and judging valuations.

Chapter 7 showed how tranches can be split into floater–inverse floater combinations, depending on the attributes of the parent tranche and the floater to be created. We can express the relationships among the collateral tranche, the floater, and the corresponding inverse floater as follows:

$$\text{Parent tranche} = \text{Floater} + \text{Inverse floater}$$

That is, the sum of the value of the floater and the value of the inverse floater should equal the value of the collateral tranche from which they are created. This relationship holds for both the face value and the dollar value of the bonds; if this relationship is materially violated, arbitrage profits are possible. The relationship can therefore also be expressed as follows:

$$\text{MV of inverse floater} = \text{MV of parent tranche} - \text{MV of floater}$$

where MV is the market value (in total dollar value) of each tranche in question. This expression states that the value of an inverse floater can be found by valuing both the collateral tranche and the floater, and then calculating the difference between the two values. In this case, the value of an inverse floater is not found directly, but instead inferred from the value of the collateral tranche and the floater. The market value of the parent tranche and the floater can be determined through a variety of techniques, including the type of Monte Carlo simulations discussed previously.

The same relationship also holds if dollar prices are used. In this case, however, the leverage of the inverse must be taken into account. For example, an inverse with 4× leverage means that there are four times as many floaters as inverse floaters in the structure. If the parent tranche's face value is \$100 million, there are \$80 million in floaters and \$20 million in inverse floaters. Thus the following relationship holds:

$$100 \times \text{Parent tranche price} = (20 \times \text{Inverse price}) + (80 \times \text{Floater price})$$

This can also be expressed as

$$[20 \times (1 + 4) \times (\text{Parent tranche price})]$$
$$= (20 \times \text{Inverse price}) + [20 \times (4 \times \text{Floater price})]$$

Dividing both sides by 20 results in

$$[(1 + 4) \times (\text{Parent trance price})] = \text{Inverse price} + (4 \times \text{Floater price})$$

This can be generalized for any leverage L as

$$[(1 + L) \times (\text{Parent tranche price})] = \text{Inverse price} + (L \times \text{Floater price})$$

Solving for the inverse floater price results in

$$\text{Inverse price} = [(1 + L) \times (\text{Parent tranche price})] - (L \times \text{Floater price})$$

This relationship have a number of important implications. First, it is typically not difficult to price the floater, especially if it is comparable to other tranches being created in the market. The greater difficulty is usually associated with determining the parent tranche's price. However, the pricing of the parent tranche has a major impact on the pricing of the inverse, due to the impact of the leverage. Put differently, the above equation indicates that every point that the parent tranche is mispriced results in a $1+ L$ mispricing of the inverse floater. In the previous example, a one-point mispricing of the parent tranche would result in the inverse price being off by five points.

The second implication is that, in this context, the price of the inverse is not related to the level of the reference rate. Rather, the reference rate is reflected in the value of the floater, specifically in the value of the cap associated with the floater. Were rates to rise to a level near that of the floater's effective cap, the market value of the floater would fall; if the price of the parent tranche remained stable, the inverse's price would therefore increase. Finally, in this framework the impact of factors such as the shape of the yield curve and the levels of implied volatilities impact the pricing of the inverse indirectly through their effect on the value of the parent tranche and the floater.

As noted, creation value can be a useful guide to the value of an inverse under certain conditions. It is particularly useful in gauging the value of bonds comparable to those being produced in the new-issue market. However, it is not feasible to assess creation value for bonds that cannot, at that point in time, be created. If the production coupon for 30-year pools is 5.5%, for example, it would be impossible to judge the creation value of a bond backed by Gold 7.0s, as none of the components could be priced effectively. This is especially true in the context of the pricing errors that would occur as a result of the inverse's leverage on its price. Finally, structures are often quite complex. Using the standard analytical systems (such as Bloomberg), it is often difficult to deduce exactly how some structures work; in addition, more than one complex bond will need to be valued. For example, the presence of two-tiered index bonds (TTIBs) in a structure requires the analyst to understand how the cash flows are allocated to both the TTIB and the inverse floater; in addition, the TTIB would need to be valued, along with the floater and the parent tranche, in order to value the inverse. In most cases, this is too complex an undertaking, and too prone to error, to be useful.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Yield Matrix
Yield Table
Yield-to-Price Table
Yield-to-Price Table
Principal Window
Discount Margin (DM)
Bond Equivalent Effective Margin (BEEM)
Yield-to-Index Matrix
Rolldown Effect
Bear Flattener
Bull Steepener
Bull Flattener
Bull Steepener
Creation Value

CHAPTER 13

Analysis of Nonagency MBS

While the evaluation of private-label mortgage-backed securities utilizes many of the techniques discussed in Chapter 12, the need to incorporate credit risk and adjust returns for expected principal losses requires additional analysis and metrics. The fact that the credit risk in these securities is not assumed by the government, either explicitly or implicitly, forces investors to evaluate and judge both the timing of the return of principal as well as the amount of principal, if any, that investors can expect to receive. Moreover, credit analysis has moved up what is called the *credit stack*. As we noted in Chapter 12, a major change stemming from the mortgage crisis is that investors can no longer assume that senior private-label mortgage-backed securities have virtually the same credit risk as agency MBS. Any bond that does not have agency credit support must be treated as a "credit piece" requiring the analysis of a variety of internal and external factors.

In this chapter we outline the various elements that drive the performance of nonagency MBS, and also examine the interactions of these factors. We then examine a useful framework for understanding the evolution of a population's credit profile, and conclude with a discussion of a variety of techniques used to evaluate the credit risk and expected returns of private-label securities.

FACTORS IMPACTING RETURNS FROM NONAGENCY MBS

The analysis of agency MBS is focused on estimating the timing of principal cash flows since the government backing of these securities eliminates investors' exposure to principal writedowns. (Of course, the larger issues regarding the future involvement of the government in the mortgage market must be considered.) Private-label securities require layers of additional analysis. This is because of the introduction of a series of additional factors that determine the bond's cash flows and thus their projected returns. These factors can be broadly characterized as:

- The amount of principal expected to be returned.
- The timing of principal returns.
- The allocation of principal within the transaction.

Before proceeding, it will be helpful to review a few concepts. As discussed in Chapter 4, prepayments on nonagency securities must be classified based on their causation. Unlike agency securities, the return of principal to the securitization (or, more specifically, the investment trust) must be treated differently depending on whether it resulted from a voluntary action by the borrower or is forced by credit-related difficulties. Modeling the impact of voluntary prepayments is relatively straightforward; investors can assume that 100% of principal being prepaid will be returned on the next payment date. By contrast, projecting the impact of involuntary prepayments requires an estimate of both *how much* of every principal dollar prepaid will actually be paid to the investor, as well as *when* principal payments will be received by the trust.

The Amount and Timing of Principal Return

The issue of how much principal is projected to be received as a result of involuntary prepayments is a straightforward function of the assumed default rate and ***loss severity***. Default rates are quoted as CDRs (i.e., the annualized rate of default as a percentage of the current balance), while loss severities are simply the percentage of the defaulted principal that will ultimately not be returned to the investment trust. The inverse of loss severity is the ***recovery percentage***.

The issues associated with the timing of principal return are more complex. Since the CDR is by definition the involuntary prepayment rate, a higher default rate assumes the faster return of at least some principal to investors. As a result, the faster return of principal to the trust due to higher default rates can offset the effects of principal loss. This effect is a function of the price of the security, the loss severity, and the tranche's position in the transaction's structure (i.e., under what circumstances the security will absorb losses).

In addition, the amount of time between when a default occurs and recovered principal is received by the trust (the *lag*) can have a major influence on investor returns, especially for bonds that are more junior in priority. A longer lag between the time of default and the receipt of recovered principal delays the writedown of the junior bond's principal value. This means that the investor may receive interest payments for a longer period of time, improving the value of securities for which the interest payments comprise the bulk of expected cash flows. (In fact, lower-priority subordinates are sometimes referred to as ***credit IOs***, since investors assume that no principal will be returned, and the only cash flows that they expect to receive are coupon payments. Since the outstanding principal is written off more slowly, investors holding the tranche receive a larger and longer stream of interest payments as the lag extends.)

There are a variety of factors that influence the lag. Both the amount of seriously delinquent loans at a point in time and the actions of servicers play major roles in the timing of defaults and principal recoveries. The period after 2007, for example, saw a huge increase in the number of seriously delinquent loans outstanding. At the same time, servicers (i.e., the entities that process borrower payments and manage the foreclosure process) were unable to effectively manage the huge surge in problem loans. This resulted in an enormous backup in the ***foreclosure pipeline***, and led to long lags between the time when loans stopped performing and the properties were liquidated.

Legal and political factors also impact lag times. Since real estate transactions are governed by state and local laws, there are differences in the timing of principal returns based on the state in which a loan resides. Some states, which are referenced as ***judicial states***, require that a foreclosure be approved by a judge, which typically slows the foreclosure process. Foreclosures in ***nonjudicial states*** can be processed faster, resulting in shorter lags. Also, the foreclosure process itself can become a matter of controversy. In 2010, for example, problems with the legal documentation of foreclosure filings led to the suspension of foreclosure proceedings in some states, as well as calls for a national foreclosure moratorium.

Generally speaking, the amount and timing of cash flows to the trust are impacted by a variety of actions and decisions taken by both borrower and servicers, and are also influenced by exogenous factors. We discuss how these behaviors can be understood and modeled in a later section.

Deal-Specific Factors

There are also a series of other subtle and obscure factors that can impact the cash flows and returns of nonagency securities. Some of these factors result from decisions by the servicer, while others vary depending on how an individual transaction's governing documents were written. These factors include (but are not limited to) the following:

- Servicers are required to advance principal and interest on delinquent loans. However, the governing documents of most deals state that the servicer is not required to advance any amount it deems "nonrecoverable" through the foreclosure process. The interpretation of "recoverability" depends on servicers' policies with respect to how long they will advance against seriously delinquent loans, along with the LTVs of properties backing these loans. (Since expected recoveries are a function of the current LTV, servicers often will stop advancing on loans where the current LTV exceeds a certain threshold.)

- The treatment of "modified" loans (i.e., loans for which the terms were altered in order to help borrowers meet their obligations) within individual transactions was rarely outlined in deals issued prior to the mortgage crisis. For example, there have been controversies regarding whether "forborne" (i.e., deferred) principal resulting from loan modifications should be written off immediately (which typically benefits the senior bondholders in a transaction) or deferred until the point where principal losses are realized by the trust, which would result in more interest flowing to the subordinates.
- The allocation of losses due to principal and interest "shortfalls" can become highly complex and deal-specific, particularly once the subordinate bonds in an overcollateralization structure are paid off. For example, some deals (typically those issued before mid-2005) only allow for the balances of senior bonds to be reduced by payments actually made by borrowers. These structures can experience a phenomenon called *negative overcollateralization*, which means that losses for the seniors are "implied." As a result, losses on the senior tranches are only realized when the collateral pool is entirely paid off and the trust is terminated with some bond balances still outstanding.

One conclusion that can be drawn is that investors in private-label MBS must have the willingness and ability to read and understand the documents governing their holdings. Events and factors that were either not contemplated or were viewed as highly improbable can, under adverse conditions, become important in determining investor returns.

UNDERSTANDING THE EVOLUTION OF CREDIT PERFORMANCE WITHIN A TRANSACTION

As discussed previously, the actions and decisions taken by both borrowers and servicers, along with outside environmental factors, determine both the amount and timing of cash flows received by the trust. This behavior can be conceptualized through the use of ***transition*** (or *roll*) ***matrices***. Such matrices show the probability of loans moving from one credit status (or "state") to another in any month. This technique is often used as a foundation for formally modeling voluntary and involuntary speeds. We address it here, however, to help conceptualize the "life cycle" of a transaction's credit profile. The methodology offers useful techniques for demonstrating how the credit problems of obligors evolve into delinquencies and defaults and flow through a transaction over time. It is also useful in describing and quantifying how changes in the overall credit environment might impact the performance of a loan population.[1]

Exhibit 13.1 contains a hypothetical example of a roll matrix for a loan population, which can be defined either narrowly (e.g., for a single transaction) or more broadly (to represent a particular product and vintage). The vertical axis of the matrix shows the current (or "from") states of the population, while the horizontal axis shows the future (i.e., "to") states of the loans, typically one month hence. The horizontal axis also allows for two additional states, which would represent termination of the loans either through "payoff" (i.e., prepaid voluntarily) or "liquidation" (involuntarily prepaid). Each row must sum to 100%, as every loan in the population at time zero must transition to some state in the following month.

The matrix itself can be created through a variety of techniques. In some cases, the matrix simply represents historical experience (over either a short- or long-term horizon), while other analysts use loan-level simulations to generate the matrix. Note that not all cells have values greater than zero, as some transitions are impossible; for example, a loan cannot go from current to 60-days delinquent without first residing in the 30-days delinquent bucket.

Once a transition matrix is created, it can be applied to the population's current profile (i.e., at time T_0) as a means of projecting the population's credit performance in a future month. Exhibit 13.2 illustrates the matrix math involved in generating the population's profile in month T_1, treating the T_0 profile as a 1×7 matrix shown in Exhibit 13.2(A) to be multiplied times the 7×9 transition matrix in Exhibit 13.1.[2] Exhibit 13.2(B) shows the resulting profile one month hence (i.e., at time T_1) after summing each column, along with the percentage of loans that drop out of the population through voluntary or involuntary prepayment. The remaining population profile is then normalized by dividing the percentages of remaining loans in each credit state (i.e., excluding loans that are paid off or liquidated) by the remaining percentage in the pool. (In the exhibit, 98.8% represents the portion of the population that remains active; the 59.2% of loans expected to be current in month T_1 is divided by this percentage to get the 59.9% normalized total.)

[1]The authors acknowledge the contributions of Paul Jacob to this section.

[2]The example uses the common notation where loans that are 30 to 59 days delinquent are shown as D30, loans that are 90 or more days delinquent are D90+, and so on. "Payoff" accounts for loans that are voluntarily prepaid; "Liq" are seriously delinquent loans that are liquidated, with T_1 representing the month when recoveries are received by the trust.

EXHIBIT 13.1 Hypothetical Transition Matrix

		T_1 ("to") State									
		Payoff	Current	D30	D60	D90+	Bk	Fcl	REO	Liq	Total
T_0 ("from") State	Current	0.6%	94.6%	4.6%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	100.0%
	D30	0.2%	20.0%	42.4%	36.9%	0.0%	0.4%	0.0%	0.0%	0.1%	100.0%
	D60	0.1%	2.8%	8.9%	34.1%	52.8%	0.5%	0.7%	0.0%	0.2%	100.0%
	D90+	0.1%	1.9%	0.7%	1.0%	85.7%	0.7%	8.3%	0.2%	1.5%	100.0%
	Bk	0.1%	0.1%	0.3%	0.2%	3.7%	86.8%	8.3%	0.4%	0.1%	100.0%
	Fcl	0.1%	0.7%	0.1%	0.0%	4.2%	1.3%	88.7%	3.4%	1.5%	100.0%
	REO	0.7%	0.0%	0.0%	0.0%	0.2%	0.1%	0.4%	82.3%	16.3%	100.0%

EXHIBIT 13.2 Applying the Current Population Profile to the Transition Matrix

A. Current Deal Profile

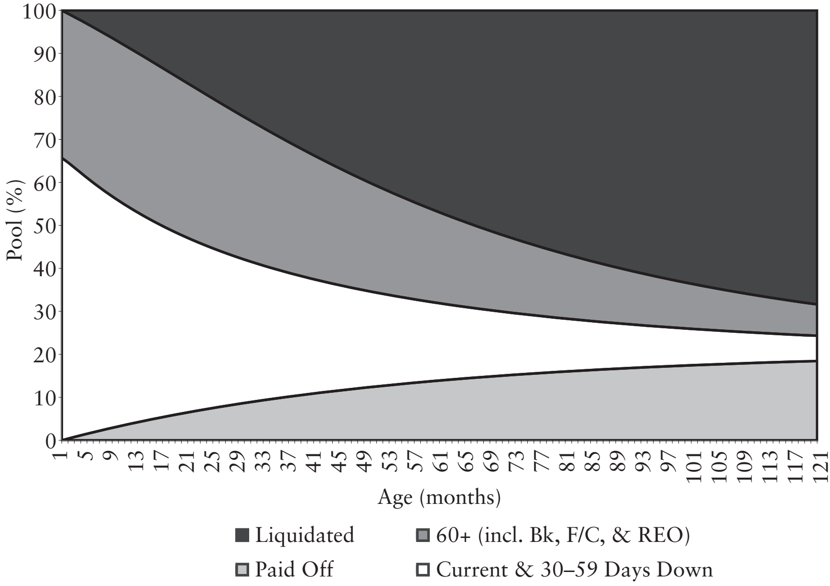
	Percent of UPB
Current	61.1%
D30	4.6%
D60	2.1%
D90+	16.6%
Bk	2.2%
Fcl	11.4%
REO	2.0%

B. Multiply Current Performance by Transition Matrix

		T_1 ("to") State									
		Payoff	Current	D30	D60	D90+	Bk	Fcl	REO	Liq	
T_0 ("from") State	Current	0.3%	57.8%	2.8%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	
	D30	0.0%	0.9%	2.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	
	D60	0.0%	0.1%	0.2%	0.7%	1.1%	0.0%	0.0%	0.0%	0.0%	
	D90+	0.0%	0.3%	0.1%	0.2%	14.2%	0.1%	1.4%	0.0%	0.2%	
	Bk	0.0%	0.0%	0.0%	0.0%	0.1%	1.9%	0.2%	0.0%	0.0%	
	Fcl	0.0%	0.1%	0.0%	0.0%	0.5%	0.1%	10.1%	0.4%	0.2%	
	REO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%	0.3%	
	Subtotal	0.4%	59.2%	5.1%	2.6%	15.9%	2.3%	11.7%	2.1%	0.8%	98.8%
Normalized Total[a]			59.9%	5.1%	2.7%	16.1%	2.3%	11.8%	2.1%		100.0%

[a]Excluding payoffs and liquidations.

EXHIBIT 13.3 Projected Long-Term Performance Trends for Subject Deal

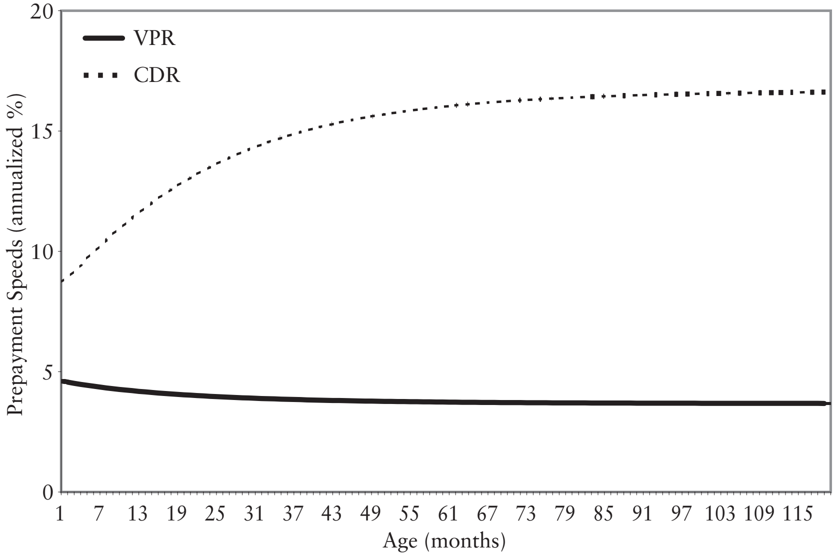


The process can be performed iteratively in order to show how the population's profile can, given unchanged transition behavior, be expected to evolve over time. (This means that the profile at T_1 can be multiplied by the transition matrix to generate a profile for time T_2, etc.) Exhibit 13.3 contains a chart showing the projected profile of the population over the next 10 years by iteratively applying the transition matrix in Exhibit 13.1 to the evolving population. The chart indicates that liquidated loans (i.e., loans that go into default and are removed from the pool through the foreclosure process) will comprise the largest single cohort in around three years if current transition probabilities hold. Moreover, two-thirds of the current population can be expected to be liquidated in 10 years.

The iterative calculation can also be used to generate projections for voluntary and involuntary prepayment speeds. The percentages of the population that pay off and are liquidated can be treated as monthly prepayment rates (i.e., VMMs and MDRs, using the nomenclature from Chapter 4), and can then be annualized to create the equivalent of VPR and CDR vectors that can be utilized to in yield and cash flow calculators.[3] Exhibit 13.4 shows the vectors generated by the analysis over 120 months.

[3]The vectors technically are not the equivalent of VPRs and CPRs since they don't account for the effects of amortization on the cash flows.

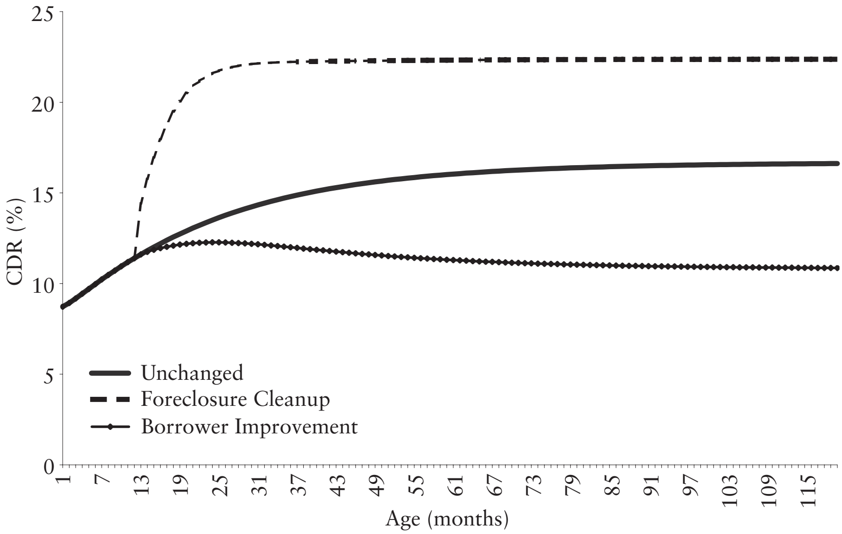
EXHIBIT 13.4 VPRs and CDRs for Subject Deal Using Unchanged Transition Matrix



Interestingly, the vectors are neither constant nor linear; note that the CDR vector increases fairly steadily for the first few years before leveling off around month 60. This pattern highlights the intrinsic nature of population transitions. Loans flow through the different credit states at varying rates that are a function of transition probabilities captured by the matrix. Therefore, the levels of VPRs and CDRs over time will vary even if transition activity is assumed to remain stable.

However, transition patterns normally *do* vary over time, reflecting changes in the economic and lending landscape as well as in the actions of servicers. The impact of changing behaviors can be captured by altering the transition matrix at a point in time. For example, a move on the part of servicers to more aggressively clean up the foreclosure pipeline would be captured in a transition framework by increasing the percentages in "late-stage" transitions (i.e., D90+ to FC, FC to REO, and REO to Liq) at a point in the future. Conversely, a full foreclosure moratorium (which was discussed in 2010) would be taken into account by changing all probabilities "from" the D90+, FC and REO buckets to zero for the expected length of the moratorium. Finally, improved borrower performance would be captured by increasing "cures," (i.e., D30 and D60 to Current) while decreasing the Current to D30 percentage. The updated matrix would be utilized at the point when the changes in behavior were expected to go into effect.

EXHIBIT 13.5 CDR Projections for Different Scenarios after 12 Months



Incorporating such changes in servicer and/or borrower behavior would result in discontinuities in the VPR and CDR vectors. Along with the base vector, Exhibit 13.5 shows the projected CDRs for the subject population if the vectors are calculated using transition matrices after month 12 that reflect the "Foreclosure Cleanup" and "Borrower Improvement" scenarios described above.

THE PROCESS OF ESTIMATING PRIVATE-LABEL MBS RETURNS

The analysis and valuation of private-label MBS is complicated by the need to project and account for a number of variables over and above those required to evaluate agency securities. As noted previously, the analysis requires additional metrics necessary to project the principal and interest cash flows paid to the trust, as well as how they will be allocated to the different tranches, under a variety of scenarios.

The additional complexity associated with private-label MBS means that the dominant metric used to assess expected returns is ***loss-adjusted yield***. This represents the IRR for the security's projected cash flows using the additional factors and variables discussed previously after adjusting for the normal MBS-specific issues such as payment frequency and delay. The increased complexity associated with the product means that some methodologies, such as total return analysis, are infrequently utilized in evaluating credit pieces. For example, total return requires the estimation of a terminal value at the horizon for each scenario being analyzed. The complexity involved in projecting future prices makes them, and thus the analysis, quite subjective.

In the following sections, we analyzed a series of tranches, as well as the collateral, from a representative 2007-vintage hybrid ARM transaction.[4] The three tranches examined include a super–senior (SS) tranche with 24.2% original credit support; a senior mezzanine (SM) tranche (i.e., a bond originally rated triple-A but junior in priority to the SS) with original credit support of 5.25%; and a subordinate (sub) bond or tranche that originally had 3.85% credit enhancement.

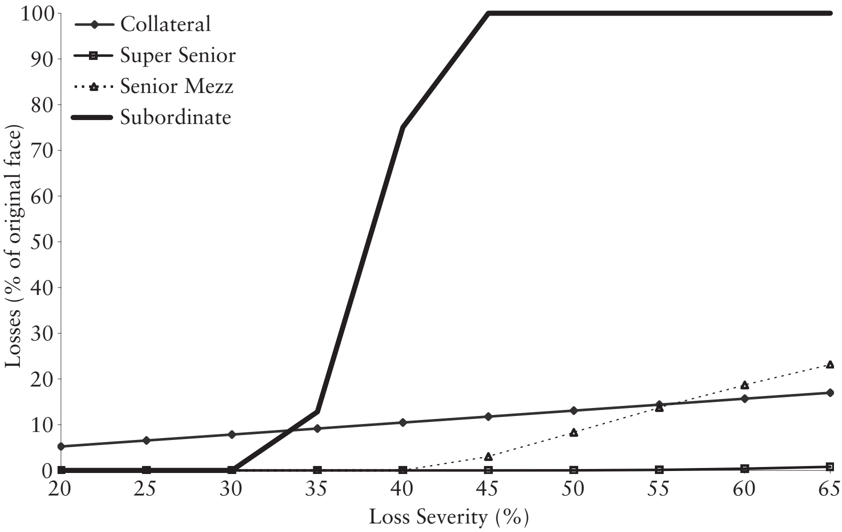
Differentiating between Collateral and Tranche Losses

The various factors outlined above have interesting effects and interactions within individual transactions with respect to losses. For one thing, it is important to differentiate between losses on a deal's collateral pool (i.e., at the trust level) and those impacting individual bonds within a transaction. As outlined in Chapters 8 and 9, private-label MBS have a variety of internal mechanisms that allocate cash flows and principal losses within the structure to tranches having different degrees of seniority. Therefore, losses absorbed by individual bonds are a function of both the losses absorbed by the trust and the amount of credit support available to them.

The chart in Exhibit 13.6 shows projected losses, as a percentage of original face, for both the overall collateral pool of the deal as well as the three tranches described above. Losses were calculated using different loss severity assumptions while assuming a constant 4% VPR and CDR. (These levels are hypothetical and used for illustrative purposes only.) While the line showing projected losses on the collateral has a linear upward slope, the profile of projected losses for the tranches are quite different. For example, the SS tranche suffers no losses until severities are greater than 50%, while the SM begins to experience losses at severities greater than 40%. The sub tranche, however, has a unique loss profile. It experiences no losses until severities exceed 30%, but at that point losses spike higher; virtually the entire principal value of the bond is written off once the assumed loss severity reaches 45%. The chart highlights a critical conclusion; in addition to being different from the collateral, each bond's exposure to losses is a function of its place in the transaction's capital structure.

[4]The analysis utilized CWALT 07-HY8C A1, A2, and M1.

EXHIBIT 13.6 Collateral and Bond Projected Losses at Different Loss Severities (assumption: 4% VPR, 4% CDR,12-month lag)

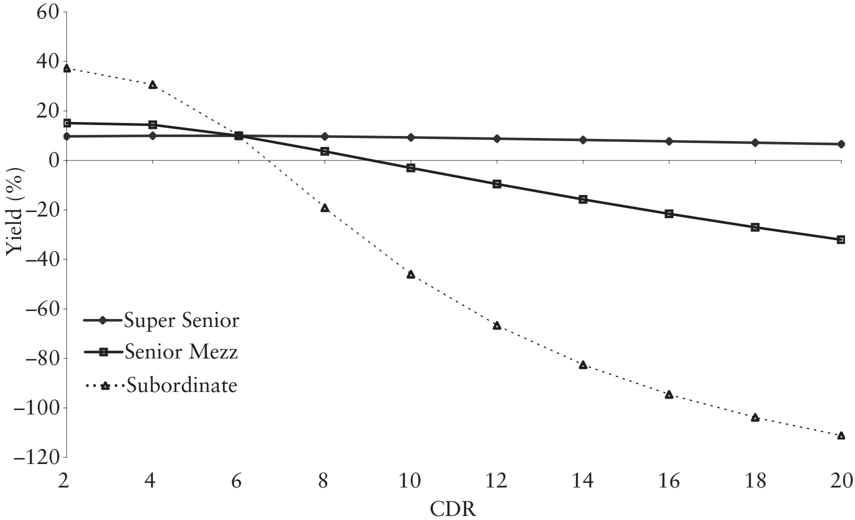


The Interaction of Credit Inputs

There are also a series of interesting observations that can be made by comparing the yields of the three bonds under a variety of scenarios. For the purposes of the analysis, the bonds were all run at the hypothetical level of a 10% yield to assumptions of 4% VPR, a 6% CDR, a 60% loss severity, and a 12-month lag. (This resulted in prices of 64-12, 48-00, and 6-22 for the three securities.) Using those base-case prices, we ran a few representative scenarios in which different variables were altered, with the goal of exploring some of the subtleties of the different tranches' returns.

Exhibit 13.7 shows yields on the three securities calculated using different CDR projections, assuming a constant 4% VPR along with a 60% loss severity and a 12-month lag. The yield on the SS tranche remains fairly stable (and actually increases slightly until the CDR reaches 6%). The reason for this behavior is that faster CDRs effectively increase the overall rate of prepayments to the SS tranche; however, the bond does not absorb losses until the 6% CDR level is breached due to its credit support. Given the tranche's highly discounted dollar price, the faster rate of prepayments increases its yield. By contrast, yields on the more junior tranches decline as CDRs are increased since both bonds realized losses once their limited credit support is exhausted.

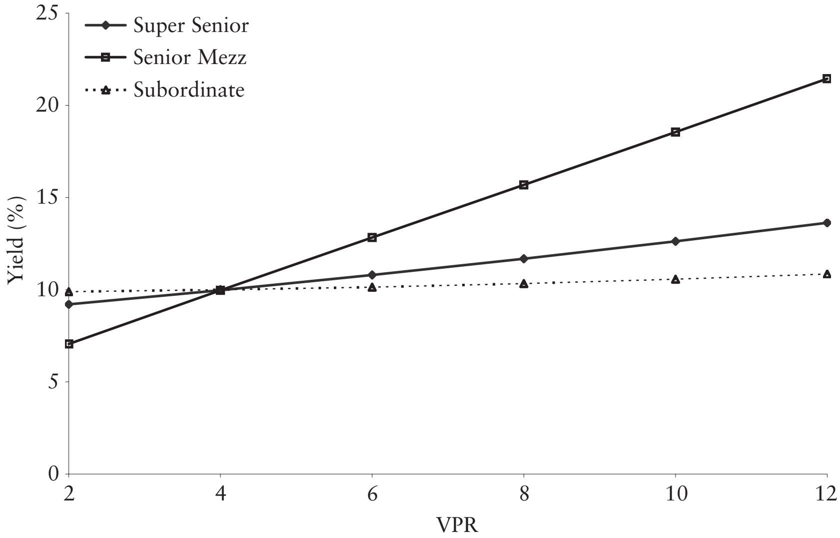
EXHIBIT 13.7 Projected Yields on Different Tranches Using Different CDR (assumption: 4% VPR, 60% severity, 12-month lag)



The rate of voluntary prepayments also influences returns for some bonds in the transaction. Exhibit 13.8 shows projected yields on the three tranches at different assumed VPRs, using a constant 6% CDR (and, as before, 60% severity and a 12-month lag assumption). While their profiles partially reflect the impact of faster prepayments on bonds with deeply discounted prices, voluntary prepayments also have a subtle impact on nonagency MBS. When voluntary prepayments increase, principal is paid back to investors at 100% of face value. This means that there is less principal outstanding that can later go into default, even if the CDR and loss severity are held constant. As a result, yields for the senior tranches are influenced (and in the SM's case, strongly so) by the expected voluntary prepayment speed.

By contrast, the yield on the sub tranche class is insensitive to changes in the VPR assumption, in part as a result of its place in the deal's structure. (As discussed in Chapter 9, subordinates generally don't receive voluntary prepayments in an overcollateralization structure unless the deal "steps down," which does not happen under these assumptions.) Its returns, however, are highly sensitive to the combination of assumptions used for CDRs, loss severities, and lags. In particular, the severity assumption plays a key role despite the fact that the bond does not receive principal under most scenarios. As a credit IO, the tranche's outstanding principal value serves as its notional value by dictating how much interest is paid to investors in any single month. Since

EXHIBIT 13.8 Projected Yields on Different Tranches Using Different VPR (assumption: 6% CDR, 60% severity, 12-month lag)



the severity strongly influences how fast the tranche's face value is written off, it (along with the lag assumption) dictates how long the bond will remain outstanding and thus how much interest investors can expect to receive.

Evaluating Available Credit Support

Before evaluating projected yields and cash flows for a tranche, a prudent step is to assess the security's remaining credit support relative to the expected level of losses. The objective is to evaluate whether a bond's remaining credit support (i.e., the amount and proportion of bonds junior in priority) is adequate given the losses that the transaction is expected to absorb. The following discussion outlines a simple yet useful methodology for gauging a security's credit support relative to expected losses by using its current performance profile.

The analysis begins by evaluating a transaction's capital structure. Exhibit 13.9(A) shows the original and current credit structure of a deal. (While hypothetical, the deal's structure and profile is representative of transactions issued in 2006 and 2007.) The next step, shown in Exhibit 13.9(B), uses a simple technique to estimate future cumulative losses for the transaction. Utilizing the current performance profile of the transaction, each performance cohort is assigned a probability of ultimate default, along

EXHIBIT 13.9 Calculating "Coverage Ratios" for Tranches in a Transaction

A. Original and Current Deal Credit Structure

Tranche	Orig. Rating	Orig. C/E	Curr. C/E	Curr. Factor
A1 (super senior)	AAA	25.0%	23.2%	0.6950
A2 (senior mezz)	AAA	7.5%	4.5%	0.6950
M1	AA	4.0%	2.4%	1.0000
M2	A	3.5%	1.6%	1.0000
M3	BBB	3.0%	0.8%	1.0000
M4	BB	2.5%	0.0%	1.0000
M5	B	1.5%	0.0%	0.0180
M6	NR	0.0%	n/a	0.0000

B. Current Credit Profile of Transaction

Performance	UPB	Eventual Default	Assumed Severity	Expected Loss
Current	63.1%	10%	75%	4.73%
D30	4.4%	50%	75%	1.65%
D60	3.1%	90%	75%	2.11%
D90	14.6%	100%	75%	10.96%
FC	12.8%	100%	75%	9.61%
REO	2.0%	100%	75%	1.48%
Total				30.54%

C. Calculating Coverage Ratio

Tranche	Curr. C/E	Coverage Ratio (curr. CE/expected loss)
A1 (super senior)	23.2%	0.760
A2 (senior mezz)	4.5%	0.147
M1	2.4%	0.079
M2	1.6%	0.052
M3	0.8%	0.026
M4	0.0%	0.000
M5	0.0%	0.000
M6	n/a	n/a

with an assumed loss severity. The example uses a 10% estimate of ultimate default on current loans, a 50% estimate for loans that are D30, while 100% of loans that are seriously delinquent (D90, FC, and REO) are expected to ultimately default. (Note that loans in bankruptcy are not included in this calculation since they are generally captured in other delinquency buckets.) Each delinquency cohort is multiplied by its assigned percentages and the loss severity assumption; the sum of these figures represents the percentage of losses that the deal will ultimately be expected to absorb.

The final step is to divide each tranche's current credit support percentage by the transaction's total expected losses, as shown in Exhibit 13.9(C). This ***coverage ratio*** measures how much credit support is available to each tranche if the expected losses are eventually realized. In the example, the 76% coverage ratio of the A1 tranche suggests that the bond is likely to experience significant future losses, despite its current sizeable cushion. Expected losses will probably also be large enough to eventually caused the other outstanding bonds in the capital structure (i.e., the A2 down to the M5) to be entirely written down.

While this analysis serves as a useful first step in evaluating individual tranches, it is limited by its simplistic approach. The default percentages assigned to each credit bucket are arbitrary, and also cannot account for changes in the credit environment (such as those discussed in the earlier section on Transitions). It also doesn't take into account the issue of time, that is, when losses will accrue and bonds will be written down. This limits its usefulness in evaluating credit IOs and more junior securities. Finally, the analysis doesn't take some forms of credit support, such as excess spread and insurance wraps, into account.

Despite its limitations, however, the methodology serves as a useful first step in evaluating the credit enhancement currently supporting a tranche. In addition, investors evaluating potential purchases of newer securities will find this and related techniques particularly helpful in evaluating both the adequacy of a bond's credit support and whether it is vulnerable to a downgrade by the rating agencies.

Yield and Loss Matrix Analysis

As noted previously, the complexities associated with the product have made loss-adjusted yield the primary metric for evaluating and comparing credit-related MBS. However, standard yield matrices must be altered in order to account for the numerous additional inputs and outputs necessary to properly evaluate private-label MBS. The additional inputs include separate entries for voluntary and involuntary prepayments, along with the inclusion of expected loss severities, lags, and servicer advances. In some cases, the analysis must also account for the presence of insurance wraps and how long they might remain in place; expectations for how long servicers will continue to advance principal and interest; and whether the deal will pass its triggers (i.e., the tests that dictate cash flow distributions within individual transactions, as described in Chapter 9).

In addition, a number of additional outputs are necessary in order to assess a bond's value. In addition to average life, spreads and durations, investors need to assess expected losses on both the tranche and the deal's collateral at different levels of the inputs. Also useful are the points in time, if applicable, that the bond will experience its first principal loss, along with the amount of liquidations and losses previously realized.

Exhibit 13.10 contains examples of yield matrices that might be used to evaluate the super–senior and senior mezzanine tranches introduced in an earlier section. Exhibit 13.10(A) shows tables for the SS (super–senior) tranche and the senior mezzanine (SM) tranche in (B), priced (as before) at a 10% loss-adjusted yield to a 4% VPR/6% CDR base assumption. The tables in the exhibit show loss-adjusted yields and credit performance data for a range of CDRs, while holding the other variables (i.e., VPR, loss severity and lag) constant. In addition to yields and average lives, the matrices show the durations, the dates of the first writedown, and the percentages of bond and collateral losses at the different CDR assumptions (which are the same for both tranches in this case).

However, the necessity of holding multiple inputs constant makes this format somewhat awkward and time-consuming. For example, the tables would need to be recalculated multiple times in order to account for other assumptions for VPRs, loss severities, and lags. An alternative and somewhat more flexible scheme displays two variables as the axes, with yields and/or bond losses as the output (creating three-dimensional "surfaces" of yields and losses). Exhibit 13.11 contains a matrix for the SM tranche showing VPRs on the vertical axis and CDRs on the horizontal, while holding the loss severity and lag assumptions constant. As with other forms of matrices, however, this format is also limited to showing two variables at any one time. Additional matrices would need to be constructed in order to display different factors, depending on how relevant they were to the analysis.

Model-Generated Analysis

The variables used in the above analysis can be generated in a variety of ways, depending on both investors' practices and the prevailing circumstances. During periods of relatively stable credit and housing performance, for example, some investors may choose to simply utilize recent history for inputs such VPRs, CDRs, and loss severities, while making subjective adjustments based on an examination of the transaction's current collateral profile.

EXHIBIT 13.10 Example of Yield Tables for Private-Label MBS Tranches Pricing at 10% Yield at 4% VPR/6% CDR, 60% Severity, and a 12-Month Lag

A. Super–Senior Tranche (Px 64-12)

VPR	4	4	4	4	4	4
CDR	2	4	6	8	10	12
Yield	*9.725*	*9.978*	*9.977*	*9.711*	*9.310*	*8.835*
WAL	10.39	9.96	8.93	7.95	7.11	6.4
Duration	6.49	6.09	5.71	5.36	5.05	4.77
First-Loss Dt	N/A	09/25/2032	08/25/2023	11/25/2019	12/25/2017	09/25/2016
% Tranche Loss (orig. face)	0.0	0.4	3.7	7.6	11.1	13.9
% Collat. Loss (orig. face)	9.0	15.5	20.4	24.0	26.8	28.9
% Collat. Loss (curr. face)	13.0	22.5	29.6	34.8	38.8	41.9

B. Senior Mezzanine Tranche (Px 48-00)

VPR	4	4	4	4	4	4
CDR	2	4	6	8	10	12
Yield	*15.066*	*14.406*	*9.995*	*3.784*	*–2.785*	*–9.137*
WAL	10.38	6.69	4.1	3.01	2.46	2.13
Duration	5.18	4.37	3.59	3.08	2.74	2.52
First Loss Dt	N/A	06/25/2019	10/25/2015	05/25/2014	08/25/2013	04/25/2013
% Tranche Loss (orig. face)	0.0	18.8	34.0	41.2	45.1	47.6
% Collat. Loss (orig. face)	9.0	15.5	20.4	24.0	26.8	28.9
% Collat. Loss (curr. face)	13.0	22.5	29.6	34.8	38.8	41.9

EXHIBIT 13.11 Yield and Bond Loss Matrix for Senior Mezzanine Tranche at Base-Case Price

		CDR 2	CDR 4	CDR 6	CDR 8	CDR 10	CDR 12
VPR	2	13.420 / 0.0%	12.166 / 25.1%	7.081 / 39.9%	0.309 / 46.0%	–6.665 / 49.2%	–13.249 / 51.1%
	4	15.067 / 0.0%	14.402 / 18.8%	9.992 / 34.1%	3.781 / 41.2%	–2.786 / 45.1%	–9.137 / 47.6%
	6	16.893 / 0.0%	16.681 / 13.9%	12.847 / 29.1%	7.128 / 36.9%	0.922 / 41.4%	–5.209 / 44.4%
	8	18.890 / 0.0%	19.010 / 9.9%	15.681 / 24.8%	10.396 / 33.1%	4.515 / 38.1%	–1.409 / 41.4%
	10	21.050 / 0.0%	21.394 / 6.6%	18.515 / 21.1%	13.621 / 29.7%	8.033 / 35.0%	2.306 / 38.6%
	12	23.368 / 0.0%	23.843 / 4.0%	21.368 / 17.9%	16.830 / 26.6%	11.509 / 32.2%	5.968 / 36.0%

Alternatively, some investors may choose to utilize more sophisticated analysis, which can incorporate both the attributes of a deal's collateral along with exogenous economic and market variables. The models can be further incorporated into integrated systems that generate yield and loss figures while simultaneously analyzing and stratifying the collateral. Partial output from such an integrated system is shown in Exhibit 13.12. The exhibit shows a yield matrix from Vichara Technology's system for the SS tranche.[5] The matrix shows a variety of outputs at different multiples of the prepayment and default models, assuming unchanged home prices and interest rates. In addition, separate tables generated by the analysis (not shown) display the current credit structure of the deal, the tranche's cash flows, and analyses of the collateral. (The model also allows for the generation of a "credit OAS," although this metric is not widely utilized by investors at this writing due to its sensitivity to modeling error.)

Additional analysis can be generated for different *home price appreciation* (HPA) and interest rate assumptions. For example, a conservative set

EXHIBIT 13.12 Partial Output of Integrated Model for SS Bond

HPI FLAT/+0 IR Shock Scenario				
Percent of Prepay Model		Percent of Default Model		
	Analytics	75%	100%	125%
75%	Yield	10.561	8.416	7.295
	Price	64.38	64.38	64.38
	WAL	5.454	5.295	4.979
	MDuration	3.661	3.878	3.855
	Convexity	0.263	0.303	0.308
	Present Value	157,012,886	157,012,886	157,012,886
	Present Value+Accrued	157,021,422	157,021,422	157,021,422
	Collateral Loss %	37.84%	44.74%	47.97%
	Bond Collateral Loss	37.84%	44.74%	47.97%
	Bond Principal Window	1-333	1-356	1-379
	Bond Principal Writedown	31,919,013	51,373,711	61,802,013
	First Period Writedown	37	31	27
	Bond Principal Writedown	13.09%	21.06%	25.34%
	Total Interest Shortfall	—	—	—

[5]The system utilizes the deal libraries of Intex Solutions; the analysis shown used models and data provided by CoreLogic.

EXHIBIT 13.12 (Continued)

HPI FLAT/+0 IR Shock Scenario				
Percent of Prepay Model		**Percent of Default Model**		
	Analytics	**75%**	**100%**	**125%**
100%	Yield	14.344	10.668	8.359
	Price	64.38	64.38	64.38
	WAL	4.252	4.336	4.268
	MDuration	2.695	3.062	3.250
	Convexity	0.144	0.186	0.216
	Present Value	157,012,886	157,012,886	157,012,886
	Present Value + Accrued	157,021,422	157,021,422	157,021,422
	Collateral Loss	29.62%	39.49%	45.29%
	Bond Collateral Loss	29.62%	39.49%	45.29%
	Bond Principal Window	1-328	1-355	1-388
	Bond Principal Writedown	17,307,456	40,600,481	56,914,682
	First Period Writedown	40	30	27
	Bond Principal Writedown	7.10%	16.65%	23.33%
	Total Interest Shortfall	—	—	—
125%	Yield	17.718	14.530	10.856
	Price	64.38	64.38	64.38
	WAL	3.495	3.576	3.631
	MDuration	2.183	2.379	2.650
	Convexity	0.094	0.112	0.140
	Present Value	157,012,886	157,012,886	157,012,886
	Present Value + Accrued	157,021,422	157,021,422	157,021,422
	Collateral Loss	24.23%	32.30%	40.38%
	Bond Collateral Loss	24.23%	32.30%	40.38%
	Bond Principal Window	1-328	1-356	1-394
	Bond Principal Writedown	9 ,427,796	26,037,741	45,698,364
	First Period Writedown	44	32	27
	Bond Principal Writedown	3.87%	10.68%	18.74%
	Total Interest Shortfall	—	—	—

Source: Vichara Technologies. Analysis utilizes deal libraries of Intex Solutions, and models and data provided by CoreLogic.

of assumptions might call for a 100 basis point parallel increase in rates accompanied by a 10% immediate decline in home prices. In addition, models for HPA that project different appreciation rates based on geographic and economic factors can also be utilized.

In the case of private-label securities, the normal challenge of assessing a model's "reasonableness" is complicated by the interactive nature of the variables. Unlike agency securities, where "model-equivalent CPRs" can be easily estimated (i.e., the bond's average life is iteratively calculated at various CPRs until it equals the model's calculated WAL), the division of prepayments into voluntary and involuntary categories means that a model-equivalent CDR cannot be calculated unless the VPR is held constant, and vice versa. This necessitates the need for additional output in order to view and judge the model's VPR and CDR projections.

Interpreting the Outputs

The analysis and valuation of most securities (and virtually all fixed income investments) can be broadly summarized as assessing the "correct" level of expected returns given both market conditions and the bond's risks. This means that a number of factors need to be evaluated, including:

- The security's base-case yields and returns.
- Its returns in best- and worst-case scenarios.
- The likelihood of different scenarios being realized.

The relative complexity of analyzing private-label MBS, particularly compared to evaluating agency-backed securities, results from both the multiplicity of factors influencing returns as well as the many exogenous elements that drive these factors.

For example, a cursory evaluation of the yield matrix for the SM tranche (contained in Exhibit 13.10(B)) indicates that that the bond's projected yields decline rapidly as CDRs are increased. However, the matrix in Exhibit 13.11 also shows that the tranche's yields remain relatively high if VPRs increase commensurately with CDRs (i.e., in the lower-right quadrant of the matrix). Alternatively, its projected yields are negative when higher CDRs are paired with lower VPRs (in the upper-right quadrant), while yields greater than 20% can be achieved with a combination of fast VPRs and slowing CDRs (the lower-left quadrant). If an investor decides that the combination of VPRs and CDRs in the upper-right quadrant represents a likely scenario, the negative yields projected for such scenarios indicates that the base-case yield assumption is too low to compensate investors for the risks being accepted.

Utilizing just these two variables, the analysis requires investors to assess the returns of potential investments in a range of different prepayment and default scenarios with varying degrees of plausibility. Further inquiries should be made regarding expected principal losses on the investment under the assumed scenarios, taking the availability and adequacy of credit support into account. The sensitivity of the bond's returns to changes in other relevant factors must then be examined. As an example, expectations for real estate prices will directly impact expected loss severities, which will in turn affect an investor's willingness to buy securities that are more junior in priority. Another example relates to the state of the foreclosure pipeline and its influence on lags. During much of 2009 and 2010, the backup in the foreclosure pipeline meant that buying credit IOs, which benefited from the extended lag, was a profitable strategy as long as servicers continued to advance P&I.

The most difficult aspect of the analysis is generating expectations for factors that are difficult or impossible to quantify. The previous example of the value of credit IOs serves as an example. In addition to the dearth of significant information from servicers (who treat much of the information as having proprietary value), certain factors simply defy quantification. In addition, investors must continuously check their analysis to be certain that they understand what factors are driving their results. This means that the sort of analyses performed earlier in this chapter (particularly in the section describing the interaction of factors) is highly useful in developing intuitions for how bonds can be expected to perform under varying conditions.

Note that this chapter's discussions were focused on the evaluation of ***legacy bonds***, that is, private-label MBS issued in the period prior to mid-2007. The techniques described in this chapter, however, can also be used to evaluate newly issued securities, although some adjustments to the methodologies might need to be made. Investors analyzing the adequacy of credit support using the "coverage ratio" methodology demonstrated in Exhibit 13.9, for example, would need to replace the use of a transaction's current credit profile with alternative ways of predicting future losses.

Finally, noticeably absent from these discussions were any mention of the rating agencies. Bond ratings cannot and should never substitute for rigorous analysis, as investors that experienced the post-2007 credit meltdown can attest. Ratings are relevant mainly due to constraints and restrictions on the holdings of regulated investors; when bond holdings are downgraded to "below investment grade," many investors are forced to liquidate them, causing their prices to crater. Techniques similar to the coverage ratios outlined previously can be used to monitor the adequacy of bonds' credit support and identify bonds that are vulnerable to being downgraded.

CONCEPTS PRESENTED IN THIS CHAPTER (IN ORDER OF PRESENTATION)

Loss Severity
Recovery Percentage
Credit IOs
Foreclosure Pipeline
Judicial States
Nonjudicial States
Transition (roll) Matrices
Loss-Adjusted Yield
Coverage Ratio
Legacy Bonds

Appendix

An Option-Theoretic Approach to Valuing MBS*

Throughout this book, the importance of understanding the underpinnings of prepayment behavior has been emphasized as well as their effects on mortgage-backed security valuations. Prepayment speeds are the dominant consideration in MBS analysis. The evolving nature of borrower behavior was first described in Chapter 4. In Chapters 10 through 12, how prepayment projections are taken into account in valuation, relative value, and risk models was examined. Most prepayment models in current use are econometric models that have been calibrated to historical prepayment data. Although the right to refinance a mortgage is widely recognized as a call option granted by the lender to the homeowner, *option-theoretic* models are not currently used in prepayment modeling despite their use for valuing corporate bonds and agency debentures with embedded option. There are two reasons often cited for not employing option-theoretic models to value an MBS: (1) Most borrowers do not exercise the option optimally; and (2) empirically it has been found that option-based models are not able to explain observed prices of MBS.

In this appendix, we describe a relatively new approach for valuing MBS developed by Kalotay, Yang, and Fabozzi (KYF hereafter)[1] and show

[1]For a complete description of the model, see Andrew Kalotay, Deane Yang, and Frank J. Fabozzi, "An Option-Theoretic Prepayment Model for Mortgages and Mortgage-Backed Securities," *International Journal of Theoretical and Applied Finance* 7, no. 8 (December 2004): 949–978. See also Andrew Kalotay, Deane Yang, and Frank J. Fabozzi, "An Option-Theoretic Approach to MBS Valuation," Chapter 33 in Frank J. Fabozzi (ed.), *The Handbook of Mortgage-Backed Securities: 6th Edition* (Burr Ridge, IL: McGraw-Hill, 2006). For an option-based model for mortgage refinancing, see Andrew Kalotay, Deane Yang, and Frank J. Fabozzi, "Optimal Mortgage Refinancing: Application of Bond Valuation Tools to Household Risk Management," Andrew Kalotay Associates (October 2006).

* This appendix is coauthored by Frank Fabozzi, Andrew Kalotay, and Deane Yang.

how it can be used to value pools of mortgages and MBS issued by Ginnie Mae, Fannie Mae, and Freddie Mac (i.e., high-grade pools, where neither the credit risk of the homeowner nor that of the issuer is a significant factor). The approach distinguishes between prepayments that do not depend on interest rates and refinancings that do. Turnover and curtailment comprise what in the model is referred to as *baseline prepayments*. These prepayments are modeled using a vector of prepayment speeds, while refinancings are modeled using a pure option-based approach. In the model, the full spectrum of refinancing behavior is described using a notion of *refinancing efficiency*. Borrowers are classified as follows:

- *Financial engineers*. Borrowers who refinance at just the right time.
- *Leapers*. Borrowers who refinance too early.
- *Laggards*. Borrowers who wait too long to refinance.

The initial mortgage pool is partitioned into *efficiency buckets*, with the size of each bucket calibrated to market prices. The composition of a seasoned pool is then determined by the excess refinancings over baseline prepayments. Leapers are eliminated first, then financial engineers, and finally laggards. The composition of the mortgage pool gradually shifts towards laggards over time, automatically accounting for the *prepayment burnout* behavior observed in the market.

OPTION-THEORETIC MODELS FOR VALUING MBS

Historically, several option-theoretic approaches to valuing MBS have been proposed. These models were first introduced in the academic literature in the early 1980s but did not appear to have been used by participants in the mortgage market then or now.[2] These models assumed optimal refinancing decisions by homeowners and exogenous reasons for other prepayments and later extended by incorporating transaction cost or other market frictions to explain why nonoptimal refinancing decisions were observed in the market. The chief pitfall of these models was that they assumed the refinancing behavior of all homeowners was identical and optimal under specified economic conditions, implying that all refinancings occur simultaneously in a given mortgage pool.

[2]See, Kenneth B. Dunn and John J. McConnell, "A Comparison of Alternative Models for Pricing GNMA Mortgage-Backed Securities," *Journal of Finance* 36, no. 2 (1981): 471–483; Kenneth B. Dunn and John J. McConnell, "Valuation of Mortgage-Backed Securities," *Journal of Finance* 36, no. 3 (1981): 599–617; and Richard Stanton, "Rational Prepayment and the Valuation of Mortgage-Backed Securities," *Review of Financial Studies* 8, no. 3 (1995): 677–708.

Wall Street firms sought to develop models that overcame the drawbacks of the option-theoretic models in the academic literature. In 1987, two researchers then at Merrill Lynch, Andrew Davidson, and Michael Hershovitz, developed a model that they coined the "threshold refinancing pricing model."[3] While in their model, they also attributed nonoptimal refinancing as being due to transaction costs, but assumed that a mortgage pool is heterogeneous with different homeowners facing different transaction costs. Similar heterogeneous pool models have also been proposed and analyzed by other practitioners and in the academic literature. While the Davidson-Hershovitz model was implemented at Merrill Lynch, it never gained wide acceptance in the mortgage market and was eventually abandoned. One key problem in earlier option-theoretic models was the unrealistically high transaction costs required to fit market prices for MBS.

AN OPTION-BASED PREPAYMENT MODEL FOR MORTGAGES

The KYF model is similar in some regards to earlier option-theoretic models, but differs in crucial aspects. It is similar because the model of refinancing behavior is based on an optimal option exercise strategy. They also model heterogeneity by decomposing the mortgage pool into buckets and assuming that each bucket represents different refinancing behavior. The crucial features distinguishing the model from the others are the following:

- Mortgage cash flows and the cash flows of MBS are discounted using different yield curves, a procedure not followed in previous option-theoretic models.
- Prepayments are classified as one of two different types and then each is modeled differently. The first type, turnover, is assumed to be independent of interest rates, and the second, refinancings, is assumed to depend on interest rates.
- Refinancing behavior is not modeled in terms of transaction costs but in terms of an "imputed coupon," which is defined later.

This immediately affords a simple and natural way to model the credit profile and the credit impairment of the homeowner (as an OAS). The model handles real transaction costs in a straightforward manner.[4] In addition, the

[3]Andrew Davidson and Michael Hershovitz, "The Refinancing Threshold Pricing Model: An Economic Approach to Valuing MBS," Merrill Lynch Mortgage-Backed Research, November 1987.

[4]Therefore, the *lifetime refinancing cost* as studied in the academic literature is considered.

model provides a simple means of parameterizing the full range of possible suboptimal refinancing tendencies (leapers to laggards).

Existing prepayments models are based upon overly complex descriptions of prepayments. They all have many input parameters to set or calibrate and run into the danger of overfitting. The KYF model, in contrast, is a parsimonious prepayment model that uses the simplest possible mechanisms to account for all crucial factors that drive the price of an MBS. The KYS model employs only a few input parameters set at reasonable and realistic values—and is able to reproduce the market prices of new mortgage pools and pass-through securities, and how they change as market conditions change. The prepayment process of the mortgagor is modeled in considerable detail, the basic idea being that once a simple and realistic formulation of the prepayment process is obtained, it will be clear how "turning the knobs" affects cash flows and value.

The KYF model makes a distinction between interest rate-driven refinancings and all other prepayments. It assumes that the sole purpose of refinancings is to reduce interest expense. Using the term more broadly than is customary, they refer to all other prepayments as turnover. While the distinction between refinancing and turnover is admittedly somewhat blurry—home sales may in fact depend on interest rates—for modeling purposes they consider the approach adequate.

Model of Turnover

While reasons such as defaults, disasters leading to a destruction of the property, and property appreciation may explain turnover, the primary cause of turnover is sale of the property. (As discussed in Chapter 4, a proxy for turnover is annualized existing home sales as a percentage of the total number of homes.) A prepayment attributable to the mortgagor seeking to take advantage (monetizing) the appreciation in the value of the mortgage property is referred to as a *cashout refinancing*, and its impact on prepayment speeds is often generally ascribed to *turnover*.

In the KYS model, turnover is described in terms of a vector of monthly prepayment speeds over the legal life of the mortgages (e.g., a vector of prepayment rates quoted in terms of the PSA benchmark). In data from periods of high interest rates—and, therefore, low rates of economical refinancing—turnover is somewhere between 75% PSA and a 100% PSA. KYS show how their model can determine the market-implied turnover rate. Their results are in good agreement with expert opinion and historical experience, which find that 50% PSA is too low and 150% PSA is too high. In their illustrations, a turnover rate of 75% PSA is used and is referred to as the *baseline rate*. Assuming that the interest rate for new mortgages incorporates the market's expectation of turnover, they estimate the baseline rate.

Model of Refinancing Behavior

From the perspective of the mortgagor, the risks entailed in the refinancing decision are obvious: Ex post, refinancing is seen as premature if rates continue to decline, while waiting is perceived to be a mistake if rates rise. There are rigorous option-based valuation tools available to assist borrowers with the timing decision. Many corporate and municipal bond issuers routinely employ the "efficiency" approach described below in their refunding decisions.[5] Why the concept of refinancing efficiency has been absent from the MBS literature is an enigma.

The basic idea is to treat the mortgagor's right to refinance as a formal call option, exercisable at any time at par.[6] Given the prevailing mortgage rates and a market-based interest rate volatility, the mortgagor can determine the value of the refinancing option and compare it to the attainable savings (expressed in present value terms). The ratio of savings to option value is called *refinancing efficiency*. Although refinancing efficiency cannot exceed 100%, it will reach 100% if rates are sufficiently low. At 100% efficiency the expected cost of waiting for interest rates to decline further exceeds the cost of the new mortgage. Financially sophisticated borrowers will refinance when refinancing efficiency reaches 100%.

An optionless yield curve is needed to compute the savings and option value. While optionless borrowing rates are readily available for institutional borrowers, commonly quoted residential mortgage rates are technically immediately callable and this point is addressed next.

Few homeowners possess the financial sophistication described so far. In the KYF model, those that do have that capability are referred to as *financial engineers*. Most homeowners refinance too early (at an refinancing efficiency less than 100% of the option value) or too late (they continue waiting after refinancing efficiency has reached 100%). Early refinancers are referred to as *leapers* in the model, while those who act late are referred to as *laggards*. Together, financial engineers, leapers, and laggards span the entire spectrum of refinancing behavior. KYF establish that a rational leaper cannot refinance much sooner than a financial engineer; doing so would actually result in a loss, rather than in savings. For this reason, they focus on laggards, rather than on leapers.

[5]See William M. Boyce and Andrew J. Kalotay, "Optimum Bond Calling and Refunding," *Interfaces* 9, no. 5 (1979): 36–49; and C. Douglas Howard and Andrew J. Kalotay, "Embedded Call Options and Refunding Efficiency," in F. J. Fabozzi, *Advances in Futures and Options Research, vol. 3*, pp. 97–117 (New York: JAI Press, 1988). For a review of the underlying theory, see Andrew J. Kalotay, George O. Williams, and Frank J. Fabozzi, "A Model for Valuing Bonds and Embedded Options," *Financial Analysts Journal* 49 (May–June 1993): 35–46.

[6]As discussed in Chapter 1, some loans are structured with prepayment penalties.

KYF provide a formal definition for leapers and laggards. Their parameterization is a natural extension of the definition of the financial engineer, characterizing refinancing behavior by assigning the mortgagor an *imputed coupon*. The mortgagor will refinance whenever a financial engineer would refinance a maturity-matched mortgage with the imputed coupon. For example, consider two 7% mortgagors who refinance suboptimally—one does so when a financial engineer refinances a 6% mortgage and the other when a financial engineer refinances a 7.5% mortgage. Because the former's imputed coupon is 6% and actual is 7%, we refer to the borrower as a 1% laggard (who refinances late). Similarly, the one with an imputed coupon of 7.5% is a 0.5% leaper (or equivalently a –0.5% laggard), who refinances early.

The following related assumptions are made in the model:

1. The turnover rate is uniform across all types of mortgagors, be they leapers, laggards, or financial engineers.
2. Migration over time across behavioral types is not allowed: once a laggard, always a laggard.
3. The refinancing decision of a financial engineer does not depend on the expected turnover of the pool. In other words, the cash flow savings and the option value are calculated assuming the full remaining term of the mortgage.

Burnout

Prepayment burnout, or simply *burnout*, refers to the observed slowdown of interest rate driven prepayments following periods of intensive refinancings. It is attributed to the changing distribution of the pool: The most aggressive mortgagors (leapers) are the first to refinance, leaving behind the slower reacting laggards.

Conventional MBS analysis handles burnout by changing the parameters of the prepayment function. One possible refinement is to partition the pool by prepayment speeds, so that the earliest prepayments will be attributed to the fastest sector.[7]

From the pool factor—the ratio of the mortgage pool's remaining principal balance outstanding to the mortgage pool's original principal balance outstanding—the extent of prepayments can be inferred. Contractual (i.e., regularly scheduled) amortization determines at any given time the maximum possible value of the pool factor, assuming no prepayments at all (i.e., 0% PSA). Any difference between this maximum value and the actual value is due to prepayments. Although conventional prepayment models do not

[7] Alexander Levin, "Active-Passive Decomposition in Burnout Modeling," *Journal of Fixed Income* 10, no. 4 (2001): 27–40.

explicitly distinguish between turnover and refinancing *ex post*, low pool factors for high-coupon mortgage pools are understood to be primarily due to refinancings.

In the KYF model, burnout requires no special treatment. The assumed turnover determines a baseline value for the pool factor. Any difference between the baseline pool factor and the actual pool factor is attributed to refinancings. Because the model specifies the order in which mortgagors refinance (leapers first, followed by financial engineers, and then by laggards), the pool factor unambiguously determines who has left and who still remains in the mortgage pool. In statistical terms, the pool factor determines the *conditional distribution* of leapers and laggards, given an initial distribution.

Therefore, burnout is a natural consequence of the model. Given two otherwise identical mortgage pools, the one with the smaller pool factor will automatically prepay more slowly.

VALUATION OF MORTGAGES

To understand the KYF option-based mortgage valuation model, we begin with a discussion of the term structure of optionless mortgage rates. While these rates are readily observable in virtually all other sectors of the credit markets, in the realm of residential mortgages they are virtually nonexistent. One of our principle objectives is to determine, in terms of basis points, the market cost of the prepayment option. By carefully distinguishing between turnover and refinancings, KYF establish that turnover actually reduces the cost of the option.

The Term Structure of Mortgage Rates

Arbitrage-free valuation of a fixed income instrument requires as an input an optionless yield curve. This curve can be converted into spot and discount rates by bootstrapping, or into a lattice to value an instrument with an embedded option.[8]

Because conventional residential mortgages are immediately prepayable, an optionless yield curve cannot be observed directly. In addition, standard mortgages rates are for amortizing structures rather than bullets. KYF analyze mortgages assuming that an optionless yield curve is actually observable. Later on the KYF framework explains how this yield curve can be inferred from prevailing mortgage rates.

[8]See Kalotay, Williams, and Fabozzi, "A Model for Valuing Bonds and Embedded Options."

EXHIBIT A.1 Optionless "Bullet" Mortgage Yield Curve

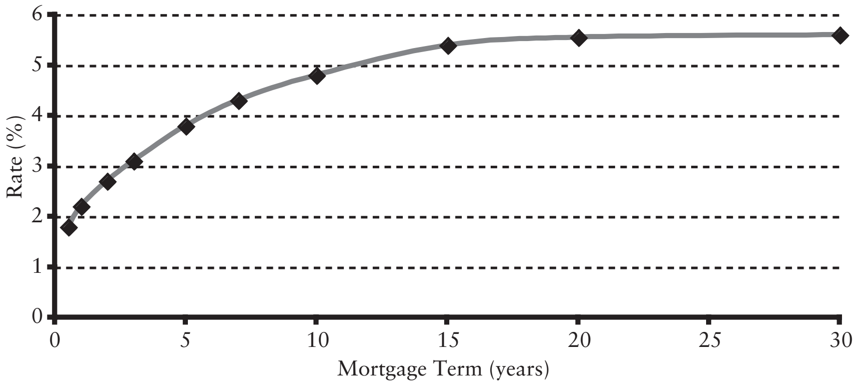
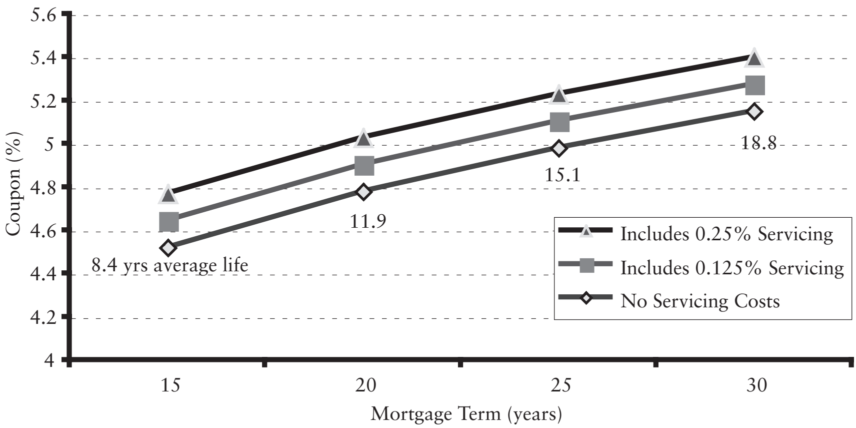


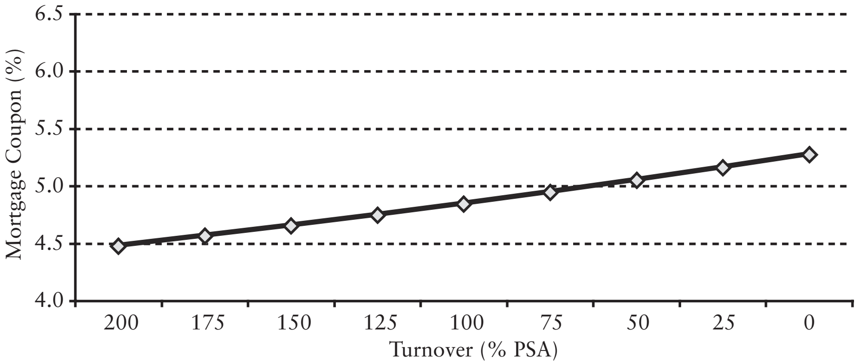
EXHIBIT A.2 Fair Coupon on Nonprepayable Mortgages



KYF first discuss the effect of servicing cost. The cash flows received by an investor is net servicing cost: The higher this cost is the lower, the value of the mortgage. Given the annual servicing cost, the fair value of an optionless mortgage with a specified interest rate and maturity can be determined. Or one can determine the interest rate on a new optionless mortgage that sells at par. Exhibit A.1 shows their assumed optionless bullet mortgage rates. This mortgage curve is 80 basis points above the fixed side of a maturity-matched LIBOR swap curve. Note that the yield curve is steeply upward sloping and that the 30-year "bullet" (i.e. nonamortizing) rate is 5.60%.

Exhibit A.2 shows the fair interest rate of optionless amortizing mortgages of various maturities. For example, in the absence of servicing cost,

EXHIBIT A.3 Fair Coupon of 30-Year Prepayable but Nonrefinanceable Mortgage (including 0.125% refinancing cost)



the fair rate on a 30-year level-pay mortgage is 5.15%, 45 basis points below the 30-year bullet rate. The reason for the difference is the upward sloping yield curve—the average life of a 30-year mortgage is only 18.75 years. In general, the shorter the final maturity the lower is the rate. Also shown in Exhibit A.2 are fair mortgage rates incorporating service costs. The servicing cost is essentially additive. For example, if the annual servicing cost is 0.25%, the fair mortgage rate increases from 5.15% to 5.40%.

Consider a large pool of new 30-year mortgages and assume that its annual turnover can be accurately predicted. KYF parametrize turnover as a multiple of the PSA speed; in particular 0% depicts no prepayments at all. The annual servicing cost is assumed to be 0.125%. Exhibit A.3 shows how turnover affects the rate of a new 30-year nonrefinanceable mortgage. As in Exhibit A.2, because of the upward-sloping yield curve the higher the turnover (i.e. the shorter the average life) the lower will be the mortgage interest rate.

Expert estimates of the annual servicing cost vary between 0.0625% and 0.25%. In the examples presented by KYF and that are reproduced below, it is assumed that the cost is 0.125%, resulting in a rate of roughly 5.28% for a new 30-year mortgage

How Turnover Affects Mortgage Rates

KYK calculate the fair interest rate of optionless mortgages. Consider hypothetical mortgages that *can be prepaid but cannot be refinanced*. This notion is the exact analogue of the familiar "callable but not refundable" feature of corporate bonds. But while for bonds this notion is relatively unimportant, for mortgages it is extremely significant because turnover is an important, if not the principal source, of prepayment activity.

The Refinancing Decision

KYF then analyze the effect of the refinancing option. First they develop a model of how mortgagors can approach the refinancing decision using the notion of refunding efficiency. For illustration purposes, they consider mortgages with 25 years remaining to maturity. Because they report all values as a percentage of the outstanding face amount, the dollar size of the mortgage is irrelevant. For illustration purposes, they assume that refinancing expenses amount to 1%.

For valuation purposes, the mortgagor and the investor should use the same yield curve (and associated lattice) because both are looking at essentially the same cash flows.

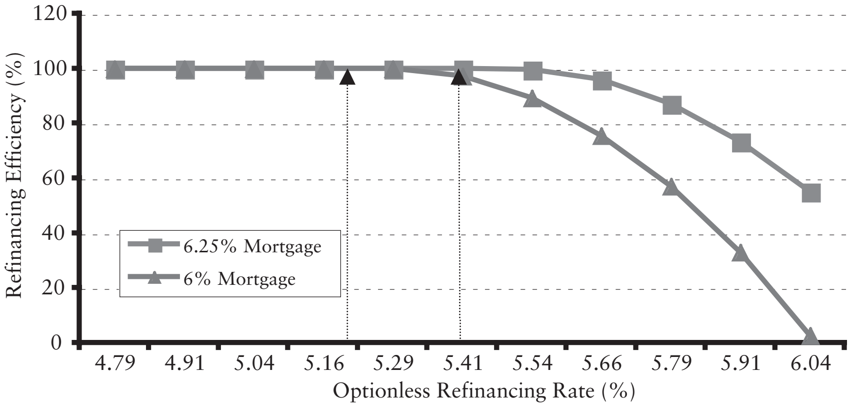
The textbook approach[9] to determine savings assumes that the new mortgage is optionless and matches the amortization schedule of the outstanding one, for the remaining 25 years. In practice the terms tend to be mismatched and the new mortgage is immediately repayable. (KYF examine this issue but we will not cover it here.) Consider a 6% mortgage with 25 years to maturity; its remaining average life is about 15.5 years. The rate of a matching refinancing mortgage turns out to be 5.41%. The savings are equal to the difference between the present values of the existing mortgage and the new one. A computation shows that the amount saved (net refinancing cost) would be 5.05% of outstanding principal. On the other hand, at 16% volatility the option value (accounting for potential future refinancing costs) is 5.675% of the outstanding principal amount. The resulting refinancing efficiency is their ratio, 89.2%. For a 6.25% mortgage the savings is 8.602% to 1.010% and the refunding efficiency is 99.5%. Exhibit A.4 displays how the refinancing efficiency responds to changes in of the mortgage yield curve. For example, the yield curve would have to decline 23 basis points, corresponding to a 5.18% refinancing rate, in order that the efficiency of the 6% mortgage reach 100%.

It can be concluded that a financial engineer would refinance a 6% mortgage with 25 years to maturity if he or she could obtain a matching 5.18% mortgage (an annual saving of 82 basis points before transaction cost), while the target rate for a 6.25% mortgage is about 5.40% (a saving of 85 basis points).

Note that efficiency depends not only on the refinancing rate but also on the shape of the yield curve and the interest rate volatility, here assumed

[9]See John D. Finnerty and Douglas R. Emery, *Debt Management* (Boston: Harvard Business School Press, 2001).

EXHIBIT A.4 Refinancing Efficiency for 25-Year Mortgages



to be 16%. At a higher volatility the option value would increase and, therefore, the 100% efficiency level would require a lower rate. (Standard econometric models do not consider the effect of interest rate volatility on prepayment speed.)

As mentioned already, in practice the new mortgage does not match the maturity structure of the outstanding one and it is also repayable. How does the refinancing efficiency approach cope with these considerations? The basic idea is that as long as the refinancing mortgage is fairly priced, its precise structure is irrelevant; its maturity and coupon structure can be arbitrary. For example, it is possible to determine the savings from refunding a 25-year, fixed rate mortgage with a 30-year, adjustable rate mortgage. Returning to the example of the 6% mortgage with 25 years left to maturity, we saw that it should be refinanced if it is possible to obtain a matching 5.18%, 25-year mortgage. But the mortgagor could also opt for a 30-year, nonrefinanceable mortgage with a slightly higher rate (say 5.22%) or even a 30-year, refinanceable rate (say 5.62%, more about this later). The practical problem is that a mismatch introduces interest rate risk and, therefore, the savings are not guaranteed. For example, if interest rates rise, refinancing a fixed rate mortgage with one that floats (i.e., a short-reset ARM) can result in a loss rather than a savings. Note that this problem does not arise when the mortgages are matched because the periodic cash flow savings are known.

The refinanceabilty of the new mortgage poses a similar problem. Because a refinanceable mortgage bears a coupon higher than an otherwise identical optionless mortgage, the nominal cash flow savings are lower. On the other hand, there is the potential of additional savings should rates continue to decline further. The critical question is whether or not the refinancing feature is fairly priced by the market.

Adjusting both savings and option value for possible mispricing of the new mortgage is straightforward. If such mispricing favors the borrower, the adjusted refinancing efficiency will be higher, and this should advance the timing of refinancing.

The Market Cost of the Refinancing Option

KYF extend the valuation method described above to determine how many basis points the market charges for the refinancing option on a new 30-year mortgage. Exhibit A.3 serves as a reference: It shows the nonrefinanceable rate at an assumed turnover.

Exhibit A.5 displays the basic results reported by KYF. The critical assumptions are that the interest rate volatility is 16%, the refinancing cost is 1%, and the refinancing decisions are optimal (i.e., every mortgagor is a financial engineer). Each of these assumptions can be easily changed. For now, the implications of the KYF findings are reported.

Exhibit A.6 shows the cost of the refinancing option as a function of turnover, obtained by subtracting the optionless rates from the refinanceable rates. Observe that the lower the turnover the more the market charges for the refinancing option: for example, at a turnover of 0% PSA, the cost would be 86 basis points, while at 150 PSA it is only 20 basis points. As indicated earlier, KYF assume that the expected turnover rate for a new mortgage pool is 75% of PSA; at that rate the current estimated cost of the refinancing option would be roughly 40 basis points. This result seems

EXHIBIT A.5 Fair Coupon for 30-Year Mortgages (including 0.125% servicing cost)

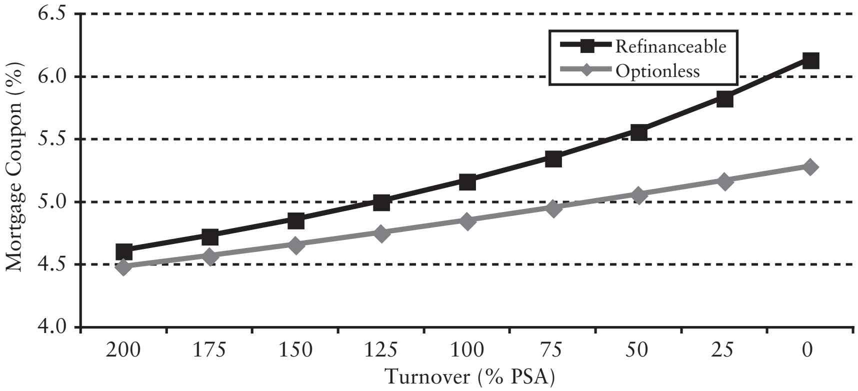
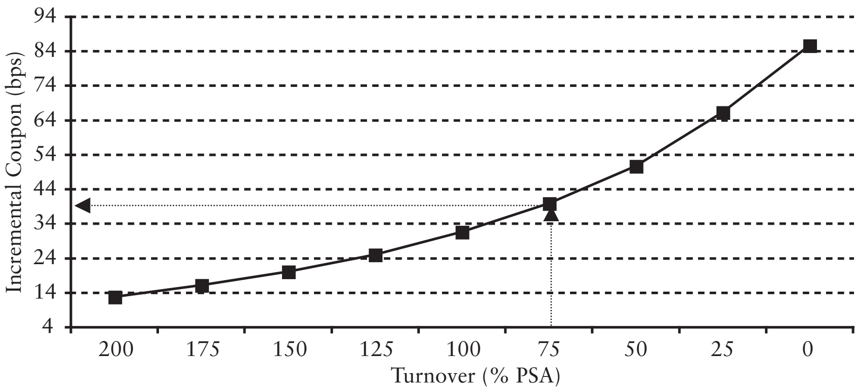


EXHIBIT A.6 Cost of Refinancing Option



reasonable and it provides additional justification for using the 75% PSA assumption for turnover in this context.

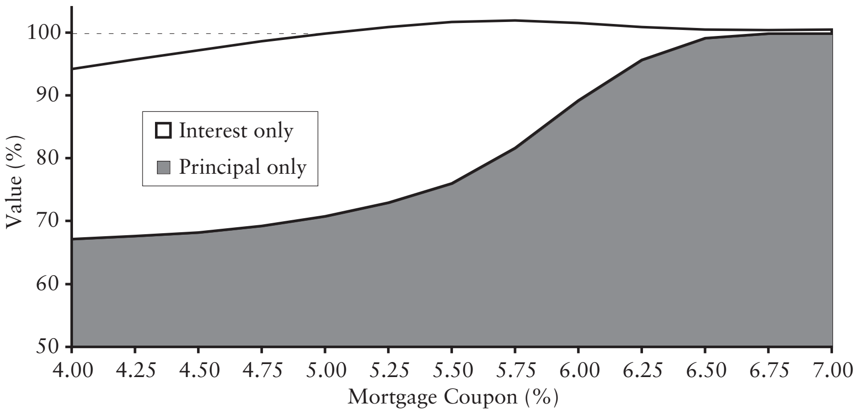
The above results are based on the assumption that every mortgagor is a financial engineer. This assumption to a specified leader–laggard behavior can be easily modified, or it can be more generally assumed that the initial pool can be represented by some distribution of leaders and laggards. KYF state that the cost of the refinancing option of new mortgages depends primarily on turnover, and only weakly on leaper–laggard distribution. At the same time, they observe that as the pool ages it becomes skewed toward laggards and, therefore, the leaper–laggard distribution is critical in valuing seasoned pools.

In summary, KYF show that a financial engineer would refinance a long-term mortgage with a like nonrefinanceable mortgage if he or she could save about 85 basis points. But the market offers only refinanceable mortgages at roughly 40 basis points higher. Therefore, a financial engineer will refinance a long-term mortgage when the market rate is about 45 basis points (85 to 40) below the rate of the outstanding mortgage.

Seasoned Mortgages and Tranches

For seasoned mortgages, KYF assume that the mortgagor is a financial engineer and, in order to demonstrate certain points, that the servicing cost is zero. Exhibit A.7 shows the values of pools of conventional (i.e., uninsured) 30-year mortgages over a wide range of coupons. In anticipation of valuing mortgage derivatives products (collateralized mortgage obligations and mortgage strips), the exhibit also displays the interest and principal components.

EXHIBIT A.7 Value of Principal and Interest Components of Conventional Mortgage Pools



Note that the value initially increases, reaching a peak of roughly 101 at a 6% coupon. As the coupon further increases, the value declines to slightly above 100. There are reasons for this phenomenon.

Consider the right side of Exhibit A.7. Because a financial engineer will refinance a mortgage whose coupon is very high without delay, the value of such mortgage is expected to be very close to 100. The slight premium observed in the exhibit is due to the additional interest received by the investor during the period from when the homeowner notifies the mortgage servicer of his or her intent to refinance to the actual refinancing date.

It is less intuitive, however, how the value of a mortgage can exceed 101 if the refinancing option is optimally exercised. The 1% refinancing cost is clearly insufficient to explain this phenomenon. The fundamental reason is that the mortgagor's refinancing decision disregards turnover. *In essence, the mortgagor refinances only when it would make sense to do so with a maturity-matched mortgage*. In the refinancing decision, the mortgagee does not take into account the possibility of having to prepay the mortgage for reasons unrelated to interest rates. Because, when he or she refinances, a mortgagor does not plan on moving in the foreseeable future, such a "myopic" decision policy seems realistic. The effect of turnover on the value of the mortgage is extenuated when the yield curve is steeply` upward sloping, as is the case here. While financial engineer mortgagors are patiently waiting for interest rates to decline to a level where refinancing is optimal, some of them end up prepaying for unrelated reasons.

A CLOSER LOOK AT LEAPERS AND LAGGARDS

The Range of Leaper–Laggard Spreads

While the ultimate goal of the KYF model is to value MBS, it is worthwhile to continue to focus on the underlying unsecuritized mortgage pool. The differences between the MBS and the pool are twofold. First, only a specified portion of the mortgage interest is passed through to the MBS holder, and second, because of credit enhancement and liquidity considerations, the MBS cash flows are preferable to the mortgage cash flows—and hence discounted at a lower rate. KYF reexamine these issues in the valuation of MBS.

As discussed above, implementation of the KYF model requires a user-specified turnover rate and leaper–laggard distribution. They provided anecdotal evidence to the reasonableness of using 75% PSA for the turnover rate. Assuming this and that the mortgagor is a financial engineer, they calculated the fair interest rate of a new refinanceable mortgage.

They then relax the assumption that every mortgagor is a financial engineer and consider how a heterogeneous pool affects value based on the given rigorous definition for leapers and laggards. Using financial engineers as a point of reference, KYF specify behavior by a spread relative to the financial engineer. Next, they establish the relevant range of these spreads.

KYF use the following argument to establish that leaper spreads should be less than 0.5%. Consider a 0.5% leaper with a 6% mortgage (i.e. a 6% mortgagor whose imputed coupon is 6.5%). As explained earlier, a financial engineer will refinance a 6.5% mortgage when market rates (of refinanceable mortgages) are in the 6.0% range. Accordingly, a 0.5% leaper would refinance his or her 6% mortgage at the time the mortgage is received, a behavior which is clearly nonsensical. Prepayment of a 6% mortgage, when rates are at 6%, can be attributed only to turnover, not to refinancing. Therefore, KYF cap leaper spreads at 0.25%.

Laggard spreads, on the other hand, can be much wider; but unless the mortgagor is credit-impaired, he or she should not exceed 1.5%. A 1.5% laggard would not refinance his or her 6% mortgage until market rates have fallen below 4%. Given the readily available information about current mortgage rates (the *media effect*), anyone who does not refinance a 6% mortgage when rates are at 4% is unlikely to ever refinance.

While the behavior of mortgagors can vary widely, it is reasonable to assume that when a new mortgage pool is assembled, it is dominated by mortgagors in the +25 to –25 basis point range. But, as discussed earlier, the distribution tends to become more and more laggardly as the pool ages.

The Effect of Leapers and Laggards on Value

Leaving all other assumptions (turnover equal to 75% PSA, refinancing cost equal to 1%, servicing cost equal to 0.125%, etc.) unchanged, Exhibit A.8 shows the fair coupon and the cost of the refinancing option for new 30-year mortgages over the relevant range of leapers and laggards. The cost of the option is obtained by subtracting the 4.95% optionless rate corresponding to 75% PSA (shown in Exhibit A.3). Evidently with the exception of extreme laggards, behavior has little impact on the cost. This confirms that the market rate of new mortgages can be explained by the assumption that financial engineers dominate the initial pool.

Exhibit A.9 displays how refinancing behavior affects the value of 30-year, 5%, 6%, and 7% unsecuritized mortgage pools and in the process also demonstrates how the KYF approach captures the burnout phenomenon. For leapers or financial engineers, the value of a premium 7% mortgage is barely over par, but laggardly behavior greatly increases the value because the mortgages will remain outstanding longer. As the amount outstanding (i.e., the factor) declines, the mix automatically shifts towards laggards, increasing the dollar price of the amount that remains outstanding.

Laggard Spread Distribution

How refinancing behavior, as depicted by laggard spread, affects the value of an unsecured mortgage pool was shown earlier. For a given a distribution of laggard spreads, the value of the pool and that of the corresponding

EXHIBIT A.8 Fair Coupon (with 0.125% servicing fee) for 30-Year Refinanceable Mortgage across Behavior Spectrum

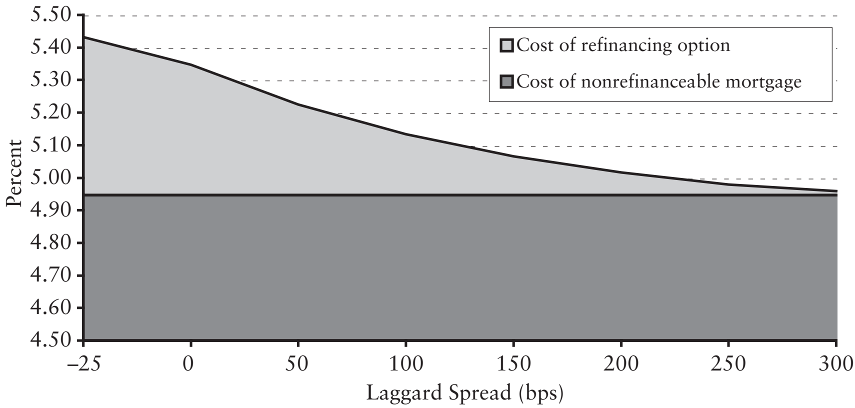
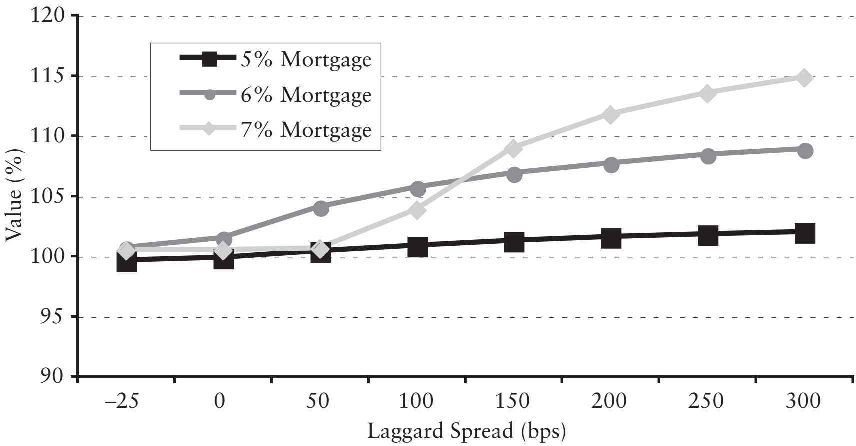


EXHIBIT A.9 Mortgage Value Depends on Refinancing Behavior



MBS can be determined. Next we outline the KYF approach for creating a laggard distribution.

KYF recommend inferring the distribution from the market prices of actively traded securities. In their illustration, they confine themselves to a very simple family of distributions, namely the negative exponential distribution anchored at 0 basis points laggard spread.

In implementing the model, they represent the distributions by placing appropriate weights in evenly spaced buckets along the laggard axis. Exhibit A.10 demonstrates the process. Starting with the financial engineers at the origin, the buckets are spaced at 50 basis point intervals. The weight is assumed to decline from bucket to bucket by a factor of 0.5. Accordingly the weight assigned to financial engineers is 0.50 and the weight of 50 basis point laggards is 0.25, and so on. This distribution is used as a point of reference and referred to it as the *naïve distribution*.

The naïve distribution can be modified by either adjusting the spacing of the buckets (e.g., 40 basis points) or the rate of decline (e.g., 0.6). While the two representations are mathematically equivalent, in numerical implementation one of them may turn out to be preferable to the other.

KYF illustrate how the rate of decline affects the value of unsecured mortgage pools, keeping the spacing of the buckets at 50 basis points. They consider pools of 30-year mortgages over a wide range of coupons, assuming that refinancing behavior follows the naïve distribution. Exhibit A.11 shows the values of new pools (factor equal to 1.0), and of seasoned pools following major refinancing activity (factor equal to 0.5).

EXHIBIT A.10 Naive Laggard Distribution

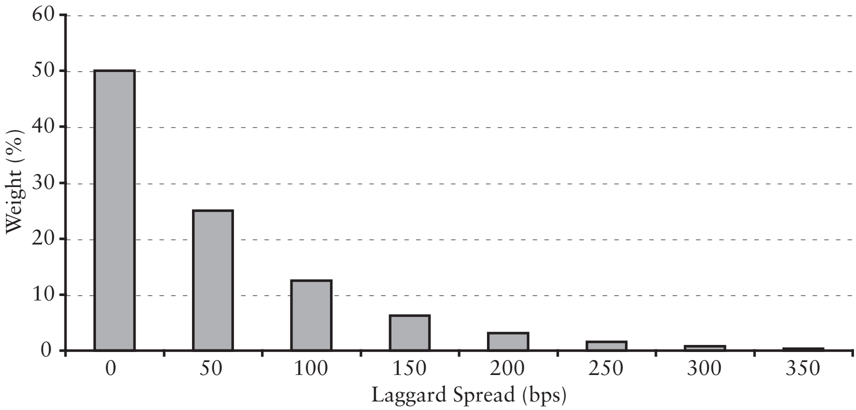
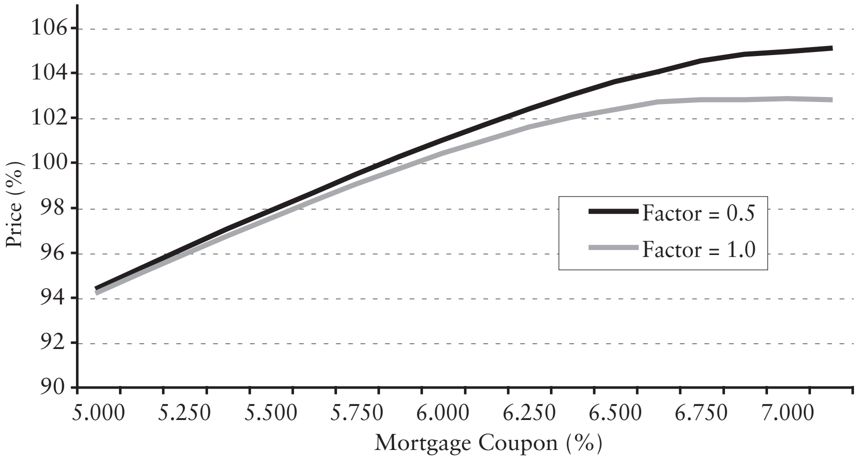


EXHIBIT A.11 How Factor Affects Value of Pool of 30-Year Mortgages Naïve Laggard Distribution



Evidently, the values are barely distinguishable for moderate coupons. In contrast, for high-coupon mortgages, the value of a seasoned pool is much higher; in fact, as the coupon increases, the value of a new pool actually declines, exhibiting negative duration. In the case of a seasoned pool with a small factor, the same phenomenon would occur only at a much higher coupon level.

VALUATION OF MBS

The description thus far has focused on the KYF approach to valuation of unsecured mortgage pools. Here we describe their model for valuing MBS. All other factors being the same, there are two major reasons why an MBS is preferable to an uninsured mortgage pool. First, because it is credit enhancement (either through the GSEs or the subordination mechanism), an MBS is more creditworthy. Second, because an MBS is a security, it is more liquid than the underlying mortgage pool. For these reasons the cash flows of an MBS are discounted at a lower rate than those of an unsecured mortgage pool.

Valuation Framework

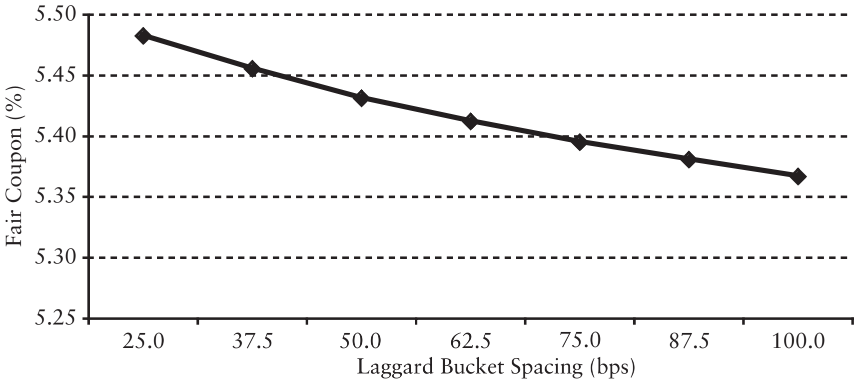
KYF represent the yield curves for an MBS and for a mortgage pool by respective OAS's relative to a benchmark swap curve. As long as the OASs are fixed, the yield curves will be perfectly correlated. For the reasons just cited, the OAS of an MBS should be lower than that of its underlying mortgage pool. In the KYF examples that follow, it is assumed that the OAS of every MBS is the same and demonstrate that robust and sensible results are obtained even under this simplistic assumption. Of course, one could fine-tune the analysis by using MBS-specific OASs.

Based on its duration, and because the credit of a residential mortgage is comparable to a corporate bond with a single-A rating, KYF estimated that at the time they prepared their illustration the OAS of an unsecured mortgage pool should be roughly 70 to 90 basis points to the swap curve. In the valuation of MBS, the fundamental role of the mortgage OAS is to project refinancing activity; the value of the mortgage pool is only of secondary interest. The higher this OAS, the slower will be the rate of refinancing, and the greater will be the value of an MBS with an above-market coupon.

As discussed, the OAS of an MBS should be much tighter than that of a mortgage pool. A reasonable comparable is the OAS of an debenture of similar duration by the GSE that issued the MBS. The OAS of intermediate agency debentures at the time that they prepared their illustration was roughly 25 to 35 basis points to the swap curve. This OAS has no effect on the cash flows; its sole function is discounting. The higher it is, the lower will be the value of the MBS.

Exhibit A.12 shows the values of new MBS. The coupon of the MBS is assumed to be 50 basis points below the weighted average coupon (WAC) of its mortgage pool. The mortgage OAS in their illustration was assumed to be 80 basis points, the MBS OAS was therefore 30 basis points, and the naïve distribution used to describe refinancing behavior (buckets placed 50 basis points apart, weights of adjacent buckets decline by a factor of 2).

EXHIBIT A.12 Fair MBS Coupon as Laggard Spacing Changes (adjacent weights decline by 50%)



Implied Prepayment Distribution

KYS apply the model to real market prices. Exhibit A.13 shows the terms of 14 Fannie Mae MBS along with their prices as of September 30, 2003.[10] Note the wide range of MBS coupons and pool factors. The U.S. dollar swap curve on the same day is shown below:

Term	1 mo.	3 mo.	6 mo.	1 yr.	2 yr.	3 yr.	5 yr.	10 yr.	30 yr.
Yield (%)	1.160	1.160	1.180	1.290	1.886	2.498	3.374	4.495	5.303

The table below displays the modeling assumptions:

Turnover rate	75% PSA
Refinancing cost	1% of mortgage
Mortgage OAS	80 bps
MBS OAS	30 bps
Short-term interest rate volatility	16% (0% mean reversion)

Based on the above, they find that the laggard distribution that provides the best fit to the given prices. In this application, they created 10 equally spaced buckets and assumed that the weights of adjacent buckets decline by a factor of 2. They then varied the spacing of the buckets to determine the best fit. As displayed in Exhibit A.14, the spacing that optimizes the fit occurs at 46 basis points, and it results in an average error of 0.85%. Exhibit A.15 shows the corresponding fitted values along with the actual prices of the MBS.

[10]The data were provided by Countrywide Securities.

EXHIBIT A.13 Fannie Mae Prices of September 30, 2003

MBS	WAC (%)	Original Amortization (mos.)	Age (mos.)	WAM (mos.)	Factor	Price (%)
FNMA 5.0 TBA	5.52	360	4	355	0.99	100.000
FNMA 5.0 2002	5.64	360	12	345	0.93	100.000
FNMA 5.5 TBA	5.94	360	6	352	0.92	101.984
FNMA 5.5 2002	6.03	360	11	347	0.78	101.984
FNMA 5.5 2001	6.13	360	23	332	0.61	102.047
FNMA 6.0 TBA	6.52	360	14	344	0.84	103.188
FNMA 6.0 2001	6.59	360	25	330	0.40	103.188
FNMA 6.0 1999	6.64	360	56	293	0.30	103.313
FNMA 6.0 1998	6.65	360	61	287	0.26	103.406
FNMA 6.5 2001	7.02	360	26	329	0.27	104.219
FNMA 6.5 1998	7.07	360	63	284	0.17	104.281
FNMA 7.0 1999	7.55	360	51	298	0.16	105.563
FNMA 7.0 1998	7.49	360	67	282	0.14	105.688
FNMA 7.5 2000	8.13	360	38	313	0.09	106.563

EXHIBIT A.14 Determining Implied Prepayment Distribution: FNMA MBS prices of 9/30/03

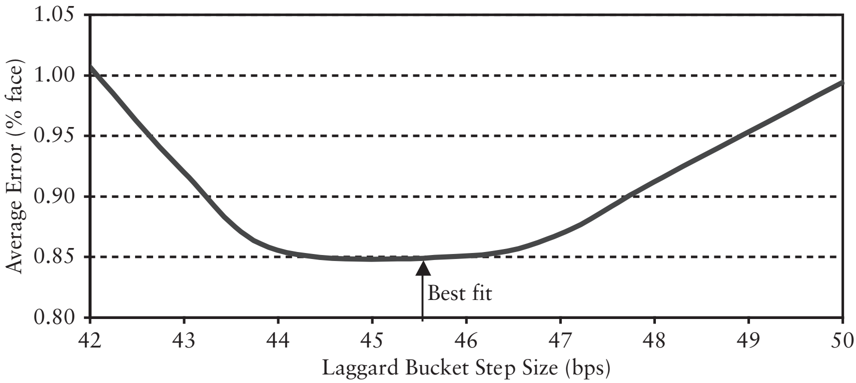
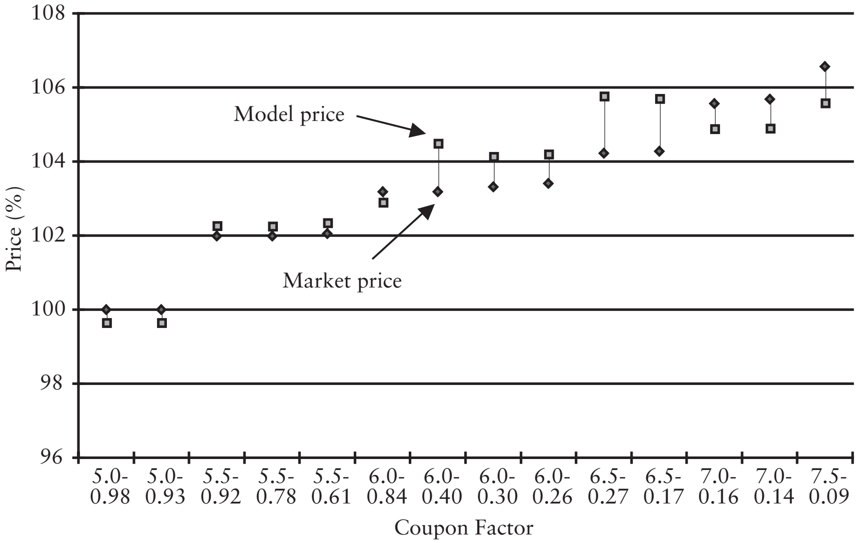


EXHIBIT A.15 FNMA MBS Prices of 9/30/03



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