CFA Institute®
CFA Program

ASSET ALLOCATION, DERIVATIVES, AND CURRENCY MANAGEMENT

CFA® Program Curriculum
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How to Use the CFA Program Curriculum

Congratulations on reaching Level III of the Chartered Financial Analyst® (CFA®) Program. This exciting and rewarding program of study reflects your desire to become a serious investment professional. You have embarked on a program noted for its high ethical standards and the breadth of knowledge, skills, and abilities (competencies) it develops. Your commitment to the CFA Program should be educationally and professionally rewarding.

The credential you seek is respected around the world as a mark of accomplishment and dedication. Each level of the program represents a distinct achievement in professional development. Successful completion of the program is rewarded with membership in a prestigious global community of investment professionals. CFA charterholders are dedicated to life-long learning and maintaining currency with the ever-changing dynamics of a challenging profession. The CFA Program represents the first step toward a career-long commitment to professional education.

The CFA examination measures your mastery of the core knowledge, skills, and abilities required to succeed as an investment professional. These core competencies are the basis for the Candidate Body of Knowledge (CBOK™). The CBOK consists of four components:

- A broad outline that lists the major topic areas covered in the CFA Program (https://www.cfainstitute.org/programs/cfa/curriculum/cbok);
- Topic area weights that indicate the relative exam weightings of the top-level topic areas (https://www.cfainstitute.org/programs/cfa/curriculum/overview);
- Learning outcome statements (LOS) that advise candidates about the specific knowledge, skills, and abilities they should acquire from readings covering a topic area (LOS are provided in candidate study sessions and at the beginning of each reading); and
- The CFA Program curriculum that candidates receive upon examination registration.

Therefore, the key to your success on the CFA examinations is studying and understanding the CBOK. The following sections provide background on the CBOK, the organization of the curriculum, features of the curriculum, and tips for designing an effective personal study program.

BACKGROUND ON THE CBOK

The CFA Program is grounded in the practice of the investment profession. Beginning with the Global Body of Investment Knowledge (GBIK), CFA Institute performs a continuous practice analysis with investment professionals around the world to determine the competencies that are relevant to the profession. Regional expert panels and targeted surveys are conducted annually to verify and reinforce the continuous feedback about the GBIK. The practice analysis process ultimately defines the CBOK. The

CBOK reflects the competencies that are generally accepted and applied by investment professionals. These competencies are used in practice in a generalist context and are expected to be demonstrated by a recently qualified CFA charterholder.

The CFA Institute staff, in conjunction with the Education Advisory Committee and Curriculum Level Advisors, who consist of practicing CFA charterholders, designs the CFA Program curriculum in order to deliver the CBOK to candidates. The examinations, also written by CFA charterholders, are designed to allow you to demonstrate your mastery of the CBOK as set forth in the CFA Program curriculum. As you structure your personal study program, you should emphasize mastery of the CBOK and the practical applications of that knowledge. For more information on the practice analysis, CBOK, and development of the CFA Program curriculum, please visit www.cfainstitute.org.

ORGANIZATION OF THE CURRICULUM

The Level III CFA Program curriculum is organized into seven topic areas. Each topic area begins with a brief statement of the material and the depth of knowledge expected. It is then divided into one or more study sessions. These study sessions—16 sessions in the Level III curriculum—should form the basic structure of your reading and preparation. Each study session includes a statement of its structure and objective and is further divided into assigned readings. An outline illustrating the organization of these 16 study sessions can be found at the front of each volume of the curriculum.

The readings are commissioned by CFA Institute and written by content experts, including investment professionals and university professors. Each reading includes LOS and the core material to be studied, often a combination of text, exhibits, and in-text examples and questions. A reading typically ends with practice problems followed by solutions to these problems to help you understand and master the material. The LOS indicate what you should be able to accomplish after studying the material. The LOS, the core material, and the practice problems are dependent on each other, with the core material and the practice problems providing context for understanding the scope of the LOS and enabling you to apply a principle or concept in a variety of scenarios.

The entire readings, including the practice problems at the end of the readings, are the basis for all examination questions and are selected or developed specifically to teach the knowledge, skills, and abilities reflected in the CBOK.

You should use the LOS to guide and focus your study because each examination question is based on one or more LOS and the core material and practice problems associated with the LOS. As a candidate, you are responsible for the entirety of the required material in a study session.

We encourage you to review the information about the LOS on our website (www.cfainstitute.org/programs/cfa/curriculum/study-sessions), including the descriptions of LOS “command words” on the candidate resources page at www.cfainstitute.org.

FEATURES OF THE CURRICULUM

OPTIONAL SEGMENT

Required vs. Optional Segments You should read all of an assigned reading. In some cases, though, we have reprinted an entire publication and marked certain parts of the reading as “optional.” The CFA examination is based only on the required segments, and the optional segments are included only when it is determined that they might help you to better understand the required segments (by seeing the required material in its full context). When an optional segment begins, you will see an icon and a dashed vertical bar in the outside margin that will continue until the optional segment ends, accompanied by another icon. *Unless the material is specifically marked as optional, you should assume it is required.* You should rely on the required segments and the reading-specific LOS in preparing for the examination.

END OPTIONAL SEGMENT

Practice Problems/Solutions *All practice problems at the end of the readings as well as their solutions are part of the curriculum and are required material for the examination.* In addition to the in-text examples and questions, these practice problems should help demonstrate practical applications and reinforce your understanding of the concepts presented. Some of these practice problems are adapted from past CFA examinations and/or may serve as a basis for examination questions.

Glossary For your convenience, each volume includes a comprehensive glossary. Throughout the curriculum, a **bolded** word in a reading denotes a term defined in the glossary.

Note that the digital curriculum that is included in your examination registration fee is searchable for key words, including glossary terms.

LOS Self-Check We have inserted checkboxes next to each LOS that you can use to track your progress in mastering the concepts in each reading.

Source Material The CFA Institute curriculum cites textbooks, journal articles, and other publications that provide additional context and information about topics covered in the readings. As a candidate, you are not responsible for familiarity with the original source materials cited in the curriculum.

Note that some readings may contain a web address or URL. The referenced sites were live at the time the reading was written or updated but may have been deactivated since then.

Some readings in the curriculum cite articles published in the *Financial Analysts Journal*®, which is the flagship publication of CFA Institute. Since its launch in 1945, the *Financial Analysts Journal* has established itself as the leading practitioner-oriented journal in the investment management community. Over the years, it has advanced the knowledge and understanding of the practice of investment management through the publication of peer-reviewed practitioner-relevant research from leading academics and practitioners. It has also featured thought-provoking opinion pieces that advance the common level of discourse within the investment management profession. Some of the most influential research in the area of investment management has appeared in the pages of the *Financial Analysts Journal*, and several Nobel laureates have contributed articles.

Candidates are not responsible for familiarity with *Financial Analysts Journal* articles that are cited in the curriculum. But, as your time and studies allow, we strongly encourage you to begin supplementing your understanding of key investment management issues by reading this practice-oriented publication. Candidates have full online access to the *Financial Analysts Journal* and associated resources. All you need is to log in on www.cfapubs.org using your candidate credentials.

Errata The curriculum development process is rigorous and includes multiple rounds of reviews by content experts. Despite our efforts to produce a curriculum that is free of errors, there are times when we must make corrections. Curriculum errata are periodically updated and posted on the candidate resources page at www.cfainstitute.org.

DESIGNING YOUR PERSONAL STUDY PROGRAM

Create a Schedule An orderly, systematic approach to examination preparation is critical. You should dedicate a consistent block of time every week to reading and studying. Complete all assigned readings and the associated problems and solutions in each study session. Review the LOS both before and after you study each reading to ensure that you have mastered the applicable content and can demonstrate the knowledge, skills, and abilities described by the LOS and the assigned reading. Use the LOS self-check to track your progress and highlight areas of weakness for later review.

Successful candidates report an average of more than 300 hours preparing for each examination. Your preparation time will vary based on your prior education and experience, and you will probably spend more time on some study sessions than on others. As the Level III curriculum includes 16 study sessions, a good plan is to devote 15–20 hours per week for 16 weeks to studying the material, and use the final four to six weeks before the examination to review what you have learned and practice with practice questions and mock examinations. This recommendation, however, may underestimate the hours needed for appropriate examination preparation depending on your individual circumstances, relevant experience, and academic background. You will undoubtedly adjust your study time to conform to your own strengths and weaknesses and to your educational and professional background.

You should allow ample time for both in-depth study of all topic areas and additional concentration on those topic areas for which you feel the least prepared.

As part of the supplemental study tools that are included in your examination registration fee, you have access to a study planner to help you plan your study time. The study planner calculates your study progress and pace based on the time remaining until examination. For more information on the study planner and other supplemental study tools, please visit www.cfainstitute.org.

As you prepare for your exam, we will e-mail you important examination updates, testing policies, and study tips. Be sure to read these carefully.

CFA Institute Practice Questions Your examination registration fee includes digital access to hundreds of practice questions that are additional to the practice problems at the end of the readings. These practice questions are intended to help you assess your mastery of individual topic areas as you progress through your studies. After each practice question, you will be able to receive immediate feedback noting the correct responses and indicating the relevant assigned reading so you can identify areas of weakness for further study. For more information on the practice question sets, please visit www.cfainstitute.org.

CFA Institute Mock Examinations Your examination registration fee also includes digital access to three-hour mock examinations that simulate the morning and afternoon sessions of the actual CFA examination. These mock examinations are intended to be taken after you complete your study of the full curriculum and take practice questions so you can test your understanding of the curriculum and your readiness for the examination. You will receive feedback at the end of the mock examination, noting the correct responses and indicating the relevant assigned readings so you can assess areas of weakness for further study during your review period. We recommend that you take mock examinations during the final stages of your preparation for the actual CFA examination. For more information on the mock examinations, please visit www.cfainstitute.org.

Preparatory Providers After you enroll in the CFA Program, you may receive numerous solicitations for preparatory courses and review materials. When considering a prep course, make sure the provider belongs to the CFA Institute Approved Prep Provider Program. Approved Prep Providers have committed to follow CFA Institute guidelines and high standards in their offerings and communications with candidates. For more information on the Approved Prep Providers, please visit www.cfainstitute.org/programs/cfa/exam/prep-providers).

Remember, however, that there are no shortcuts to success on the CFA examinations; reading and studying the CFA curriculum *is* the key to success on the examination. The CFA examinations reference only the CFA Institute assigned curriculum—no preparatory course or review course materials are consulted or referenced.

SUMMARY

Every question on the CFA examination is based on the content contained in the required readings and on one or more LOS. Frequently, an examination question is based on a specific example highlighted within a reading or on a specific practice problem and its solution. To make effective use of the CFA Program curriculum, please remember these key points:

1. All pages of the curriculum are required reading for the examination except for occasional sections marked as optional. You may read optional pages as background, but you will not be tested on them.
2. All questions, problems, and their solutions—found at the end of readings—are part of the curriculum and are required study material for the examination.
3. You should make appropriate use of the practice questions and mock examinations as well as other supplemental study tools and candidate resources available at www.cfainstitute.org.
4. Create a schedule and commit sufficient study time to cover the 16 study sessions, using the study planner. You should also plan to review the materials and take practice questions and mock examinations.
5. Some of the concepts in the study sessions may be superseded by updated rulings and/or pronouncements issued after a reading was published. Candidates are expected to be familiar with the overall analytical framework contained in the assigned readings. Candidates are not responsible for changes that occur after the material was written.

FEEDBACK

At CFA Institute, we are committed to delivering a comprehensive and rigorous curriculum for the development of competent, ethically grounded investment professionals. We rely on candidate and investment professional comments and feedback as we work to improve the curriculum, supplemental study tools, and candidate resources.

Please send any comments or feedback to info@cfainstitute.org. You can be assured that we will review your suggestions carefully. Ongoing improvements in the curriculum will help you prepare for success on the upcoming examinations and for a lifetime of learning as a serious investment professional.

Portfolio Management

STUDY SESSIONS

This volume includes Study Sessions 5 and 6.

TOPIC LEVEL LEARNING OUTCOME

The candidate should be able to prepare an appropriate investment policy statement and asset allocation; formulate strategies for managing, monitoring, and rebalancing investment portfolios; and evaluate portfolio performance.

PORTFOLIO MANAGEMENT
STUDY SESSION

5

Asset Allocation and Related Decisions in Portfolio Management

Often considered the most important activity in the investment process, the strategic asset allocation decision takes place after the formation of capital market expectations. The portfolio's long-term asset class, or factor, exposures and the best means to achieve these exposures are determined only after considering the investor's unique financial situation and objectives, risk–return tradeoffs, and other key inputs.

This study session provides a conceptual framework for understanding asset allocation considerations and key implementation approaches. Consideration of an investor's overall financial context using an economic balance sheet to incorporate all relevant investor assets and liabilities is presented. Three major approaches to asset allocation are described: asset only, liability relative, and goals based. Concepts underlying active and passive implementation and strategic rebalancing are also introduced.

In practice, the asset allocation decision is affected by numerous constraints that present practical challenges to asset allocation. Significant investor-based constraints include investable assets, liquidity needs, time horizon, and regulatory and tax environments. The final reading examines the effects of these constraints and presents adaptations to address them by institutional investor type. Also discussed are behavioral biases that influence the asset allocation process and ways to overcome these biases.

READING ASSIGNMENTS

Reading 12	Overview of Asset Allocation by William W. Jennings, PhD, CFA, and Eugene L. Podkaminer, CFA
Reading 13	Principles of Asset Allocation by Jean L.P. Brunel, CFA, Thomas M. Idzorek, CFA, and John M. Mulvey, PhD

(continued)

Reading 14	Asset Allocation with Real-World Constraints by Peter Mladina, Brian J. Murphy, CFA, Mark Ruloff, FSA, EA, CERA

READING

12

Overview of Asset Allocation

by William W. Jennings, PhD, CFA, and Eugene L. Podkaminer, CFA

William W. Jennings, PhD, CFA, is at the US Air Force Academy (USA). Eugene L. Podkaminer, CFA, is at Franklin Templeton Investments (USA).

LEARNING OUTCOMES

Mastery	*The candidate should be able to:*
☐	**a.** describe elements of effective investment governance and investment governance considerations in asset allocation;
☐	**b.** prepare an economic balance sheet for a client and interpret its implications for asset allocation;
☐	**c.** compare the investment objectives of asset-only, liability-relative, and goals-based asset allocation approaches;
☐	**d.** contrast concepts of risk relevant to asset-only, liability-relative, and goals-based asset allocation approaches;
☐	**e.** explain how asset classes are used to represent exposures to systematic risk and discuss criteria for asset class specification;
☐	**f.** explain the use of risk factors in asset allocation and their relation to traditional asset class–based approaches;
☐	**g.** select and justify an asset allocation based on an investor's objectives and constraints;
☐	**h.** describe the use of the global market portfolio as a baseline portfolio in asset allocation;
☐	**i.** discuss strategic implementation choices in asset allocation, including passive/active choices and vehicles for implementing passive and active mandates;
☐	**j.** discuss strategic considerations in rebalancing asset allocations.

1 INTRODUCTION

Asset owners are concerned with accumulating and maintaining the wealth needed to meet their needs and aspirations. In that endeavor, investment portfolios—including individuals' portfolios and institutional funds—play important roles. Asset allocation is a strategic—and often a first or early—decision in portfolio construction. Because it holds that position, it is widely accepted as important and meriting careful attention. Among the questions addressed in this reading are the following:

- What is a sound governance context for making asset allocation decisions?
- How broad a picture should an adviser have of an asset owner's assets and liabilities in recommending an asset allocation?
- How can an asset owner's objectives and sensitivities to risk be represented in asset allocation?
- What are the broad approaches available in developing an asset allocation recommendation, and when might one approach be more or less appropriate than another?
- What are the top-level decisions that need to be made in implementing a chosen asset allocation?
- How may asset allocations be rebalanced as asset prices change?

The strategic asset allocation decision determines return levels[1] in which allocations are invested, irrespective of the degree of active management. Because of its strategic importance, the investment committee, at the highest level of the governance hierarchy, typically retains approval of the strategic asset allocation decision. Often a proposal is developed only after a formal asset allocation study that incorporates obligations, objectives, and constraints; simulates possible investment outcomes over an agreed-on investment horizon; and evaluates the risk and return characteristics of the possible allocation strategies.

In providing an overview of asset allocation, this reading's focus is the alignment of asset allocation with the asset owner's investment objectives, constraints, and overall financial condition. This is the first reading in several sequences of readings that address, respectively, asset allocation and portfolio management of equities, fixed income, and alternative investments. Asset allocation is also linked to other facets of portfolio management, including risk management and behavioral finance. As coverage of asset allocation progresses in the sequence of readings, various connections to these topics, covered in detail in other areas of the curriculum, will be made.[2]

In the asset allocation sequence, the role of this reading is the "big picture." It also offers definitions that will provide a coordinated treatment of many later topics in portfolio management. The second reading provides the basic "how" of developing an asset allocation, and the third reading explores various common, real-world complexities in developing an asset allocation.

This reading is organized as follows: Section 2 explains the importance of asset allocation in investment management. Section 3 addresses the investment governance context in which asset allocation decisions are made. Section 4 considers asset allocation from the comprehensive perspective offered by the asset owner's economic balance sheet. Section 5 distinguishes three broad approaches to asset allocation and explains how they differ in investment objective and risk. In Section 6, these three approaches are discussed at a high level in relation to three cases. Section 7 provides a top-level orientation to how a chosen asset allocation may be implemented, providing a set of definitions that underlie subsequent readings. Section 8 discusses rebalancing considerations, and Section 9 provides a summary of the reading.

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1 See Ibbotson and Kaplan (2000, p. 30) and Xiong, Ibbotson, and Chen (2010). The conclusion for the aggregate follows from the premise that active management is a zero-sum game overall (Sharpe 1991).
2 Among these readings, see Blanchett, Cordell, Finke, and Idzorek (2016) concerning human capital and longevity and other risks and Pompian (2011a and 2011b) and Pompian, McLean, and Byrne (2011) concerning behavioral finance.

ASSET ALLOCATION: IMPORTANCE IN INVESTMENT MANAGEMENT

2

Exhibit 1 places asset allocation in a stylized model of the investment management process viewed as an integrated set of activities aimed at attaining investor objectives.

Exhibit 1 The Portfolio Management Process

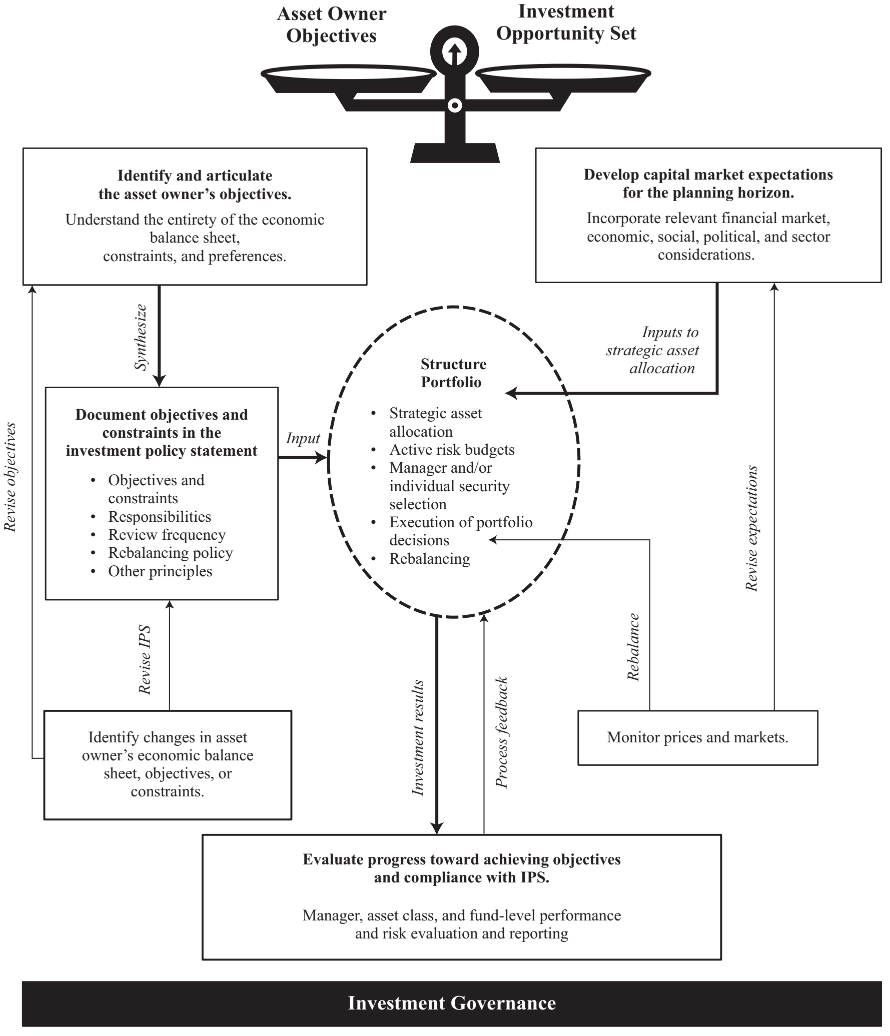


Exhibit 1 shows that an investment process that is in the asset owner's best interest rests on a foundation of good investment governance, which includes the assignment of decision-making responsibilities to qualified individuals and oversight of processes. The balance at the top of the chart suggests that the portfolio management process must reconcile (balance) investor objectives (on the left) with the possibilities offered by the investment opportunity set (on the right).

The investment process shows a sequence of activities that begins with understanding the asset owner's entire circumstance; objectives, including any constraints; and preferences. These factors, in conjunction with capital market inputs,[3] form the basis for asset allocation as a first step in portfolio construction and give a structure within which other decisions—such as the decision to invest passively or actively—take place. In the flow chart, thick lines show initial flows (or relations of logic) and thin lines show feedback flows.

Asset allocation is widely considered to be the most important decision in the investment process. The strategic asset allocation decision completely determines return levels[4] in which allocations are invested passively and also in the aggregate of all investors, irrespective of the degree of active management.

In providing an overview of asset allocation, this reading's focus is the alignment of asset allocation with the asset owner's investment objectives, constraints, and overall financial condition. The presentation begins with an introduction to the investment governance context of asset allocation. It then moves to present the economic balance sheet as the financial context for asset allocation itself.

3 THE INVESTMENT GOVERNANCE BACKGROUND TO ASSET ALLOCATION

Investment governance represents the organization of decision-making responsibilities and oversight activities. Effective investment governance ensures that assets are invested to achieve the asset owner's investment objectives within the asset owner's risk tolerance and constraints, and in compliance with all applicable laws and regulations. In addition, effective governance ensures that decisions are made by individuals or groups with the necessary skills and capacity.

Investment performance depends on asset allocation *and* its implementation. Sound investment governance practices seek to align asset allocation and implementation to achieve the asset owner's stated goals.

Investment governance structures are relevant to both institutional and individual investors. Because such structures are often formalized and articulated in detail for defined benefit pension plans, we will build our discussion using a pension plan governance framework. Elements of pension plan governance that are not directly related to the management of plan assets—plan design, funding policy, and communications to participants—are not discussed in this reading. Instead, we focus on those aspects of governance that directly affect the asset allocation decision.

3.1 Governance Structures

Governance and management are two separate but related functions. Both are directed toward achieving the same end. But governance focuses on clarifying the mission, creating a plan, and reviewing progress toward achieving long- and short-term objectives,

3 The set of potential inputs to portfolio construction shown in Exhibit 1 is not exhaustive. For example, for investors delegating asset management, investment managers' performance records are relevant.

4 See Ibbotson and Kaplan (2000, p.30) and Xiong, Ibbotson, Idzorek, and Chen (2010). The conclusion for the aggregate follows from the premise that active management is a zero-sum game overall (Sharpe 1991).

whereas management efforts are geared to outcomes—the execution of the plan to achieve the agreed-on goals and objectives. A common governance structure in an institutional investor context will have three levels within the governance hierarchy:

- governing investment committee
- investment staff
- third-party resources

The investment committee may be a committee of the board of directors, or the board of directors may have delegated its oversight responsibilities to an internal investment committee made up of staff. Investment staff may be large, with full in-house asset management capabilities, or small—for example, two to five investment staff responsible for overseeing external investment managers and consultants. It may even be part time—a treasurer or chief financial officer with many other, competing responsibilities. The term "third-party resources" is used to describe a range of professional resources—investment managers, investment consultants, custodians, and actuaries, for example.

Although there are many governance models in use, most effective models share six common elements. Effective governance models perform the following tasks:

1. Articulate the long- and short-term objectives of the investment program.
2. Allocate decision rights and responsibilities among the functional units in the governance hierarchy effectively, taking account of their knowledge, capacity, time, and position in the governance hierarchy.
3. Specify processes for developing and approving the investment policy statement that will govern the day-to-day operations of the investment program.
4. Specify processes for developing and approving the program's strategic asset allocation.
5. Establish a reporting framework to monitor the program's progress toward the agreed-on goals and objectives.
6. Periodically undertake a governance audit.

In the sections that follow, we will discuss selected elements from this list.

3.2 Articulating Investment Objectives

Articulating long- and short-term objectives for an investor first requires an understanding of purpose—that is, what the investor is trying to achieve. Below are examples of simple investment objective statements that can be clearly tied to purposes:

- *Defined benefit pension fund.* The investment objective of the fund is to ensure that plan assets are sufficient to meet current and future pension liabilities.
- *Endowment fund.* The investment objective of the endowment is to earn a rate of return in excess of the return required to fund, after accounting for inflation, ongoing distributions consistent with the endowment's mission.
- *Individual investor.* The investment objective is to provide for retirement at the investor's desired retirement age, family needs, and bequests, subject to stated risk tolerance and investment constraints.

A return requirement is often considered the essence of an investment objective statement, but for that portion of the objective statement to be properly understood requires additional context, including the obligations the assets are expected to fund, the nature of cash flows into and out of the fund, and the asset owner's willingness and ability to withstand interim changes in portfolio value. The ultimate goal is to find the best risk/return trade-off consistent with the asset owner's resource constraints and risk tolerance.

As an example of how the overall context can affect decision making, the pension fund may be an active plan, with new participants added as they are hired, or it may be "frozen" (no additional benefits are being accrued by participants in the plan). The status of the plan, considered in conjunction with its funded ratio (the ratio of pension assets to pension liabilities), has a bearing on future contributions and benefit payments. The company offering the pension benefit may operate in a highly cyclical industry, where revenues ebb and flow over the course of the economic cycle. In this case, the plan sponsor may prefer a more conservative asset allocation to minimize the year-to-year fluctuations in its pension contribution.

The nature of inflows and outflows for an endowment fund can be quite different from those of a pension fund. An endowment fund may be used to support scholarships, capital improvements, or university operating expenses. The fund sponsor has some degree of control over the outflows from the fund but very little control over the timing and amounts of contributions to the fund because the contributions are typically coming from external donors.

These cash inflow and outflow characteristics must be considered when establishing the goals and objectives of the fund.

A third, inter-related aspect of defining the sponsor's goals and objectives is determining and communicating risk tolerance. There are multiple dimensions of risk to be considered: liquidity risk, volatility, risk of loss, and risk of abandoning a chosen course of action at the wrong time.

Effective investment governance requires consideration of the liquidity needs of the fund and the liquidity characteristics of the fund's investments. For example, too large an allocation to relatively illiquid assets, such as real estate or private equity, might impair the ability to make payouts in times of market stress.

A high risk/high expected return asset allocation is likely to lead to wider swings in interim valuations. Any minimum thresholds for funded status that, if breached, would trigger an adverse event, such as higher pension insurance premiums, must be considered in the asset allocation decision.

For individual investors, the risk of substantial losses may be unacceptable for a variety of financial and psychological reasons. When such losses occur after retirement, lost capital cannot be replaced with future earnings.

Asset owners have their own unique return requirements and risk sensitivities. Managing an investment program without a clear understanding of long- and short-term objectives is similar to navigating without a map: Arriving at the correct destination on time and intact is not compatible with leaving much to chance.

3.3 Allocation of Rights and Responsibilities

The rights and responsibilities necessary to execute the investment program are generally determined at the highest level of investment governance. The allocation of those rights and responsibilities among the governance units is likely to vary depending on the size of the investment program; the knowledge, skills, and abilities of the internal staff; and the amount of time staff can devote to the investment program if they have other, competing responsibilities. Above all, good governance requires that decisions be delegated to those best qualified to make an informed decision.

The resources available to an organization will affect the scope and complexity of the investment program and the allocation of rights and responsibilities. A small investment program may result in having a narrower opportunity set because of either asset size (too small to diversify across the range of asset classes and investment managers) or staffing constraints (insufficient asset size to justify a dedicated internal staff). Complex strategies may be beyond the reach of entities that have chosen not to develop investment expertise internally or whose oversight committee lacks individuals with sufficient investment understanding. Organizations willing to invest in attracting, developing, and retaining staff resources and in developing strong internal control processes, including risk management systems, are better able to adopt more complex investment programs. The largest investors, however, may find their size creates governance issues: Manager capacity constraints might lead to so many managers that it challenges the investor's oversight capacity.

Allocation of rights and responsibilities across the governance hierarchy is a key element in the success of an investment program. Effective governance requires that the individuals charged with any given decision have the required *knowledge* and expertise to thoroughly evaluate the alternative courses of action and the *capacity* to take on the ongoing responsibility of those decisions, and they must be able to execute those decisions in a timely fashion. (Individual investors engaging a private wealth manager are delegating these expertise, capacity, and execution responsibilities.)

Exhibit 2 presents a systematic way of allocating among governance units the primary duties and responsibilities of running an investment program.

Exhibit 2 Allocation of Rights and Responsibilities

Investment Activity	Investment Committee	Investment Staff	Third-Party Resource
Mission	Craft and approve	n/a	n/a
Investment policy statement	Approve	Draft	Consultants provide input
Asset allocation policy	Approve with input from staff and consultants	Draft with input from consultants	Consultants provide input
Investment manager and other service provider selection	Delegate to investment staff; approval authority retained for certain service providers	Research, evaluation, and selection of investment managers and service providers	Consultants provide input
Portfolio construction (individual asset selection)	Delegate to outside managers, or to staff if sufficient internal resources	Execution if assets are managed in-house	Execution by independent investment manager
Monitoring asset prices & portfolio rebalancing	Delegate to staff within confines of the investment policy statement	Assure that the sum of all sub-portfolios equals the desired overall portfolio positioning; approve and execute rebalancing	Consultants and custodian provide input
Risk management	Approve principles and conduct oversight	Create risk management infrastructure and design reporting	Investment manager manages portfolio within established risk guidelines; consultants may provide input and support
Investment manager monitoring	Oversight	Ongoing assessment of managers	Consultants and custodian provide input
Performance evaluation and reporting	Oversight	Evaluate manager's continued suitability for assigned role; analyze sources of portfolio return	Consultants and custodian provide input
Governance audit	Commission and assess	Responds and corrects	Investment Committee contracts with an independent third party for the audit

The available knowledge and expertise at each level of the hierarchy, the resource capacity of the decision makers, and the ability to act on a timely basis all influence the allocation of these rights and responsibilities.

3.4 Investment Policy Statement

The investment policy statement (IPS) is the foundation of an effective investment program. A well-crafted IPS can serve as a blueprint for ongoing fund management and assures stakeholders that program assets are managed with the appropriate care and diligence.

Often, the IPS itself will be a foundation document that is revised slowly over time, whereas information relating to more variable aspects of the program—the asset allocation policy and guidelines for individual investment managers—will be contained in a more easily modified appendix.

3.5 Asset Allocation and Rebalancing Policy

Because of its strategic importance, the investment committee, at the highest level of the governance hierarchy, typically retains approval of the strategic asset allocation decision. A proposal is often developed only after a formal asset allocation study that incorporates obligations, objectives, and constraints; simulates possible investment outcomes over an agreed-on investment horizon; and evaluates the risk and return characteristics of the possible allocation strategies.

Governance considerations inform not only the overall strategic asset allocation decision but also rebalancing decisions. The IPS should contain at least general orienting information relevant to rebalancing. In an institutional setting, rebalancing policy might be the responsibility of the investment committee, organizational staff, or the external consultant. Likewise, individual investors might specify that they have delegated rebalancing authority to their investment adviser. Specification of rebalancing responsibilities is good governance.

3.6 Reporting Framework

The reporting framework in a well-run investment program should be designed in a manner that enables the overseers to evaluate quickly and clearly how well the investment program is progressing toward the agreed-on goals and objectives. The reporting should be clear and concise, accurately answering the following three questions:

- Where are we now?
- Where are we relative to the goals and objectives?
- What value has been added or subtracted by management decisions?

Key elements of a reporting framework should address performance evaluation, compliance with investment guidelines, and progress toward achieving the stated goals and objectives.

- Benchmarking is necessary for performance measurement, attribution, and evaluation. Effective benchmarking allows the investment committee to evaluate staff and external managers. Two separate levels of benchmarks are appropriate: one that measures the success of the investment managers relative to the purpose for which they were hired and another to measure the gap between the policy portfolio and the portfolio as actually implemented.

- Management reporting, typically prepared by staff with input from consultants and custodians, provides responsible parties with the information necessary to understand which parts of the portfolio are performing ahead of or behind the plan and why, as well as whether assets are being managed in accordance with investment guidelines.
- Governance reporting, which addresses strengths and weaknesses in program execution, should be structured in such a way that regular committee meetings can efficiently address any concerns. Although a crisis might necessitate calling an extraordinary meeting, good governance structures minimize this need.

3.7 The Governance Audit

The purpose of the governance audit is to ensure that the established policies, procedures, and governance structures are effective. The audit should be performed by an independent third party. The governance auditor examines the fund's governing documents, assesses the capacity of the organization to execute effectively within the confines of those governing documents, and evaluates the existing portfolio for its "efficiency" given the governance constraints.

Effective investment governance ensures the durability or survivability of the investment program. An investment program must be able to survive unexpected market turmoil, and good investment governance makes certain that the consequences of such turmoil are considered before it is experienced. Good governance seeks to avoid **decision-reversal risk**—the risk of reversing a chosen course of action at exactly the wrong time, the point of maximum loss. Good investment governance also considers the effect of investment committee member and staff turnover on the durability of the investment program. Orientation sessions for new committee members and proper documentation of investment beliefs, policies, and decisions enhance the likelihood that the chosen course of action will be given sufficient time to succeed. New staff or investment committee members should be able to perceive easily the design and intent of the investment program and be able to continue to execute it. Similarly, good investment governance prevents key person risk—overreliance on any one staff member or long-term, illiquid investments dependent on a staff member.

Good governance works to assure accountability. O'Barr and Conley (1992, p.21), who studied investment management organizations using anthropological techniques, found that blame avoidance (not accepting personal responsibility when appropriate to do so) is a common feature of institutional investors. Good governance works to prevent such behavior.

EXAMPLE 1

Investment Governance: Hypothetical Case 1

In January 2016, the Caflandia Office Workers Union Pension (COWUP) made the following announcement:

> "COWUP will fully exit all hedge funds and funds of funds. Assets currently amounting to 15% of its investment program are involved. Although hedge funds are a viable strategy for some, when judged against their complexity and cost, hedge fund investment is no longer warranted for COWUP."

One week later, a financial news service reported the following:

> "The COWUP decision on hedge funds was precipitated by an allegation of wrongdoing by a senior executive with hedge fund selection responsibilities in COWUP's alternative investments strategy group."

1 Considering only the first statement, state what facts would be relevant in evaluating whether the decision to exit hedge funds was consistent with effective investment governance.

2 Considering both statements, identify deficiencies in COWUP's investment governance.

Solution to 1:

The knowledge, capacity, and time available within COWUP to have an effective hedge fund investment program would need to be assessed against the stated concern for complexity and cost. The investment purpose served by hedge funds in COWUP's investment program before it exited them needs to be analyzed.

Solution to 2:

The second statement raises these concerns about the decision described in the first statement:

- Hiring and oversight of COWUP executives may have been inadequate.
- The initial COWUP information release was incomplete and possibly misleading. Public communications appear not to have received adequate oversight.
- Divesting hedge funds may be a reaction to the personnel issue rather than being based on investment considerations.

EXAMPLE 2

Investment Governance: Hypothetical Case 2

The imaginary country of Caflandia has a sovereign wealth fund with assets of CAF$40 billion. A governance audit includes the following:

> "The professional chief investment officer (CIO) reports to a nine-member appointed investment committee board of directors headed by an executive director. Investment staff members draft asset allocation policy in conjunction with consultants and make recommendation to the investment committee; the investment committee reviews and approves policy and any changes in policy, including the strategic asset allocation. The investment committee makes manager structure, conducts manager analysis, and makes manager selection decisions. The CIO has built a staff organization, which includes heads for each major asset class. In examining decisions over the last five years, we have noted several instances in which political or non-economic considerations appear to have influenced the investment program, including the selection of local private equity investments. Generally, the board spends much of its time debating individual manager strategies for inclusion in the portfolio and in evaluating investment managers' performance with comparatively little time devoted to asset allocation or risk management."

Based on this information and that in Exhibit 2, identify sound and questionable governance practices in the management of the Caflandia sovereign wealth fund.

Solution:

Sound practices: The allocation of responsibilities for asset allocation between investment staff and the investment committee is sound practice. Staff investment expertise should be reflected in the process of asset allocation policy and analysis. The investment committee assumes final responsibility for choices and decisions, which is appropriate given its position in receiving information from all parts of the organization and from all interested parties.

Questionable practices: The investment committee's level of involvement in individual manager selection and evaluation is probably too deep. Exhibit 2 indicates that these functions more effectively reside with staff. Individual manager selection is an implementation and execution decision designed to achieve strategic decisions made by the investment committee and is typically not a strategic decision itself. Manager evaluation has substantial data analysis and technical elements that can be efficiently provided by staff experts and consultants. The finding about political/non-economic influences indicates multiple problems. It confirms that the investment manager analysis and selection processes were misplaced. It also suggests that the investment committee has an inadequate set of governance principles or checks and balances as relates to the investment committee itself.

4 THE ECONOMIC BALANCE SHEET AND ASSET ALLOCATION

An accounting balance sheet reflects a point-in-time snapshot of an organization's financial condition and shows the assets, liabilities, and owners' equity recognized by accountants. An **economic balance sheet** includes conventional assets and liabilities (called "financial assets" and "financial liabilities" in this reading) as well as additional assets and liabilities—known as **extended portfolio assets and liabilities**—that are relevant in making asset allocation decisions but do not appear on conventional balance sheets.

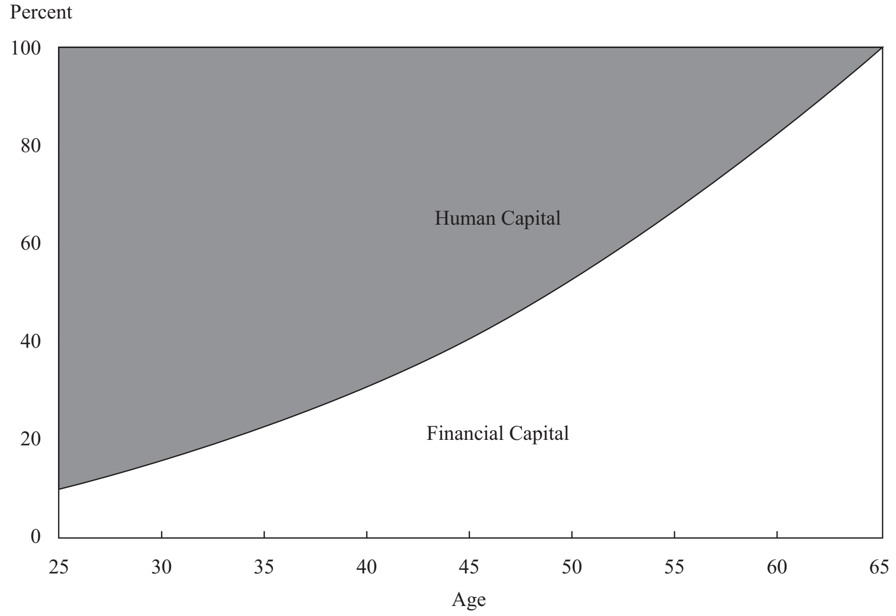
For individual investors, extended portfolio assets include human capital (the present value of future earnings), the present value of pension income, and the present value of expected inheritances. Likewise, the present value of future consumption is an extended portfolio liability.

For an institutional investor, extended portfolio assets might include underground mineral resources or the present value of future intellectual property royalties. Extended portfolio liabilities might include the present value of prospective payouts for foundations, whereas grants payable would appear as conventional liabilities.

Theory and, increasingly, practice suggest that asset allocation should consider the full range of assets and liabilities—both the financial portfolio and extended portfolio assets and liabilities—to arrive at an appropriate asset allocation choice. For example, an asset allocation process that considers the extended balance sheet, including the sensitivity of an individual investor's earnings to equity market risk (and that of the industry in which the individual is working), may result in a more appropriate allocation to equities than one that does not.

Life-cycle balanced funds (also known as target date funds) are examples of investments that seek to coordinate asset allocation with human capital. A 2040 life-cycle balanced fund that seeks to provide a retirement investment vehicle appropriate for many individuals retiring in 2040. Exhibit 3 illustrates a typical path for the composition of an individual's economic balance sheet from age 25 through age 65.

Exhibit 3 Human Capital (HC) and Financial Capital (FC) relative to Total Wealth



At age 25, with most of the individual's working life ahead of him, human capital dominates the economic balance sheet. As the individual progresses through life, the present value of human capital declines as human capital is transformed into earnings. Earnings saved and invested build financial capital balances. By a retirement age of 65, the conversion of human capital to earnings and financial capital is assumed to be complete.

Life-cycle balanced funds reflect these extended portfolio assets. Research indicates that, on average, human capital is roughly 30% equity-like and 70% bond-like, with significant variation among industries.[5] Making the simplifying assumption that investors have approximately constant risk tolerance through life, their asset allocation for total overall wealth (including human capital and financial capital) should be, in theory, constant over time. In this case, the asset allocation chosen for financial capital should reflect an increasing allocation to bonds as human capital declines to age 65, holding all else constant. Exhibit 4 shows the glide path for the equity/bond allocation chosen by one US mutual fund family. The increasing allocation to bonds is consistent with the view that human capital has preponderant bond-like characteristics.

5 See Blanchett and Straehl (2015) and Blanchett and Straehl (2017).

Exhibit 4 Glide Path of Target Date Investment Funds in One Family

Assumed Age	Equity Allocation	Bond Allocation
25	85%	15%
35	82	18
45	77	23
55	63	37
65	49	51

Note: Allocations as of 31 December 2009.
Source: Based on data in Idzorek, Stempien, and Voris (2013).

Although estimating human capital is quite complex, including human capital and other extended portfolio assets and economic liabilities in asset allocation decisions is good practice.[6]

EXAMPLE 3

The Economic Balance Sheet of Auldberg University Endowment

- *Name*: Auldberg University Endowment (AUE)
- *Narrative*: AUE was established in 1852 in Caflandia and largely serves the tiny province of Auldberg. AUE supports about one-sixth of Auldberg University's CAF$60 million operating budget; real estate income and provincial subsidies provide the remainder and have been relatively stable. The endowment has historically had a portfolio limited to domestic equities, bonds, and real estate holdings; that policy is under current review. Auldberg University itself (not the endowment) has a CAF$350 million investment in domestic commercial real estate assets, including office buildings and industrial parks, much of it near the campus. AUE employs a well-qualified staff with substantial diverse experience in equities, fixed income, and real estate.
- *Assets*: Endowment assets include CAF$100 million in domestic equities, CAF$60 million in domestic government debt, and CAF$40 million in Class B office real estate. The present value of expected future contributions (from real estate and provincial subsidies) is estimated to be CAF$400 million.
- *Liabilities*: These include CAF$10 million in short-term borrowings and CAF$35 million in mortgage debt related to real estate investments. Although it has no specific legal requirement, AUE has a policy to distribute to the university 5% of 36-month moving average net assets.

6 Human capital is non-tradable, cannot be hedged, is subject to unspecified future taxes, and is a function of an individual's mortality. Human capital is technically defined as the net present value of an investor's future expected labor income weighted by the probability of surviving to each future age (see Ibbotson, Milevsky, Chen, and Zhu 2007). Thus, the present value of future earnings and pensions should be valued with mortality-weighted probabilities of receiving future cash flows, not the present value over life expectancy. There is meaningful extra value from the low-odds event of extreme longevity, which has an important portfolio implication in that individual investors can outlive their financial portfolios but not lifetime annuity payments.

In effect, the endowment supports $10 million of Auldberg University's annual operating budget. The present value of expected future support is CAF$450 million.

1 Prepare an economic balance sheet for AUE.

2 Describe elements in Auldberg University's investments that might affect AUE's asset allocation choices.

Solution to 1:

The economic balance sheet for the endowment (given in the following table) does not include the real estate owned by Auldberg University. The economic net worth is found as a plug item (600 – 10 – 35 – 450 = 105).

AUE Economic Balance Sheet (in CAF$ millions) 31 December 20x6

Assets		Liabilities and Economic Net Worth	
Financial Assets		*Financial Liabilities*	
Domestic equities	100	Short-term borrowing	10
Domestic fixed income	60	Mortgage debt	35
Class B office real estate	40		
Extended Assets		*Extended Liabilities*	
Present value of expected future contributions to AUE	400	Present value of expected future support	450
		Economic Net Worth	
		Economic net worth (Economic assets – Economic liabilities)	105
Total	600		600

Solution to 2:

AUE's Class B real estate investments' value and income are likely to be stressed during the same economic circumstances as the university's own real estate investments. In such periods, the university may look to the endowment for increased operating support and AUE may not be well positioned to meet that need. Thus, the AUE's real estate investment is actually less diversifying than it may appear and the allocation to it may need to be re-examined. Similar considerations apply to AUE's holdings in equities in relation to Auldberg University's.

5 APPROACHES TO ASSET ALLOCATION

We can identify three broad approaches to asset allocation: (1) **asset-only**, (2) **liability-relative**, and (3) **goals-based**. These are decision-making frameworks that take account of or emphasize different aspects of the investment problem.

Asset-only approaches to asset allocation focus solely on the asset side of the investor's balance sheet. Liabilities are not explicitly modeled. Mean–variance optimization (MVO) is the most familiar and deeply studied asset-only approach. MVO considers only the expected returns, risks, and correlations of the asset classes in the opportunity set. In contrast, liability-relative and goals-based approaches explicitly account for the liabilities side of the economic balance sheet, dedicating assets to meet, respectively, legal liabilities and quasi-liabilities (other needs that are not strictly liabilities but are treated as such) or goals.

Liability-relative approaches to asset allocation choose an asset allocation in relation to the objective of funding liabilities. The phrase "funding of liabilities" means to provide for the money to pay liabilities when they come due. An example is surplus optimization: mean–variance optimization applied to surplus (defined as the value of the investor's assets minus the present value of the investor's liabilities). In modeling, liabilities might be represented by a short position in a bond or series of bonds matched to the present value and duration of the liabilities. Another approach involves constructing a liability-hedging portfolio focused on funding liabilities and, for any remaining balance of assets, a risky-asset portfolio (so called because it is risky or riskier in relation to liabilities—often also called a "return-seeking portfolio" because it explicitly seeks return above and beyond the liability benchmark). **Liability-driven investing** (LDI) is an investment industry term that generally encompasses asset allocation that is focused on funding an investor's liabilities. Related fixed-income techniques are covered in the fixed-income sequence under liability-based mandates.

All approaches to asset allocation can be said to address goals. In investment practice and literature, however, the term "goals based" has come be widely associated with a particular type of approach to asset allocation and investing.

Goals-based approaches to asset allocation, as discussed here, are used primarily for individuals and families, involve specifying asset allocations for sub-portfolios, each of which is aligned to specified goals ranging from supporting lifestyle needs to aspirational. Each goal is associated with regular, irregular, or bulleted cash flows; a distinct time horizon; and a risk tolerance level expressed as a required probability of achieving the goal.[7] For example, a middle-aged individual might specify a goal of maintaining his current lifestyle and require a high level of confidence that this goal will be attained. That same individual might express a goal of leaving a bequest to his alma mater. This would be a very long-term goal and might have a low required probability. Each goal is assigned to its own sub-portfolio, and an asset allocation strategy specific to that sub-portfolio is derived. The sum of all sub-portfolio asset allocations results in an overall strategic asset allocation for the total portfolio. **Goals-based investing** (GBI) is an investment industry term that encompasses the asset allocation focused on addressing an investor's goals.

Institutions and Goals-Based Asset Allocation

Asset segmentation as practiced by some life insurers has some similarities to goals-based investing. Asset segmentation involves notionally or actually segmenting general account assets into sub-portfolios associated with specific lines of business or blocks of liabilities. On one hand, such an approach may be distinguished from goals-based asset allocation for individual investors in being motivated by competitive concerns (to facilitate offering competitive crediting rates on groups of contracts) rather than behavioral ones. On the other hand, Fraser and Jennings (2006) described a behaviorally motivated goals-based approach to asset allocation for foundations and endowments.

7 See Shefrin and Statman (2000) and Brunel (2015).

Following their approach, components of an overall appropriate mean–variance optimal portfolio are allocated to time-based sub-portfolios such that uncomfortably novel or risky positions for the entity's governing body are made acceptable by being placed in longer-term sub-portfolios.

Although any asset allocation approach that considers the liabilities side of the economic balance sheet might be termed "liability relative," there are several important distinctions between liabilities for an institutional investor and goals for an individual investor. These distinctions have meaningful implications for asset allocation:[8]

- Liabilities of institutional investors are legal obligations or debts, whereas goals, such as meeting lifestyle or aspirational objectives, are not. Failing to meet them does not trigger similar consequences.
- Whereas institutional liabilities, such as life insurer obligations or pension benefit obligations, are uniform in nature (all of a single type), an individual's goals may be many and varied.
- Liabilities of institutional investors of a given type (e.g., the pension benefits owed to retirees) are often numerous and so, through averaging, may often be forecast with confidence. In contrast, individual goals are not subject to the law of large numbers and averaging. Contrast an estimate of expected death benefits payable for a group of life insurance policies against an individual's uncertainty about the resources needed in retirement: For a 65-year-old individual, the number of remaining years of life is very uncertain, but insurers can estimate the average for a group of 65-year-olds with some precision.

Liability-Relative and Goals-Based Approaches to Investing

Various perspectives exist concerning the relationship between liability-relative and goals-based approaches to investing. Professor Lionel Martellini summarizes one perspective in the following three statements:[9]

1. Goals-based investing is related to a new paradigm that advocates more granular and investor-centric investment solutions.
2. This new investment solutions paradigm translates into goals-based investing (GBI) approaches in individual money management, in which investors' problems can be summarized in terms of their goals, and it translates into liability-driven investing (LDI) approaches in institutional money management, where the investors' liability is treated as a proxy for their goal.
3. GBI and LDI are therefore related, but each of these approaches has its own specific characteristics. For example, GBI implies the capacity to help individual investors identify a hierarchical list of goals, with a distinction between different types of goals (affordable versus non affordable, essential versus aspirational, etc.) for which no exact counterpart exists in institutional money management.

8 See Rudd and Siegel (2013), which recognizes goals-based planning as a distinct approach. This discussion draws on Brunel (2015).
9 Communication of 3 June 2016, used with permission.

5.1 Relevant Objectives

All three of the asset allocation approaches listed here seek to make optimal use of the amount of risk that the asset owner is comfortable bearing to achieve stated investment objectives, although they generally define risk differently. Exhibit 5 summarizes typical objectives.

Exhibit 5 Asset Allocation Approaches: Investment Objective

Asset Allocation Approach	Relation to Economic Balance Sheet	Typical Objective	Typical Uses and Asset Owner Types
Asset only	Does not explicitly model liabilities or goals	Maximize Sharpe ratio for acceptable level of volatility	Liabilities or goals not defined and/or simplicity is important ■ Some foundations, endowments ■ Sovereign wealth funds ■ Individual investors
Liability relative	Models legal and quasi-liabilities	Fund liabilities and invest excess assets for growth	Penalty for not meeting liabilities high ■ Banks ■ Defined benefit pensions ■ Insurers
Goals based	Models goals	Achieve goals with specified required probabilities of success	Individual investors

In a mean–variance asset-only approach, the objective is to maximize expected portfolio return per unit of portfolio volatility over some time horizon, consistent with the investor's tolerance for risk and consistent with any constraints stated in the IPS. A portfolio's Sharpe ratio is a characteristic metric for evaluating portfolios in an asset-only mean–variance approach.

The basic objective of a liability-relative asset allocation approach is to ensure payment of liabilities when they are due.

A goals-based approach is similar to a liability-relative approach in that it also seeks to ensure that there are sufficient assets to meet the desired payouts. In goals-based approaches, however, goals are generally associated with individual sub-portfolios, and an asset allocation is designed for each sub-portfolio that reflects the time horizon and required probability of success such that the sum of the sub-portfolios addresses the totality of goals satisfactorily.

5.2 Relevant Risk Concepts

Asset-only approaches focus on asset class risk and effective combinations of asset classes. The baseline asset-only approach, mean–variance optimization, uses volatility (standard deviation) of portfolio return as a primary measure of risk, which is a function of component asset class volatilities and the correlations of asset class returns. A mean–variance asset allocation can also incorporate other risk sensitivities, including risk relative to benchmarks and downside risk. Risk relative to benchmarks is usually measured by tracking risk (tracking error). Downside risk can be represented in various ways, including semi-variance, peak-to-trough maximum drawdown, and measures that focus on the extreme (tail) segment of the downside, such as value at risk.

Mean–variance results, although often the starting point for understanding portfolio risk, are regularly augmented by Monte Carlo simulation. By providing information about how an asset allocation performs when one or more variables are changed—for example, to values representing conditions of financial market stress—simulation helps complete the picture of risk, including downside and tail risk. Insights from simulation can then be incorporated as refinements to the asset allocation.

Liability-relative approaches focus on the risk of having insufficient assets to pay obligations when due, which is a kind of shortfall risk. Other risk concerns include the volatility of contributions needed to fund liabilities. Risk in a liability-relative context is generally underpinned by the differences between asset and liability characteristics (e.g., their relative size, their interest rate sensitivity, their sensitivity to inflation).

Goals-based approaches are concerned with the risk of failing to achieve goals.[10] The risk limits can be quantified as the maximum acceptable probability of not achieving a goal.[11] The plural in "liabilities" and "goals" underscores that these risks are generally related to multiple future points in time. Overall portfolio risk is thus the weighted sum of the risks associated with each goal.

Generally, a given statistical risk measure may be relevant in any of the three approaches. For example, standard deviation can be used to assess overall portfolio volatility in asset-only approaches, and it may be used to measure surplus volatility (the volatility of the difference between the values of assets and liabilities) or the volatility of the funded ratio (the ratio of the values of assets and liabilities) in liability-relative asset allocation.

5.3 Modeling Asset Class Risk

Asset classes are one of the most widely used investment concepts but are often interpreted in distinct ways. Greer (1997) defines an asset class as "a set of assets that bear some fundamental economic similarities to each other, and that have characteristics that make them distinct from other assets that are not part of that class." He specifies three "super classes" of assets:

- *Capital assets.* An ongoing source of something of value (such as interest or dividends); capital assets can be valued by net present value.
- *Consumable/transformable assets.* Assets, such as commodities, that can be consumed or transformed, as part of the production process, into something else of economic value, but which do not yield an ongoing stream of value.
- *Store of value assets.* Neither income generating nor valuable as a consumable or an economic input; examples include currencies and art, whose economic value is realized through sale or exchange.

EXAMPLE 4

Asset Classes (1)

Classify the following investments based on Greer's (1997) framework, or explain how they *do not* fit in the framework:

1 Precious metals

10 See Das, Markowitz, Scheid, and Statman (2010), who call goals "mental accounts."
11 See Brunel (2015).

2 Petroleum
3 Hedge funds
4 Timberland
5 Inflation-linked fixed-income securities
6 Volatility

Solutions:

1 Precious metals are a store of value asset except in certain industrial applications (e.g., palladium and platinum in the manufacture of catalytic converters).
2 Petroleum is a consumable/transformable asset; it can be consumed to generate power or provide fuel for transport.
3 Hedge funds do not fit into Greer's (1997) super class framework; a hedge fund strategy invests in underlying asset classes.
4 Timberland is a capital asset or consumable/transformable asset. It is a capital asset in the sense that timber can be harvested and replanted cyclically to generate a stream of cash flows; it is a consumable asset in that timber can be used to produce building materials/ packaging or paper.
5 Inflation-linked fixed-income securities is a capital asset because cash flows can be determined based on the characteristics of the security.
6 Volatility does not fit; it is a measurable investment characteristic. Because equity volatility is the underlying for various derivative contracts and an investable risk premium may be associated with it, it is mentioned by some as an asset.

Greer (1997) approaches the classification of asset classes in an abstract or generic sense. The next question is how to specify asset classes to support the purposes of strategic asset allocation.[12] For example, if a manager lumps together very different investments, such as distressed credit and Treasury securities, into an asset class called "fixed income," asset allocation becomes less effective in diversifying and controlling risk. Furthermore, the investor needs a logical framework for distinguishing an asset class from an investment strategy. The following are five criteria that will help in effectively *specifying asset classes for the purpose of asset allocation*:[13]

1 *Assets within an asset class should be relatively homogeneous.* Assets within an asset class should have similar attributes. In the example just given, defining equities to include both real estate and common stock would result in a non-homogeneous asset class.
2 *Asset classes should be mutually exclusive.* Overlapping asset classes will reduce the effectiveness of strategic asset allocation in controlling risk and could introduce problems in developing asset class return expectations. For example, if one asset class for a US investor is domestic common equities, then world equities ex-US is more appropriate as another asset class rather than global equities, which include US equities.

12 See Kritzman (1999).
13 As opposed to criteria for asset class definition in an absolute sense.

3 *Asset classes should be diversifying.* For risk control purposes, an included asset class should not have extremely high expected correlations with other asset classes or with a linear combination of other asset classes. Otherwise, the included asset class will be effectively redundant in a portfolio because it will duplicate risk exposures already present. In general, a pairwise correlation above 0.95 is undesirable (given a sufficient number of observations to have confidence in the correlation estimate).

4 *The asset classes as a group should make up a preponderance of world investable wealth.* From the perspective of portfolio theory, selecting an asset allocation from a group of asset classes satisfying this criterion should tend to increase expected return for a given level of risk. Furthermore, the inclusion of more markets expands the opportunities for applying active investment strategies, assuming the decision to invest actively has been made. However, such factors as regulatory restrictions on investments and government-imposed limitations on investment by foreigners may limit the asset classes an investor can invest in.

5 *Asset classes selected for investment should have the capacity to absorb a meaningful proportion of an investor's portfolio.* Liquidity and transaction costs are both significant considerations. If liquidity and expected transaction costs for an investment of a size meaningful for an investor are unfavorable, an asset class may not be practically suitable for investment.

Note that Criteria 1 through 3 strictly focus on assets themselves, while Criterion 5, and to some extent Criterion 4, involve potential investor-specific considerations.

Asset Classes Should Be Diversifying

Pairwise asset class correlations are often useful information and are readily obtained. However, in evaluating an investment's value as a diversifier at the portfolio level, it is important to consider an asset in relation to all other assets as a group rather than in a one-by-one (pairwise) fashion. It is possible to reach limited or incorrect conclusions by solely considering pairwise correlations. To give an example, denote the returns to three assets by X, Y, and Z, respectively. Suppose that $Z = aX + bY$; a and b are constants, not both equal to zero. Asset Z is an exact weighted combination of X and Y and so has no value as a diversifier added to a portfolio consisting of assets X and Y. Yet, if the correlation between X and Y is −0.5, it can be shown that Z has a correlation of just 0.5 with X as well as with Y.

Examining return series' correlations during times of financial market stress can provide practically valuable insight into potential diversification benefits beyond typical correlations that average all market conditions.

In current professional practice, the listing of asset classes often includes the following:

- *Global public equity*—composed of developed, emerging, and sometimes frontier markets and large-, mid-, and small-cap asset classes; sometimes treated as several sub-asset classes (e.g., domestic and non-domestic).
- *Global private equity*—includes venture capital, growth capital, and leveraged buyouts (investment in special situations and distressed securities often occurs within private equity structures too).

- *Global fixed income*—composed of developed and emerging market debt and further divided into sovereign, investment-grade, and high-yield sub-asset classes, and sometimes inflation-linked bonds (unless included in real assets; see the following bullet). Cash and short-duration securities can be included here.
- *Real assets*—includes assets that provide sensitivity to inflation, such as private real estate equity, private infrastructure, and commodities. Sometimes, global inflation-linked bonds are included as a real asset rather than fixed income because of their sensitivity to inflation.

Emerging Market Equities and Fixed Income

Investment practice distinguishes between developed and emerging market equities and fixed income within global equities. The distinction is based on practical differences in investment characteristics, which can be related to typical market differences including the following:

- diversification potential, which is related to the degree to which investment factors driving market returns in developed and emerging markets are not identical (a topic known as "market integration");
- perceived level of informational efficiency; and
- corporate governance, regulation, taxation, and currency convertibility.

As of mid-2016, emerging markets represent approximately 10% of world equity value based on MSCI indices.[14] In fixed income, investment opportunities have expanded as governments and corporations domiciled in emerging markets have increasingly issued debt in their own currency. Markets in local currency inflation-indexed emerging market sovereign debt have become more common.[15]

"Asset classes" are, by definition, groupings of assets. Investment vehicles, such as hedge funds, that apply strategies to asset classes and/or individual investments with the objective of earning a return to investment skill or providing attractive risk characteristics may be treated as a category called "strategies" or "diversifying strategies." When that is the case, this category is assigned a percentage allocation of assets, similar to a true asset class. Economically, asset classes contrast with "strategies" by offering, in general, an inherent, non-skill-based *ex ante* expected return premium.[16]

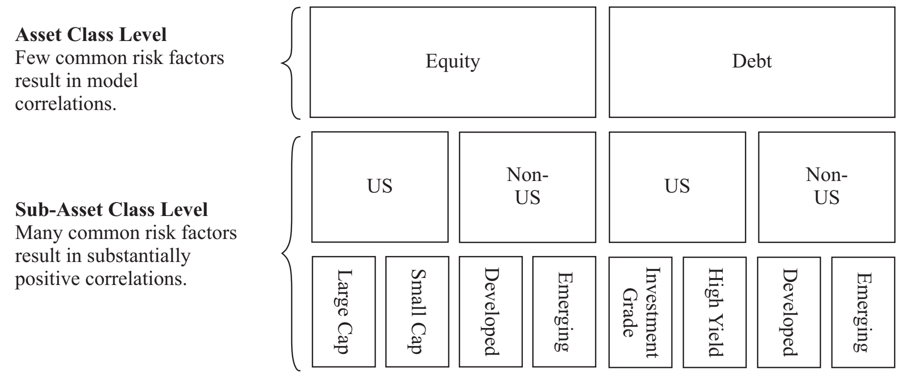
Effective portfolio optimization and construction may be hindered by excessive asset class granularity. Consider Exhibit 6.

14 MSCI uses three broad definitions to sort countries into developed, emerging, and frontier: 1) economic development, 2) size and liquidity requirements, and 3) market accessibility criteria (see the MSCI Market Classification Framework at www.msci.com/market-classification).

15 For a discussion of their potential benefits, see Burger, Warnock, and Warnock (2012), Perry (2011), and Swinkels (2012). Kozhemiakin (2011) discusses how emerging market bonds can facilitate broader representation than an equity-only portfolio because some countries (e.g., Argentina) have small equity markets but larger bond markets.

16 See Idzorek and Kowara (2013), p.20.

Exhibit 6 Examples of Asset Classes and Sub-Asset Classes



As more and more sub-asset classes are defined, they become less distinctive. In particular, the sources of risk for more broadly defined asset classes are generally better distinguished than those for narrowly defined subgroups. For example, the overlap in the sources of risk of US large-cap equity and US small-cap equity would be greater than the overlap between US and non-US equity. Using broadly defined asset classes with fewer risk source overlaps in optimization is consistent with achieving a diversified portfolio. Additionally, historical data for broadly defined asset classes may be more readily available or more reliable. The question of how much to allocate to equity versus fixed income versus other assets is far more important in strategic asset allocation than *precisely* how much to allocate to the various sub-classes of equity and fixed income. However, when the investor moves from the strategic asset allocation phase to policy implementation, sub-asset class choices become relevant.

EXAMPLE 5

Asset Classes (2)

Discuss a specification of asset classes that distinguishes between "domestic intermediate-duration fixed income" and "domestic long-duration fixed income." Contrast potential relevance in asset-only and liability-relative contexts.

Solution:

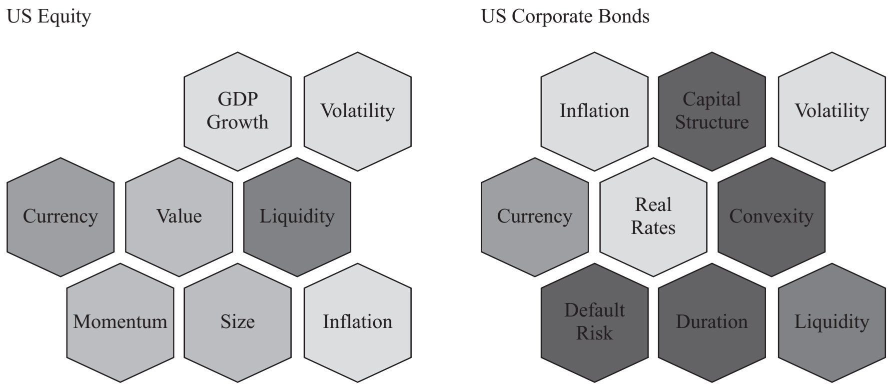
These two groups share key risk factors, such as interest rate and credit risk. For achieving diversification in asset risk—for example, in an asset-only context—asset allocation using domestic fixed income, which includes intermediate and long duration, should be effective and simple. Subsequently, allocation within domestic fixed income could address other considerations, such as interest rate views. When investing in relation to liabilities, distinctions by duration could be of first-order importance and the specification could be relevant.

Any asset allocation, by whatever means arrived at, is expressed ultimately in terms of money allocations to assets. Traditionally—and still in common practice—asset allocation uses asset classes as the unit of analysis. Thus, mean–variance optimization based on four asset classes (e.g., global public equity, global private equity, global fixed income, and real assets) would be based on expected return, return volatility, and return correlation estimates for these asset classes. (The development of such capital market assumptions is the subject of another reading.) Factor-based approaches, discussed in more detail later, do not use asset classes as the basis for portfolio construction.

Technically, the set of achievable investment outcomes cannot be enlarged simply by developing an asset allocation by a different means (for instance, using asset classes as the unit of analysis), all else being equal, such as constraints against short selling (non-negativity constraints).[17] Put another way, adopting a factor-based asset allocation approach does not, by default, lead to superior investment outcomes.

There are allocation methods that focus on assigning investments to the investor's desired exposures to specified risk factors. These methods are premised on the observation that asset classes often exhibit some overlaps in sources of risk, as illustrated in Exhibit 7.[18]

Exhibit 7 Common Factor Exposures across Asset Classes



The overlaps seen in Exhibit 7 help explain the correlation of equity and credit assets. Modeling using asset classes as the unit of analysis tends to obscure the portfolio's sensitivity to overlapping risk factors, such as inflation risk in this example. As a result, controlling risk exposures may be problematic. Multifactor risk models, which have a history of use in individual asset selection, have been brought to bear on the issue of controlling systematic risk exposures in asset allocation.

In broad terms, when using factors as the units of analysis, we begin with specifying risk factors and the desired exposure to each factor. Asset classes can be described with respect to their sensitivities to each of the factors. Factors, however, are not directly investable. On that basis, asset class portfolios that isolate exposure to the risk factor are constructed; these factor portfolios involve both long and short positions. A choice of risk exposures in factor space can be mapped back to asset class space for implementation. Uses of multifactor risk models in asset allocation have been labeled "factor-based asset allocation" in contrast to "asset class-based asset allocation," which uses asset classes directly as the unit of analysis.

Factor Representation

Although risk factors can be thought of as the basic building blocks of investments, most are not directly investable. In this context, risk factors are associated with expected return premiums. Long and short positions in assets (spread positions) may be needed

17 Stated more formally and demonstrated in Idzorek and Kowara (2013).
18 See Podkaminer (2013).

to isolate the respective risks and associated expected return premiums. Other risk factors may be accessed through derivatives. The following are a few examples of how risk factor exposures can be achieved.

- *Inflation*. Going long nominal Treasuries and short inflation-linked bonds isolates the inflation component.
- *Real interest rates*. Inflation-linked bonds provide a proxy for real interest rates.
- *US volatility*. VIX (Chicago Board Options Exchange Volatility Index) futures provide a proxy for implied volatility.
- *Credit spread*. Going long high-quality credit and short Treasuries/government bonds isolates credit exposure.
- *Duration*. Going long 10+ year Treasuries and short 1–3 year Treasuries isolates the duration exposure being targeted.

Factor Models in Asset Allocation

The interest in using factors for asset allocation stems from a number of considerations, including the following:

- The desire to shape the asset allocation based on goals and objectives that cannot be expressed by asset classes (such as matching liability characteristics in a liability-relative approach).
- An intense focus on portfolio risk in all of its various dimensions, helped along by availability of commercial factor-based risk measurement and management tools.
- The acknowledgment that many highly correlated so-called asset classes are better defined as parts of the same high-level asset class. For example, domestic and foreign equity may be better seen as sub-classes of global public equity.
- The realization that equity risk can be the dominant risk exposure even in a seemingly well-diversified portfolio.

6 STRATEGIC ASSET ALLOCATION

An asset allocation that arises in long-term investment planning is often called the "strategic asset allocation" or "policy portfolio": It is an asset allocation that is expected to be effective in achieving an asset owner's investment objectives, given his or her investment constraints and risk tolerance, as documented in the investment policy statement.

A theoretical underpinning for quantitative approaches to asset allocation is utility theory, which uses a utility function as a mathematical representation of preferences that incorporates the investor's risk aversion. According to utility theory, the optimal asset allocation is the one that is expected to provide the highest utility to the investor at the investor's investment time horizon. The optimization program, in broad terms, is

$$\underset{\text{by choice of asset class weights } w_i}{\text{Maximize}} \quad E\left[U\left(W_T\right)\right] = f\begin{pmatrix} W_0, w_i, \text{asset class return distributions,} \\ \text{degree of risk aversion} \end{pmatrix}$$

$$\text{subject to} \sum_{i=1}^{n} w_i = 1 \text{ and any other constraints on } w_i$$

The first line is the objective function, and the second line consists of constraints on asset class weights; other constraints besides those on weights can also be incorporated (for example, specified levels of bond duration or portfolio yield may be targeted). With W_0 and W_T (the values of wealth today and at time horizon T, respectively) the investor's problem is to select the asset allocation that maximizes the expected utility of ending wealth, $E[U(W_T)]$, subject to the constraints that asset class weights sum to 1 and that weights observe any limits the investor places on them. Beginning wealth, asset class weights, and asset class returns imply a distribution of values for ending wealth, and the utility function assigns a value to each of them; by weighting these values by their probability of occurrence, an expected utility for the asset allocation is determined.

An expected utility framework underlies many, but not all, quantitative approaches to asset allocation. A widely used group in asset allocation consists of power utility functions,[19] which exhibit the analytically convenient characteristic that risk aversion does not depend on the level of wealth. Power utility can be approximated by mean–variance utility, which underlies mean–variance optimization.

Optimal Choice in the Simplest Case

The simplest asset allocation decision problem involves one risky asset and one risk-free asset. Let λ, μ, r_f, and σ^2 represent, respectively, the investor's degree of risk aversion, the risk asset's expected return, the risk-free interest rate, and the variance of return. With mean–variance utility, the optimal allocation to the risky asset, w^*, can be shown to equal

$$w^* = \frac{1}{\lambda}\left(\frac{\mu - r_f}{\sigma^2}\right)$$

The allocation to the risky asset is inversely proportional to the investor's risk aversion and directly proportional to the risk asset's expected return per unit of risk (represented by return variance).[20]

Selection of a strategic asset allocation generally involves the following steps:[21]

1 Determine and quantify the investor's objectives. What is the pool of assets meant for (e.g., paying future benefit payments, contributing to a university's budget, securing ample assets for retirement)? What is the investor trying to achieve? What liabilities or needs or goals need to be recognized (explicitly or implicitly)? How should objectives be modeled?

2 Determine the investor's risk tolerance and how risk should be expressed and measured. What is the investor's overall tolerance for risk and specific risk sensitivities? How should these be quantified in the process of developing an appropriate asset allocation (risk measures, factor models)?

3 Determine the investment horizon(s). What are the appropriate planning horizons to use for asset allocation; that is, over what horizon(s) should the objectives and risk tolerance be evaluated?

19 Power utility has the form $U = \frac{W_T^{1-\lambda}}{1-\lambda}$, where $\lambda > 0$ is the parameter of risk aversion (if $\lambda \rightarrow 0$, the investor is risk neutral).

20 See Ang (2014), Chapter 4, for further analysis.

21 Arjan Berkelaar, CFA, contributed to this formulation of steps.

4 Determine other constraints and the requirements they impose on asset allocation choices. What is the tax status of the investor? Should assets be managed with consideration given to ESG issues? Are there any legal and regulatory factors that need to be considered? Are any political sensitivities relevant? Are there any other constraints that the investor has imposed in the IPS and other communications?
5 Determine the approach to asset allocation that is most suitable for the investor.
6 Specify asset classes, and develop a set of capital market expectations for the specified asset classes.
7 Develop a range of potential asset allocation choices for consideration. These choices are often developed through optimization exercises. Specifics depend on the approach taken to asset allocation.
8 Test the robustness of the potential choices. This testing often involves conducting simulations to evaluate potential results in relation to investment objectives and risk tolerance over appropriate planning horizon(s) for the different asset allocations developed in Step 7. The sensitivity of the outcomes to changes in capital market expectations is also tested.
9 Iterate back to Step 7 until an appropriate and agreed-on asset allocation is constructed.

Subsequent readings on asset allocation in practice will address the "how." The following sections give an indication of thematic considerations. We use investors with specific characteristics to illustrate the several approaches distinguished: sovereign wealth fund for asset-only allocation; a frozen corporate DB plan for liability-relative allocation; and an ultra-high-net-worth family for goals-based allocation. In practice, any type of investor could approach asset allocation with varying degrees of focus on modeling and integrating liabilities-side balance sheet considerations. How these cases are analyzed in this reading should not be viewed as specifying normative limits of application for various asset allocation approaches. For example, a liability-relative perspective has wide potential relevance for institutional investors because it has the potential to incorporate all information on the economic balance sheet. Investment advisers to high-net-worth investors may choose to use any of the approaches.

6.1 Asset Only

Asset-only allocation is based on the principle of selecting portfolios that make efficient use of asset risk. The focus here is mean–variance optimization, the mainstay among such approaches. Given a set of asset classes and assumptions concerning their expected returns, volatilities, and correlations, this approach traces out an efficient frontier that consists of portfolios that are expected to offer the greatest return at each level of portfolio return volatility. The Sharpe ratio is a key descriptor of an asset allocation: If a portfolio is efficient, it has the highest Sharpe ratio among portfolios with the same volatility of return.

An example of an investor that might use an asset-only approach is the (hypothetical) Government Petroleum Fund of Caflandia (GPFC) introduced next.

Investor Case Facts: GPFC, A Sovereign Wealth Fund

- *Name*: Government Petroleum Fund of Caflandia (GPFC)

- *Narrative*: The emerging country of Caflandia has established a sovereign wealth fund to capture revenue from its abundant petroleum reserves. The government's goal in setting up the fund is to promote a fair sharing of the benefits between current and future generations (intergenerational equity) from the export of the country's petroleum resources. Caflandia's equity market represents 0.50% of global equity market capitalization. Economists estimate that distributions in the interest of intergenerational equity may need to begin in 20 years. Future distribution policy is undetermined.
- *Tax status*: Non-taxable.
- *Financial assets and financial liabilities*: Financial assets are CAF$40 billion at market value, making GPFC among the largest investors in Caflandia. GPFC has no borrowings.
- *Extended assets and liabilities*: Cash inflows from petroleum exports are assumed to grow at inflation + 1% for the next 15 years and may change depending on reserves and global commodity demand. The present value of expected future income from state-owned reserves is estimated to be CAF$60 billion. Future spending needs are positively correlated with consumer inflation and population growth. In Exhibit 8, the amount for the present value (PV) of future spending, which GPFC has not yet determined, is merely a placeholder to balance assets and liabilities; as a result, no equity is shown.

Exhibit 8 GPFC Economic Balance Sheet (in CAF$ billions) 31 December 20x6

Assets		Liabilities and Economic Net Worth	
Financial Assets		*Financial Liabilities*	
Investments (includes cash, equities, fixed income, and other investments)	40		
Extended Assets		*Extended Liabilities*	
PV of expected future income	60	PV of future spending	100
		Economic Net Worth	
		Economic net worth	0
Total	100		100

For GPFC, the amount and timing of funds needed for future distributions to Caflandia citizens are, as yet, unclear. GPFC can currently focus on asset risk and its efficient use to grow assets within the limits of the fund's risk tolerance. In addition to considering expected return in relation to volatility in selecting an asset allocation, GPFC might include such considerations as the following:

- diversification across global asset classes (possibly quantified as a constraint on the proportion allocated to any given asset classes);
- correlations with the petroleum sources of income to GPFC;
- the potential positive correlation of future spending with inflation and population growth in Caflandia;

- long investment horizon (as a long-term investor, GPFC may be well positioned to earn any return premium that may be associated with the relatively illiquid asset classes); and
- return outcomes in severe financial market downturns.

Suppose GPFC quantifies its risk tolerance in traditional mean–variance terms as willingness to bear portfolio volatility of up to 17% per year. This risk tolerance is partly based on GPFC's unwillingness to allow the fund to fall below 90% funded. GPFC's current strategic asset allocation, along with several alternatives that have been developed by its staff during an asset allocation review, are shown in Exhibit 9. The category "Diversifying strategies" consists of a diversified allocation to hedge funds.

Exhibit 9 GPFC Strategic Asset Allocation Decision[22]

	Asset Allocation			
		Proposed		
	Current	A	B	C
Investment				
Equities				
Domestic	50%	40%	45%	30%
Global ex-domestic		10%	20%	25%
Bonds				
Nominal	30%	30%	20%	10%
Inflation linked				10%
Real estate	20%	10%	15%	10%
Diversifying strategies		10%		15%
Portfolio statistics				
Expected arithmetic return	8.50%	8.25%	8.88%	8.20%
Volatility (standard deviation)	15.57%	14.24%	16.63%	14.06%
Sharpe ratio	0.353	0.369	0.353	0.370
One-year 5% VaR	−17.11%	−15.18%	−18.48%	−14.93%

Notes: The government bond rate is 3%. The acceptable level of volatility is ≤ 17% per year. The value at risk (VaR) is stated as a percent of the initial portfolio value over one year (e.g., −16% means a decline of 16%).

GPFC decides it is willing to tolerate a 5% chance of losing 22% or more of portfolio value in a given year. This risk is evaluated by examining the one-year 5% VaR of potential asset allocations.

22 The assumed expected returns and return volatilities are (given in that order in parentheses and expressed as decimals, rather than percentages): domestic equities (0.11, 0.25), non-domestic equities (0.09, 0.18), nominal bonds (0.05, 0.10), inflation-linked bonds (0.035, 0.06), real estate (0.075, 0.16), and diversifying strategies (0.07, 0.09). A correlation matrix with hypothetical values and a hypothetical relationship between the allocations and VaR also lies behind the exhibit. Because the purpose here is to illustrate concepts rather than mechanics, inputs are not discussed although they are very important in asset allocation.

Let us examine GPFC's decision. The current asset allocation and the alternatives developed by staff all satisfy the GPFC's tolerance for volatility and VaR limit. The staff's alternatives appear to represent incremental, rather than large-scale, changes from the current strategic asset allocation. We do not know whether capital market assumptions have changed since the current strategic asset allocation was approved.

Mix A, compared with the current asset allocation, diversifies the equity allocation to include non-domestic (global ex-domestic) equities and spreads the current allocation to real estate over real estate and diversifying strategies. Given GPFC's long investment horizon and absence of liquidity needs, an allocation to diversifying strategies at 10% should not present liquidity concerns. Because diversifying strategies are more liquid than private real estate, the overall liquidity profile of the fund improves. It is important to note that given the illiquid nature of real estate, it could take considerable time to reallocate from real estate to diversifying strategies. Mix A has a lower volatility (by 133 bps) than the current allocation and slightly lower tail risk (the 5% VaR for Mix A is −15%, whereas the 5% VaR for the current asset mix is −17%). Mix A's Sharpe ratio is slightly higher. On the basis of the facts given, Mix A appears to be an incremental improvement on the current asset allocation.

Compared with Mix A and the current asset allocation, Mix B increases the allocation to equities by 15 percentage points and pulls back from the allocation to bonds and, in relation to Mix A, diversifying strategies. Although Mix B has a higher expected return and its VaR is within GPFC's tolerance of 22%, Mix B's lower Sharpe ratio indicates that it makes inefficient use of its additional risk. Mix B does not appear to deserve additional consideration.

Compared with the current asset allocation and Mix A, Mix C's total allocation to equities, at 55%, is higher and the mix is more diversified considering the allocation of 25% non-domestic equities. Mix C's allocation to fixed income is 20% compared with 30% for Mix A and the current asset mix. The remaining fixed-income allocation has been diversified with an exposure to both nominal and inflation-linked bonds. The diversifying strategies allocation is funded by a combination of the reduced weights to fixed income and real estate. The following observations may be made:

- Mix C's increase in equity exposure (compared with the equity exposure of Mix A and the current mix) has merit because more equity-like choices in the asset allocation could be expected to give GPFC more exposure to such a factor as a GDP growth factor (see Exhibit 9); population growth is one driver of GDP.
- Within fixed income, Mix C's allocation to inflation-linked bonds could be expected to hedge the inflation risk inherent in future distributions.
- Mix C has the lowest volatility and the lowest VaR among the asset allocations, although the differences compared with Mix A are very small. Mix C's Sharpe ratio is comparable to (insignificantly higher than) Mix A's.

Based on the facts given, Mix A and Mix C appear to be improvements over the current mix. Mix C may have the edge over Mix A based on the discussion. As a further step in the evaluation process, GPFC may examine the robustness of the forecasted results by changing the capital market assumptions and simulating shocks to such variables as inflation. The discussion of Mix C shows that there are means for potential liability concerns (the probable sensitivity of spending to inflation and population growth) to enter decision making even from a mean–variance optimization perspective.

EXAMPLE 6

Asset-Only Asset Allocation

1. Describe how the Sharpe ratio, considered in isolation, would rank the asset allocation in Exhibit 9.
2. State a limitation of basing a decision only on the Sharpe ratio addressed in Question 1.
3. An assertion is heard in an investment committee discussion that because the Sharpe ratio of diversifying strategies (0.55) is higher than real estate's (0.50), any potential allocation to real estate would be better used in diversifying strategies. Describe why the argument is incomplete.

Solution to 1:

The ranking by Sharpe ratios in isolation is C (3.70), A (3.69), and current and B (both 3.53). Using only the Sharpe ratio, Mix C appears superior to the other choices, but such an approach ignores several important considerations.

Solution to 2:

The Sharpe ratio, while providing a means to rank choices on the basis of return per unit of volatility, does not capture other characteristics that are likely to be important to the asset owner, such as VaR and funded ratio. Furthermore, the Sharpe ratio by itself cannot confirm that the absolute level of portfolio risk is within the investor's specified range.

Solution to 3:

It is true that the higher the Sharpe ratio of an investment, the greater its contribution to the Sharpe ratio of the overall portfolio, *holding all other things equal*. However, that condition is not usually true. Diversification potential in a portfolio (quantified by correlations) may differ. For example, including both diversifying strategies and real estate in an allocation may ultimately decrease portfolio-level risk through favorable correlation characteristics. Also, as in the solution to Question 2, other risk considerations besides volatility may be relevant.

Financial theory suggests that investors should consider the global market-value weighted portfolio as a baseline asset allocation. This portfolio, which sums all investable assets (global stocks, bonds, real estate, and so forth) held by investors, reflects the balancing of supply and demand across world markets. In financial theory, it is the portfolio that minimizes diversifiable risk, which in principle is uncompensated. Because of that characteristic, theory indicates that the global market portfolio should be the available portfolio that makes the most efficient use of the risk budget.[23] Other arguments for using it as a baseline include its position as a reference point for a highly diversified portfolio and the discipline it provides in relation to mitigating any investment biases, such as home-country bias (discussed below).

At a minimum, the global market portfolio serves as a starting point for discussion and ensures that the investor articulates a clear justification for moving away from global capitalization market weights. The global market portfolio is expressed in two phases. The first phase allocates assets in proportion to the global portfolio of stocks, bonds, and real assets. The second phase disaggregates each of these broad asset

23 According to the two-fund separation theorem, all investors optimally hold a combination of a risk-free asset and an optimal portfolio of all risky assets. This optimal portfolio is the global market value portfolio.

classes into regional, country, and security weights using capitalization weights. The second phase is typically used within a global equity portfolio where an asset owner will examine the global capitalization market weights and either accept them or alter them. Common tilts (biases) include overweighting the home-country market, value, size (small cap), and emerging markets. For many investors, allocations to foreign fixed income have been adopted more slowly than allocations to foreign equity. Most investors have at least some amount in non-home-country equity.

Home-Country Bias

A given for GPFC was that Caflandia's equity markets represent only 0.50% of the value of world equity markets. However, in all asset allocations in Exhibit 9, the share of domestic equity ranged from 50% for the current asset allocation to 30% for Mix C. The favouring of domestic over non-domestic investment relative to global market value weights is called **home-country bias** and is very common. Even relatively small economies feature pension plans, endowments, and other funds, which are disproportionately tilted toward the equity and fixed-income offerings in the domestic market. The same tendency is true for very large markets, such as the United States and the eurozone. By biasing toward the home market, asset owners may not be optimally aligning regional weights with the global market portfolio and are implicitly implementing a market view. Investment explanations for the bias, such as offsetting liabilities that are denominated in the home currency, may be relevant in some cases, however.

For reference, the MSCI All Country World Portfolio (ACWI), a proxy for the public equities portion of the global equity market portfolio, contains the following capitalization weights as of 31 December 2015:

- Developed Europe and the Middle East: 22.8%
- Developed Pacific: 11.7%
- North America: 55.9%
- Emerging markets: 9.6%

Investing in a global market portfolio faces several implementation hurdles. First, estimating the size of each asset class on a global basis is an imprecise exercise given the uneven availability of information on non-publicly traded assets. Second, the practicality of investing proportionately in residential real estate, much of which is held in individual homeowners' hands, has been questioned. Third, private commercial real estate and global private equity assets are not easily carved into pieces of a size that is accessible to most investors. Practically, proxies for the global market portfolio are often based only on traded assets, such as portfolios of exchange-traded funds (ETFs). Furthermore, some investors have implemented alternative weighting schemes, such as GDP weight or equal weight. However, it is a useful discipline to articulate a justification for any deviation from the capitalization-weighted global market portfolio.

6.2 Liability Relative

To illustrate the liability-relative approach, we take the defined benefit (DB) pension plan of (hypothetical) GPLE Corporation, with case facts given below.

A Frozen DB Plan, GPLE Corporation Pension

- *Name*: GPLE Corporation Pension
- *Narrative*: GPLE is a machine tool manufacturer with a market value of $2 billion. GPLE is the sponsor of a $1.25 billion legacy DB plan, which is now frozen (i.e., no new plan participants and no new benefits accruing for existing plan participants). GPLE Pension has a funded ratio (the ratio of pension assets to liabilities) of 1.15. Thus, the plan is slightly overfunded. Responsibility for the plan's management rests with the firm's treasury department (which also has responsibility for GPLE Corporation treasury operations).
- *Tax status*: Non-taxable.
- *Financial assets and financial liabilities*: Assets amount to $1.25 billion at market values. Given a funded ratio of 1.15, that amount implies that liabilities are valued at about $1.087 billion. Projected distributions to pension beneficiaries have a present value of $1.087 billion at market value.

GPLE does not reflect any extended assets or liabilities; thus, economic net worth is identical to traditional accounting net worth.

Exhibit 10 GPLE Pension Economic Balance Sheet (in US$ billions) 31 December 20x6

Assets		Liabilities and Economic Net Worth	
Financial Assets		*Financial Liabilities*	
Pension assets	1.250	PV of pension liability	1.087
		Economic Net Worth	
		Economic net worth	0.163
Total	1.250		1.250

GPLE, the plan sponsor, receives two asset allocation recommendations. Recommendation A does not explicitly consider GPLE's pension's liabilities but is instead based on an asset-only perspective: the mean–variance efficient frontier given a set of capital market assumptions. A second recommendation, "Recommendation B," does explicitly consider liabilities, incorporating a liability-hedging portfolio based on an analysis of GPLE pension liabilities and a return-seeking portfolio.

In evaluating asset allocation choices, consider the pensioners' and the plan sponsor's interests. Pensioners want to receive the stream of promised benefits with as little risk, or chance of interruption, as possible. Risk increases as the funded ratio declines. When the funded ratio is 1.0, pension assets just cover pension liabilities with no safety buffer. When the funded ratio is less than 1.0, the plan sponsor generally needs to make up the deficit in pension assets by contributions to the plan. For example, with a 10-year investment time horizon and a choice between two asset allocations, the allocation with the lower expected present value of cumulative contributions to Year 10 would generally be preferred by the sponsor, all else being equal. In practice, all else is usually not equal. For example, the alternative with the lower *expected* present value of contributions may involve more risk to the level of contributions in adverse market conditions. For example, the 5% of *worst outcomes* for the present value of cumulative contributions may be more severe for the lower expected contribution alternative. Thus, possible asset allocations generally involve risk trade-offs.[24] Now consider the recommendations.

Recommendation A, based on asset-only analysis, involves a 65% allocation to global equities and a 35% allocation to global fixed income. Assume that this asset allocation is mean–variance efficient and has the highest Sharpe ratio among portfolios that meet the pension's assumed tolerance for asset return volatility. Capital market assumptions indicate that equities have a significantly higher expected return and volatility than fixed income.

Recommendation B, based on a liability-relative approach to asset allocation, involves an allocation of \$1.125 billion to a fixed-income portfolio that is very closely matched in interest rate sensitivity to the present value of plan liabilities (and to any other liability factor risk exposures)—the liability hedging portfolio—and a \$0.125 allocation to equities (the return-seeking portfolio). This is a proportional allocation of 10% to equities and 90% to fixed income. The equities allocation is believed to provide potential for increasing the size of the buffer between pension assets and liabilities with negligible risk to funded status. Recommendation B lies below the asset-only efficient frontier with a considerably lower expected return vis-à-vis Recommendation A.

What are the arguments for and against each of these recommendations? Recommendation A is expected, given capital market assumptions, to increase the size of the buffer between pension assets and liabilities. But the sponsor does not benefit from increases in the buffer if the current buffer is adequate.[25] However, with a 0.65 × \$1.25 billion = \$0.8125 allocation to equities and a current buffer of assets of \$1.25 billion – \$1.087 billion = \$0.163 billion, a decline of that amount or more in equity values (a 20% decline) would put the plan into underfunded status (assuming no commensurate changes in the liability). Thus, Recommendation A creates contribution risk for the plan sponsor without a potential upside clearly benefiting either the sponsor or beneficiaries.

For Recommendation B, because the risk characteristics of the \$1.125 billion fixed-income portfolio are closely matched with those of the \$1.087 billion of pension liabilities with a buffer, the plan sponsor should not face any meaningful risk of needing to make further contributions to the pension. Pensioners expect the plan to be fully funded on an ongoing basis without any reliance on the sponsor's ability to make additional contributions. This is an excellent outcome for both. The pension liabilities are covered (defeased).

The example is highly stylized—the case facts were developed to make points cleanly—but does point to the potential value of managing risk in asset allocation explicitly in relation to liabilities. A typical use of fixed-income assets in liability-relative asset allocation should be noted: Liability-relative approaches to asset allocation tend to give fixed income a larger role than asset-only approaches in such cases as the one examined here because interest rates are a major financial market driver of both liability and bond values. Thus, bonds can be important in hedging liabilities, but equities can be relevant for liability hedging too. With richer case facts, as when liabilities accrue with inflation (not the case in the frozen DB example), equities may have a long-term role in matching the characteristics of liabilities. In underfunded plans, the potential upside of equities would often have greater value for the plan sponsor than in the fully funded case examined.

24 Collie and Gannon (2009) explore the contribution risk trade-off considered here in more detail.

25 Real-world complexities, such as DB plan termination to capture a positive surplus or pension risk transfer (annuitization), are beyond the scope of this reading; generally, there are restrictions and penalties involved in such actions, and the point made here is valid.

Liability Glide Paths

If GPLE were underfunded, it might consider establishing a liability glide path. A **liability glide path** is a technique in which the plan sponsor specifies in advance the desired proportion of liability-hedging assets and return-seeking assets and the duration of the liability hedge as funded status changes and contributions are made. The technique is particularly relevant to underfunded pensions. The idea reflects the fact that the optimal asset allocation in general is sensitive to changes in the funded status of the plan. The objective is to increase the funded status by reducing surplus risk over time. Although a higher contribution rate may be necessary to align assets with liabilities, the volatility of contributions should decrease, providing more certainty for cash flow planning purposes and decreasing risk to plan participants. Eventually, GPLE would hope to achieve and maintain a sufficiently high funded ratio so that there would be minimal risk of requiring additional contributions or transferring pension risk to an annuity provider.

The importance of such characteristics as interest rate sensitivity (duration), inflation, and credit risk in constructing a liability-hedging asset portfolio suggests the relevance of risk-factor modeling in liability-relative approaches. A risk factor approach can be extended to the return-seeking portfolio in order to minimize unintentional overlap among common factors across both portfolios—for example, credit. Exploring these topics is outside the scope of the current reading.

The next section addresses an approach to asset allocation related to liability relative in its focus on funding needs.

6.3 Goals Based

We use the hypothetical Lee family to present some thematic elements of a goals-based approach.

Investor Case Facts: The Lee Family

- *Name*: Ivy and Charles Lee
- *Narrative*: Ivy is a 54-year-old life sciences entrepreneur. Charles is 55 years old and employed as an orthopedic surgeon. They have two unmarried children aged 25 (Deborah) and 18 (David). Deborah has a daughter with physical limitations.
- *Financial assets and financial liabilities*: Portfolio of $25 million with $1 million in margin debt as well as residential real estate of $3 million with $1 million in mortgage debt.
- *Other assets and liabilities*:
  - Pre-retirement earnings are expected to total $16 million in present value terms (human capital).
  - David will soon begin studying at a four-year private university; the present value of the expected parental contribution is $250,000.
  - The Lees desire to give a gift to a local art museum in five years. In present value terms, the gift is valued at $750,000.
  - The Lees want to establish a trust for their granddaughter with a present value of $3 million to be funded at the death of Charles.
  - The present value of future consumption expenditures is estimated at $20 million.

Exhibit 11 Lee Family Economic Balance Sheet (in US$ millions) 31 December 20x6

Assets		Liabilities and Economic Net Worth	
Financial Assets		*Financial Liabilities*	
Investment portfolio	25	Margin debt	1
Real estate	3	Mortgage	1
Extended Assets		*Extended Liabilities*	
Human capital	16	David's education	0.25
		Museum gift	0.75
		Special needs trust	3
		PV of future consumption	20
		Economic Net Worth	
		Economic net worth (economic assets less economic liabilities)	18
Total	44		44

The financial liabilities shown are legal liabilities. The extended liabilities include funding needs that the Lees want to meet. The balance sheet includes an estimate of the present value of future consumption, which is sometimes called the "consumption liability." The amount shown reflects expected values over their life expectancy given their ages. If they live longer, consumption needs will exceed the $20 million in the case facts and erode the $18 million in equity. If their life span is shorter, $18 million plus whatever they do not consume of the $20 million in PV of future consumption becomes part of their estate. Note that for the Lees, the value of assets exceeds the value of liabilities, resulting in a positive economic net worth (a positive difference between economic assets and economic liabilities); this is analogous to a positive owners' equity on a company's financial balance sheet.

From Exhibit 11, we can identify four goals totaling $24 million in present value terms: a lifestyle goal (assessed as a need for $20 million in present value terms), an education goal ($0.25 million), a charitable goal ($0.75 million), and the special needs trust ($3 million).

The present value of expected future earnings (human capital) at $16 million is less than the lifestyle present value of $20 million, which means that some part of the investment portfolio must fund the Lees' standard of living. It is important to note that although the Lee family has $18 million of economic net worth, most of this comes from the $16 million extended asset of human capital. Specific investment portfolio assets have not yet been dedicated to specific goals.

Goals-based asset allocation builds on several insights from behavioral finance. The approach's characteristic use of sub-portfolios is grounded in the behavioral finance insight that investors tend to ignore money's fungibility[26] and assign specific dollars to specific uses—a phenomenon known as mental accounting. Goals-based asset allocation, as described here, systemizes the fruitful use of mental accounts. This approach may help investors embrace more-optimal portfolios (as defined in an asset-only or

26 "Fungibility" is the property of an asset that a quantity of it may be replaced by another equal quantity in the satisfaction of an obligation. Thus, any 5,000 Japanese yen note can be used to pay a yen obligation of that amount, and the notes can be said to be fungible.

asset–liability framework) by adding higher risk assets—that, without context, might frighten the investor—to longer-term, aspirational sub-portfolios while adopting a more conservative allocation for sub-portfolios that address lifestyle preservation.

In Exhibit 11, the Lees' lifestyle goal is split into three components: a component called "lifestyle—minimum" intended to provide protection for the Lees' lifestyle in a disaster scenario, a component called "lifestyle—baseline" to address needs outside of worst cases, and a component called "lifestyle—aspirational" that reflects a desire for a chance at a markedly higher lifestyle. These sum to the present value of future consumption shown in the preceding Exhibit 11. Exhibit 12 describes these qualitatively; a numerical characterization could be very relevant for some advisers, however. By eliciting information on the Lees' perception of the goals' importance, the investment adviser might calibrate the required probabilities of achieving the goals quantitatively. For example, the three lifestyle goals might have 99%, 90%, and 50% assigned probabilities of success, respectively.

Exhibit 12 Lee Family: Required Probability of Meeting Goals and Goal Time Horizons

Goal	Required Probability of Achieving	Time Horizon
Lifestyle—minimum	Extremely high	Short to distant
Lifestyle—baseline	Very high	Short to distant
Lifestyle—aspirational	Moderate	Distant
Education	Very high	Short
Trust	High	Long
Charitable	Moderate	Short

Because the Lees might delay or forego making a gift to the museum if it would affect the trust goal, the trust goal is more urgent for the Lees. Also note that although parts of the Lees' lifestyle goals run the full time horizon spectrum from short to distant, they also have significant current earnings and human capital (which transforms into earnings as time passes). This fact puts the investment portfolio's role in funding the lifestyle goal further into the future.

Goals-based approaches generally set the strategic asset allocation in a bottom-up fashion. The Lees' lifestyle goal might be addressed with three sub-portfolios, with the longest horizon sub-portfolio being less liquid and accepting more risk than the others. Although for the GPLE pension, no risk distinction was made among different parts of the pension liability vis-à-vis asset allocation, such distinctions are made in goals-based asset allocation.

What about the Lees' other goals? Separate sub-portfolios could be assigned to the special needs and charitable goals with asset allocations that reflect the associated time horizons and required probabilities of not attaining these goals. A later reading on asset allocation in practice addresses implementation processes in detail.

Types of Goals

As goals-based asset allocation has advanced, various classification systems for goals have been proposed. Two of those classification systems are as follows.

Brunel (2012):

- *Personal goals*—to meet current lifestyle requirements and unanticipated financial needs
- *Dynastic goals*—to meet descendants' needs
- *Philanthropic goals*

Chhabra (2005):

- *Personal risk bucket*—to provide protection from a dramatic decrease in lifestyle (i.e., safe-haven investments)
- *Market risk bucket*—to ensure the current lifestyle can be maintained (allocations for average risk-adjusted market returns)
- *Aspirational risk bucket*—to increase wealth substantially (greater than average risk is accepted)

EXAMPLE 7

Goals-Based Asset Allocation

The Lees are presented with the following optimized asset allocations:

Asset Allocation	Cash	Global Bonds	Global Equities	Diversifying Strategies
A	40%	50%	10%	0%
B	10%	30%	45%	15%

Assume that a portfolio of 70% global equities and 30% bonds reflects an appropriate balance of expected return and risk for the Lees with respect to a 10-year time horizon for most moderately important goals. Based on the information given:

1 What goal(s) may be addressed by Allocation A?

2 What goal(s) may be addressed by Allocation B?

Because of her industry connections in the life sciences, Ivy Lee is given the opportunity to be an early-stage venture capital investor in what she assesses is a very promising technology.

3 What insights does goals-based asset allocation offer on this opportunity?

Solution to 1:

Allocation A stresses liquidity and stability. It may be appropriate to meet short-term lifestyle and education goals.

Solution to 2:

Allocation B has a greater growth emphasis, although it is somewhat conservative in relation to a 70/30 equity/bond baseline. It may be appropriate for funding the trust because of the goal's long time horizon and the Lees' desire for a high probability of achieving it.

Solution to 3:

Early-stage venture capital investments are both risky and illiquid; therefore, they belong in the longer-term and more risk-tolerant sub-portfolios. Ivy's decision about how much money she can commit should relate to how much excess capital remains after addressing goals that have a higher priority associated with them. Note that economic balance sheet thinking would stress that the life sciences opportunity is not particularly diversifying to her human capital.

Discount Rates and Longevity Risk

Although calculation of assets needed for sub-portfolios is outside the scope of this reading, certain themes can be indicated. Consider a retiree with a life expectancy of 20 years. The retiree has two goals:

- To maintain his current lifestyle upon retirement. This goal has a high required probability of achievement that is evaluated at 95%.
- To gift $1 million to a university in five years. This is viewed as a "desire" rather than a "need" and has a required probability evaluated at 75%.

Suppose that the investor's adviser specifies sub-portfolios as follows:

- for the first decade of lifestyle spending, a 3% expected return;
- for the second decade of lifestyle spending, a 4.6% expected return; and
- for the planned gift to the university, a 5.4% expected return.

Based on an estimate of annual consumption needs and the amount of the gift and given expected returns for the assigned sub-portfolios, the assets to be assigned to each sub-portfolio could be calculated by discounting amounts back to the present using their expected returns. However, this approach does not reflect the asset owner's required probability of achieving a goal. The higher the probability requirement for a future cash need, the greater the amount of assets needed in relation to it. Because of the inverse relation between present value and the discount rate, to reflect a 95% required probability, for example, the discount rates could be set at a lower level so that more assets are assigned to the sub-portfolio, increasing the probability of achieving the goal to the required level of 95% level.

Another consideration in determining the amount needed for future consumption is longevity risk. Life expectancies are median (50th percentile) outcomes. The retiree may outlive his life expectancy. To address longevity risk, the calculation of the present value of liabilities might use a longer life expectancy, such as a 35-year life expectancy instead of his actuarial 20-year expectation. Another approach is to transfer the risk to an insurer by purchasing an annuity that begins in 20 years and makes payments to the retiree for as long as he lives. Longevity risk and this kind of deferred annuity (sometimes called a "longevity annuity") are discussed in another curriculum reading on risk management.[27]

There are some drawbacks to the goals-based approach to asset allocation. One is that the sub-portfolios add complexity. Another is that goals may be ambiguous or may change over time. Goals-based approaches to asset allocation raise the question

27 See Blanchett et al. (2016) for the management of longevity risk. Milevsky (2016) is a further reference.

of how sub-portfolios coordinate to constitute an efficient whole. The subject will be taken up in a later reading, but the general finding is that the amount of sub-optimality is small.[28]

IMPLEMENTATION CHOICES

7

Having established the strategic asset allocation policy, the asset owner must address additional strategic considerations before moving to implementation. One of these is the passive/active choice.

There are two dimensions of passive/active choices. One dimension relates to the management of the strategic asset allocation itself—for example, whether to deviate from it tactically or not. The second dimension relates to passive and active implementation choices in investing the allocation to a given asset class. The first dimension is covered in Section 5.1. The second dimension is the subject of Section 5.2.

In an advisory role, asset managers have an unequivocal responsibility to make implementation and asset selection choices that are initially, and on an ongoing basis, suitable for the client.[29]

7.1 Passive/Active Management of Asset Class Weights

Tactical asset allocation (TAA) involves deliberate short-term deviations from the strategic asset allocation. Whereas the strategic asset allocation incorporates an investor's long-term, equilibrium market expectations, tactical asset allocation involves short-term tilts away from the strategic asset mix that reflect short-term views—for example, to exploit perceived deviations from equilibrium.

Tactical asset allocation is active management at the asset class level because it involves intentional deviations from the strategic asset mix to exploit perceived opportunities in capital markets to improve the portfolio's risk–return trade-off. TAA mandates are often specified to keep deviations from the strategic asset allocation within rebalancing ranges or within risk budgets. Tactical asset allocation decisions might be responsive to price momentum, perceived asset class valuation, or the particular stage of the business cycle. A strategy incorporating deviations from the strategic asset allocation that are motivated by longer-term valuation signals or economic views is sometimes distinguished as **dynamic asset allocation** (DAA).

Tactical asset allocation may be limited to tactical changes in domestic stock–bond or stock–bond–cash allocations or may be a more comprehensive multi-asset approach, as in a global tactical asset allocation (GTAA) model. Tactical asset allocation inherently involves market timing as it involves buying and selling in anticipation of short-term changes in market direction; however, TAA usually involves smaller allocation tilts than an invested-or-not-invested market timing strategy.

Tactical asset allocation is a source of risk when calibrated against the strategic asset mix. An informed approach to tactical asset allocation recognizes the trade-off of any potential outperformance against this tracking error. Key barriers to successful tactical asset allocation are monitoring and trading costs. For some investors, higher short-term capital gains taxes will prove a significant obstacle because taxes are an additional trading cost. A program of tactical asset allocation must be evaluated through a cost–benefit lens. The relevant cost comparisons include the expected costs of simply following a rebalancing policy (without deliberate tactical deviations).

28 This is addressed technically in Das et al. (2010). See also Brunel (2015).
29 See Standard III (C) in the Standards of Practice Handbook (CFA Institute 2014).

7.2 Passive/Active Management of Allocations to Asset Classes

In addition to active and passive decisions about the asset class mix, there are active and passive decisions about how to implement the individual allocations within asset classes. An allocation can be managed passively or actively or incorporate both active and passive sub-allocations. For investors who delegate asset management to external firms, these decisions would come under the heading of manager structure,[30] which includes decisions about how capital and active risk are allocated to points on the passive/active spectrum and to individual external managers selected to manage the investor's assets.[31] (Risk budgeting is described more fully in Section 5.3.)

With a **passive management** approach, portfolio composition does not react to changes in the investor's capital market expectations or to information on or insights into individual investments. (The word *passive* means *not reacting.*) For example, a portfolio constructed to track the returns of an index of European equities might add or drop a holding in response to a change in the index composition but not in response to changes in the manager's expectations concerning the security's investment value; the market's expectations reflected in market values and index weights are taken as is. Indexing is a common passive approach to investing. (Another example would be buying and holding a fixed portfolio of bonds to maturity.)

In contrast, a portfolio manager for an active management strategy will respond to changing capital market expectations or to investment insights resulting in changes to portfolio composition. The objective of active management is to achieve, after expenses, positive excess risk-adjusted returns relative to a passive benchmark.

The range of implementation choices can be practically viewed as falling along a passive/active spectrum because some strategies use both passive and active elements. In financial theory, the pure model of a passive approach is indexing to a broad market-cap-weighted index of risky assets—in particular, the global market portfolio discussed in Section 4.1. This portfolio sums all investments in index components and is macro-consistent in the sense that all investors could hold it, and it is furthermore self-rebalancing to the extent it is based on market-value-weighted indices. A buy-and-hold investment as a proxy for the global market portfolio would represent a theoretical endpoint on the passive/active spectrum. However, consider an investor who indexes an equity allocation to a broad-based value equity style index. The investment could be said to reflect an active decision in tilting an allocation toward value but be passive in implementation because it involves indexing. An even more active approach would be investing the equity allocation with managers who have a value investing approach and attempt to enhance returns through security selection. Those managers would show positive tracking risk relative to the value index in general. Unconstrained active investment would be one that is "go anywhere" or not managed with consideration of any traditional asset class benchmark (i.e., "benchmark agnostic"). The degree of active management has traditionally been quantified by tracking risk and, from a different perspective, by active share.

Indexing is generally the lowest-cost approach to investing. Indexing involves some level of transaction costs because, as securities move in and out of the index, the portfolio holdings must adjust to remain in alignment with the index. Although indexing to a market-cap-weighted index is self-rebalancing, tracking an index based on other weighting schemes requires ongoing transactions to ensure the portfolio remains in alignment with index weights. An example is tracking an equally weighted index: As changes in market prices affect the relative weights of securities in the portfolio over

30 Manager structure is defined by the number of managers, types of managers, as well as which managers are selected.
31 See, for example, Waring, Whitney, Pirone, and Castille (2000).

time, the portfolio will need to be rebalanced to restore equal weights. Portfolios tracking fixed-income indices also incur ongoing transaction costs as holdings mature, default, or are called away by their issuers.

Exhibit 13 diagrams the passive/active choice as a continuum rather than binary (0 or 1) characteristic. Tracking risk and active share are widely known quantitative measures of the degree of active management that capture different aspects of it. Each measure is shown as tending to increase from left to right on the spectrum; however, they do not increase (or decrease) in lockstep with each other, in general.

Exhibit 13 Passive/Active Spectrum

MOST PASSIVE (indexing to market weights)	Use of information on asset classes, investment factors, and individual investments increases is often quantified by → Increasing tracking risk relative to benchmark → → Increasing active share relative to benchmark →	MOST ACTIVE (unconstrained mandates)

Asset class allocations may be managed with different approaches on the spectrum. For example, developed market equities might be implemented purely passively, whereas emerging market bonds might be invested with an unconstrained, index-agnostic approach.

Factors that influence asset owners' decisions on where to invest on the passive/active spectrum include the following:

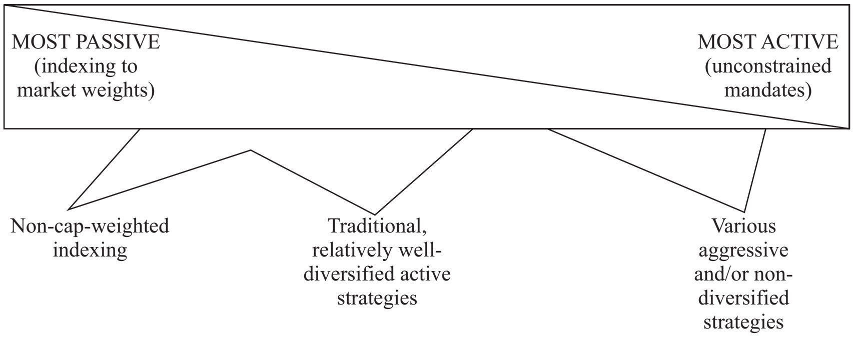
- *Available investments*. For example, the availability of an investable and representative index as the basis for indexing.
- *Scalability of active strategies being considered.* The prospective value added by an active strategy may begin to decline at some level of invested assets. In addition, participation in it may not be available below some asset level, a consideration for small investors.
- *The feasibility of investing passively while incorporating client-specific constraints*. For example, an investor's particular ESG investing criteria may not align with existing index products.
- *Beliefs concerning market informational efficiency*. A strong belief in market efficiency for the asset class(es) under consideration would orient the investor away from active management.
- *The trade-off of expected incremental benefits relative to incremental costs and risks of active choices.* Costs of active management include investment management costs, trading costs, and turnover-induced taxes; such costs would have to be judged relative to the lower costs of index alternatives, which vary by asset class.
- *Tax status.* Holding other variables constant, taxable investors would tend to have higher hurdles to profitable active management than tax-exempt investors.[32] For taxable investors who want to hold both passive and active investments, active investments would be held, in general, in available tax-advantaged accounts.

The curriculum readings on equity, fixed-income, and alternative investments will explore many strategies and the nature of any active decisions involved. Investors do need to understand the nature of the active decisions involved in implementing

32 See Jeffrey and Arnott (1993).

their strategic asset allocations and their appropriateness given the factors described. Exhibit 14 shows qualitatively (rather than precisely) some choices that investors may consider for equity and fixed-income allocations. In the exhibit, non-cap-weighted indexing includes such approaches as equal weighting and quantitative rules-based indexing approaches (discussed further in the equity readings).[33]

Exhibit 14 Placement on the Passive/Active Spectrum: Examples of Possible Choices



EXAMPLE 8

Implementation Choices (1)

1 Describe two kinds of passive/active choices faced by investors related to asset allocation.

2 An equity index is described as "a rules-based, transparent index designed to provide investors with an efficient way to gain exposure to large-cap and small-cap stocks with low total return variability." Compared with the market-cap weighting of the parent index (with the same component securities), the weights in the low-volatility index are proportional to the inverse of return volatility, so that the highest-volatility security receives the lowest weight. Describe the active and passive aspects of a decision to invest an allocation to equities in ETFs tracking such indices.

3 Describe how investing in a GDP-weighted global bond index involves both active and passive choices.

Solution to 1:

One choice relates to whether to allow active deviations from the strategic asset allocation. Tactical asset allocation and dynamic asset allocation are examples of active management of asset allocations. A second set of choices relates to where to invest allocations to asset classes along the passive/active spectrum.

Solution to 2:

The active element is the decision, relative to the parent index, to overweight securities with low volatility and underweight securities with high volatility. This management of risk is distinct from reducing portfolio volatility by combining a

33 Podkaminer (2015) provides a survey.

market-cap-weighted index with a risk-free asset proxy because it implies a belief in some risk–return advantage to favoring low-volatility equities on an individual security basis. The passive element is a transparent rules-based implementation of the weighting scheme based on inverse volatilities.

Solution to 3:

The passive choice is represented by the overall selection of the universe of global bonds; however, the active choice is represented by the weighting scheme, which is to use GDP rather than capital market weights. This is a tilt toward the real economy and away from fixed-income market values.

EXAMPLE 9

Implementation Choices (2)

Describe characteristic(s) of each of the following investors that are likely to influence the decision to invest passively or actively.

1 Caflandia sovereign wealth fund
2 GPLE corporate pension
3 The Lee family
4 Auldberg University Endowment

Solution:

1 For a large investor like the Caflandia sovereign wealth fund (CAF$40 billion), the scalability of active strategies that it may wish to employ may be a consideration. If only a small percentage of portfolio assets can be invested effectively in an active strategy, for example, the potential value added for the overall portfolio may not justify the inherent costs and management time. Although the equities and fixed-income allocations could be invested using passive approaches, investments in the diversifying strategies category are commonly active.

2 The executives responsible for the GPLE corporate pension also have other, non-investment responsibilities. This is a factor favoring a more passive approach; however, choosing an outsourced chief investment officer or delegated fiduciary consultant to manage active manager selection could facilitate greater use of active investment.

3 The fact that the Lees are taxable investors is a factor generally in favor of passive management for assets not held in tax-advantaged accounts. Active management involves turnover, which gives rise to taxes.

4 According to the vignette in Example 3, the Auldberg University Endowment has substantial staff resources in equities, fixed income, and real estate. This fact suggests that passive/active decisions are relatively unconstrained by internal resources. By itself, it does not favor passive or active, but it is a factor that allows active choices to be given full consideration.

7.3 Risk Budgeting Perspectives in Asset Allocation and Implementation

Risk budgeting addresses the questions of which types of risks to take and how much of each to take. Risk budgeting provides another view of asset allocation—through a risk lens. Depending on the focus, the risk may be quantified in various ways. For example, a concern for volatility can be quantified as variance or standard deviation of returns, and a concern for tail risk can be quantified as VaR or drawdown. Risk budgets (budgets for risk taking) can be stated in absolute or in relative terms and in money or percent terms. For example, it is possible to state an overall risk budget for a portfolio in terms of volatility of returns, which would be an example of an absolute risk budget stated in percent terms (for example, 20% for portfolio return volatility). Risk budgeting is a tool that may be useful in a variety of contexts and asset allocation approaches.

Some investors may approach asset allocation with an exclusive focus on risk. A risk budgeting approach to asset allocation has been defined as an approach in which the investor specifies how risk (quantified by some measure, such as volatility) is to be distributed across assets in the portfolio, without consideration of the assets' expected returns.[34] An example is aiming for equal expected risk contributions to overall portfolio volatility from all included asset classes as an approach to diversification, which is a risk parity (or equal risk contribution) approach. A subsequent reading in asset allocation addresses this in greater detail.

More directly related to the choice of passive/active implementation are active risk budgets and active risk budgeting. **Active risk budgeting** addresses the question of how much benchmark-relative risk an investor is willing to take in seeking to outperform a benchmark. This approach is risk budgeting stated in benchmark-relative terms. In parallel to the two dimensions of the passive/active decision outlined previously are two levels of active risk budgeting, which can be distinguished as follows:

- At the level of the overall asset allocation, active risk can be defined relative to the strategic asset allocation benchmark. This benchmark may be the strategic asset allocation weights applied to specified (often, broad-based market-cap-weighted) indices.
- At the level of individual asset classes, active risk can be defined relative to the asset class benchmark.

Active risk budgeting at the level of overall asset allocation would be relevant to tactical asset allocation. Active risk budgeting at the level of each asset class is relevant to how the allocation to those asset classes is invested. For example, it can take the form of expected-alpha versus tracking-error optimization in a manner similar to classic mean–variance optimization. If investment factor risks are the investor's focus, risk budgeting can be adapted to have a focus on allocating factor risk exposures instead. Later readings revisit risk budgeting in investing in further detail.

8 REBALANCING: STRATEGIC CONSIDERATIONS

Rebalancing is the discipline of adjusting portfolio weights to more closely align with the strategic asset allocation. Rebalancing is a key part of the monitoring and feedback step of the portfolio construction, monitoring, and revision process. An investor's rebalancing policy is generally documented in the IPS.

34 See Roncalli (2013).

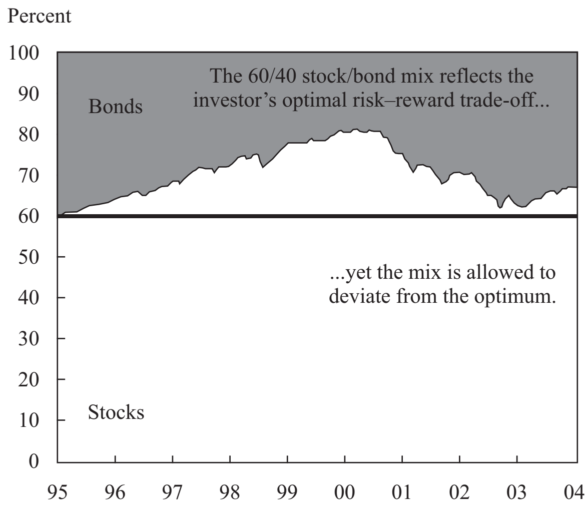
Even in the absence of changing investor circumstances, a revised economic outlook, or tactical asset allocation views, normal changes in asset prices cause the portfolio asset mix to deviate from target weights. Industry practice defines "rebalancing" as portfolio adjustments triggered by such price changes. Other portfolio adjustments, even systematic ones, are not rebalancing.

Ordinary price changes cause the assets with a high forecast return to grow faster than the portfolio as a whole. Because high-return assets are typically also higher risk, in the absence of rebalancing, overall portfolio risk rises. The mix of risks within the portfolio becomes more concentrated as well. Systematic rebalancing maintains the original strategic risk exposures. The discipline of rebalancing serves to control portfolio risks that have become different from what the investor originally intended.

Consider the example from the internet bubble (1995–2001) in Exhibit 15. The example assumes a 60/40 stock/bond portfolio, in which stocks are represented by the large-cap US growth stocks that characterized the internet bubble. In Panel B, the left-hand scale and upper two lines show month-by-month total portfolio *values* with and without monthly rebalancing ("wealth rebalanced" and "wealth unrebalanced," respectively). The right-hand scale and lower two lines show month-by-month portfolio *risk* as represented by the 5th percentile drawdown (in a VaR model) with and without monthly rebalancing ("risk rebalanced" and "risk unrebalanced," respectively).

Exhibit 15 Rebalancing

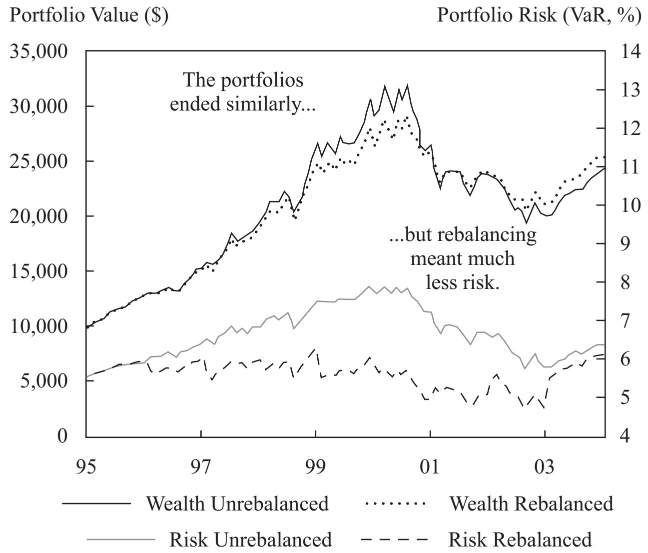
Panel A. Asset Mix



(continued)

Exhibit 15 (Continued)

Panel B. Portfolio Value and Risk



Note: The data are a 60/40 mix of the S&P 500 Growth Index and the Barclays Capital Aggregate Bond Index.

Panel A shows that, without rebalancing, the asset mix deviates dramatically from the target. Panel B shows that although the portfolios' values ended similarly (the upper two lines), disciplined rebalancing meant more-stable risks (illustrated by the lower two lines).

This risk perspective is important. Taken to the extreme, *never rebalancing* allows the high-return (and presumably higher-risk) assets to grow and dominate the portfolio. Portfolio risk rises and concentrates. Taken even further, such a philosophy of never rebalancing may suggest it would have been simpler to have invested only in the highest-expected-return asset class back when the asset mix decision was made. Not rebalancing could negate an intended level of diversification.

Because rebalancing is countercyclical, it is fundamentally a contrarian investment approach.[35] Behavioral finance tells us that such contrarianism will be uncomfortable; no one likes to sell the most recently best-performing part of the portfolio to buy the worst. Thus, rebalancing is a *discipline* of adjusting the portfolio to better align with the strategic asset allocation in both connotations of discipline—the sense of a typical practice and the sense of a strengthening regime.

8.1 A Framework for Rebalancing

The actual mechanics of rebalancing are more complex than they first appear. A number of questions arise: How often should the portfolio be rebalanced? What levels of imbalance are worth tolerating? Should the portfolio be rebalanced to the edge of the policy range or to some other point? These non-trivial questions represent the key strategic decisions in rebalancing.

35 A quantitative interpretation of rebalancing, given by Ang (2014), is that the return to rebalancing is selling out of the money puts and calls.

The simplest approach to rebalancing is **calendar rebalancing**, which involves rebalancing a portfolio to target weights on a periodic basis—for example, monthly, quarterly, semiannually, or annually. The choice of rebalancing frequency may be linked to the schedule of portfolio reviews. Although simple, rebalancing points are arbitrary and have other disadvantages.

Percent-range rebalancing permits tighter control of the asset mix compared with calendar rebalancing. Percent-range approach involves setting rebalancing thresholds or trigger points, stated as a percentage of the portfolio's value, around target values. For example, if the target allocation to an asset class is 50% of portfolio value, **trigger points** at 45% and 55% of portfolio value define a 10 percentage point **rebalancing range** (or corridor) for the value of that asset class. The rebalancing range creates a no-trade region. The portfolio is rebalanced when an asset class's weight first passes through one of its trigger points. Focusing on percent-range rebalancing, the following questions are relevant:

- How frequently is the portfolio valued?
- What size deviation triggers rebalancing?
- Is the deviation from the target allocation fully or partially corrected?

How frequently is the portfolio valued? The percent-range discipline requires monitoring portfolio values for breaches of a trigger point at an agreed-on frequency; the more frequent the monitoring, the greater the precision in implementation. Such monitoring may be scheduled daily, weekly, monthly, quarterly, or annually. A number of considerations—including governance resources and asset custodian resources—can affect valuation frequency. For many investors, monthly or quarterly evaluation efficiently balances the costs and benefits of rebalancing.

What size deviation triggers rebalancing? Trigger points take into account such factors as traditional practice, transaction costs, asset class volatility, volatility of the balance of the portfolio, correlation of the asset class with the balance of the portfolio, and risk tolerance.[36]

Before the rise of modern multi-asset portfolios, the stock/bond split broadly characterized the asset allocation and a traditional $\pm x$% rebalancing band was common. These fixed ranges would apply no matter the size or volatility of the allocation target. For example, both a 40% domestic equity allocation and a 15% real asset allocation might have ±5% rebalancing ranges. Alternatively, proportional bands reflect the size of the target weight. For example, a 60% target asset class might have a ±6% band, whereas a 5% allocation would have a ±0.5% band. Proportional bands might also be set to reflect the relative volatility of the asset classes. A final approach is the use of cost–benefit analysis to set ranges.

Is the deviation from the target allocation fully or partially corrected? Once the portfolio is evaluated and an unacceptably large deviation found, the investor must determine rebalancing trade size, as well as the timeline for implementing the rebalancing. In practice, three main approaches are used: rebalance back to target weights, rebalance to range edge, or rebalance halfway between the range-edge trigger point and the target weight.

36 See Masters (2003) for details on these factors apart from traditional factors.

8.2 Strategic Considerations in Rebalancing

The four-part rebalancing framework just described highlights important questions to address in setting rebalancing policy. Strategic considerations generally include the following, all else being equal:

- Higher transaction costs for an asset class imply wider rebalancing ranges.
- More risk-averse investors will have tighter rebalancing ranges.
- Less correlated assets also have tighter rebalancing ranges.
- Beliefs in momentum favor wider rebalancing ranges, whereas mean reversion encourages tighter ranges.
- Illiquid investments complicate rebalancing.
- Derivatives create the possibility of synthetic rebalancing.
- Taxes, which are a cost, discourage rebalancing and encourage asymmetric and wider rebalancing ranges.

Asset class volatility is also a consideration in the size of rebalancing ranges.

A cost–benefit approach to rebalancing sets ranges, taking transaction costs, risk aversion, asset class risks, and asset class correlations into consideration. For example, an asset that is more highly correlated with the rest of the portfolio than another would merit a wider rebalancing range, all else equal, because it would be closer to being a substitute for the balance of the portfolio; thus, larger deviations would have less impact on portfolio risk.

EXAMPLE 10

Different Rebalancing Ranges

The table shows a simple four-asset strategic mix along with rebalancing ranges created under different approaches. The width of the rebalancing range under the proportional range approach is 0.20 of the strategic target.

State a reason that could explain why the international equity range is wider than the domestic equity range using the cost–benefit approach.

Asset Class	Strategic Target	Fixed Width Ranges	Proportional Ranges (±1,000 bps)	Cost–Benefit Ranges
Domestic equity	40%	35%–45%	36%–44%	35%–45%
International equity	25%	20%–30%	22½%–27½%	19%–31%
Emerging markets	15%	10%–20%	13½%–16½%	12%–18%
Fixed income	20%	15%–25%	18%–22%	19%–21%

Solution:

Higher transaction costs for international equity compared with domestic equity could explain the wider range for international equity compared with domestic equity under the cost–benefit approach. Another potential explanation relates to the possibility that international equity has a higher correlation with the balance of the portfolio (i.e., the portfolio excluding international equity) than does domestic equity (i.e., with the portfolio excluding domestic equity). If that is the case then, all else being equal, a wider band would be justified for international equity.

Investors' perspectives on capital markets can affect their approach to rebalancing. A belief in momentum and trend following, for example, encourages wider rebalancing ranges. In contrast, a belief in mean reversion encourages stricter adherence to rebalancing, including tighter ranges.

Illiquid assets complicate rebalancing. Relatively illiquid investments, such as hedge funds, private equity, or direct real estate, cannot be readily traded without substantial trading costs and/or delays. Accordingly, illiquid investments are commonly assigned wide rebalancing ranges. However, rebalancing of an illiquid asset may be affected indirectly when a highly correlated liquid asset can be traded or when exposure can be adjusted by means of positions in derivatives. For example, public equity could be reduced to offset an overweight in private equity. Rebalancing by means of highly correlated liquid assets and derivatives, however, involves some imprecision and basis risk.

This insight about liquidity is an instance where thinking ahead about rebalancing can affect the strategic asset allocation. It is one reason that allocations to illiquid assets are often smaller than if trading were possible.

Factor-based asset allocation, liability-relative investing, and goals-based investing, each a valid approach to asset allocation, can give rise to different rebalancing considerations. Factor exposures and liability hedges require monitoring (and rebalancing) the factors weights and surplus duration in addition to asset class weights. Goals-based investing in private wealth management may require both asset class rebalancing and moving funds between different goal sub-portfolios.

Tax considerations also complicate rebalancing. Rebalancing typically realizes capital gains and losses, which are taxable events in many jurisdictions. For private wealth managers, any rebalancing benefit must be compared with the tax cost. Taxes, as a cost, are much larger than other transaction costs, which often leads to wider rebalancing ranges in taxable portfolios than in tax-exempt portfolios. Because loss harvesting generates tax savings and realizing gains triggers taxes, rebalancing ranges in taxable accounts may also be asymmetric. (For example, a 25% target asset class might have an allowable range of 24%–28%, which is −1% to +3%.)

Modern cost–benefit approaches to rebalancing suggest considering derivatives as a rebalancing tool. Derivatives can often be used to rebalance synthetically at much lower transaction costs than the costs of using the underlying stocks and bonds. Using a derivatives overlay also avoids disrupting the underlying separate accounts in a multi-manager implementation of the strategic asset allocation. Tax considerations are also relevant; it may be more cost effective to reduce an exposure using a derivatives overlay than to sell the underlying asset and incur the capital gains tax liability. Lastly, trading a few derivatives may be quicker and easier than hundreds of underlying securities. Of course, using derivatives may require a higher level of risk oversight, but then risk control is the main rationale for rebalancing.

Estimates of the benefits of rebalancing vary. Many portfolios are statistically indistinguishable from each other, suggesting that much rebalancing is unnecessary. In contrast, Willenbrock (2011) demonstrates that even zero-return assets can, in theory, generate positive returns through rebalancing, which is a demonstrable (and surprising) benefit. Whatever the return estimate for the value added from rebalancing, the key takeaway is that rebalancing is chiefly about risk control, not return enhancement.

SUMMARY

This reading has introduced the subject of asset allocation. Among the points made are the following:

- Effective investment governance ensures that decisions are made by individuals or groups with the necessary skills and capacity and involves articulating the long- and short-term objectives of the investment program; effectively allocating decision rights and responsibilities among the functional units in the governance hierarchy; taking account of their knowledge, capacity, time, and position on the governance hierarchy; specifying processes for developing and approving the investment policy statement, which will govern the day-to-day operation of the investment program; specifying processes for developing and approving the program's strategic asset allocation; establishing a reporting framework to monitor the program's progress toward the agreed-on goals and objectives; and periodically undertaking a governance audit.
- The economic balance sheet includes non-financial assets and liabilities that can be relevant for choosing the best asset allocation for an investor's financial portfolio.
- The investment objectives of asset-only asset allocation approaches focus on the asset side of the economic balance sheet; approaches with a liability-relative orientation focus on funding liabilities; and goals-based approaches focus on achieving financial goals.
- The risk concepts relevant to asset-only asset allocation approaches focus on asset risk; those of liability-relative asset allocation focus on risk in relation to paying liabilities; and a goals-based approach focuses on the probabilities of not achieving financial goals.
- Asset classes are the traditional units of analysis in asset allocation and reflect systematic risks with varying degrees of overlap.
- Assets within an asset class should be relatively homogeneous; asset classes should be mutually exclusive; asset classes should be diversifying; asset classes as a group should make up a preponderance of the world's investable wealth; asset classes selected for investment should have the capacity to absorb a meaningful proportion of an investor's portfolio.
- Risk factors are associated with non-diversifiable (i.e., systematic) risk and are associated with an expected return premium. The price of an asset and/or asset class may reflect more than one risk factor, and complicated spread positions may be necessary to identify and isolate particular risk factors. Their use as units of analysis in asset allocation is driven by considerations of controlling systematic risk exposures.
- The global market portfolio represents a highly diversified asset allocation that can serve as a baseline asset allocation in an asset-only approach.
- There are two dimensions of passive/active choices. One dimension relates to the management of the strategic asset allocation itself—for example, whether to deviate from it tactically or not. The second dimension relates to passive and active implementation choices in investing the allocation to a given asset class. Tactical and dynamic asset allocation relate to the first dimension; active and passive choices for implementing allocations to asset classes relate to the second dimension.

- Risk budgeting addresses the question of which types of risks to take and how much of each to take. Active risk budgeting addresses the question of how much benchmark-relative risk an investor is willing to take. At the level of the overall asset allocation, active risk can be defined relative to the strategic asset allocation benchmark. At the level of individual asset classes, active risk can be defined relative to the benchmark proxy.
- Rebalancing is the discipline of adjusting portfolio weights to more closely align with the strategic asset allocation. Rebalancing approaches include calendar-based and range-based rebalancing. Calendar-based rebalancing rebalances the portfolio to target weights on a periodic basis. Range-based rebalancing sets rebalancing thresholds or trigger points around target weights. The ranges may be fixed width, percentage based, or volatility based. Range-based rebalancing permits tighter control of the asset mix compared with calendar rebalancing.
- Strategic considerations in rebalancing include transaction costs, risk aversion, correlations among asset classes, volatility, and beliefs concerning momentum, taxation, and asset class liquidity.

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PRACTICE PROBLEMS

The following information relates to Questions 1–8

Meg and Cramer Law, a married couple aged 42 and 44, respectively, are meeting with their new investment adviser, Daniel Raye. The Laws have worked their entire careers at Whorton Solutions (WS), a multinational technology company. The Laws have two teenage children who will soon begin college.

Raye reviews the Laws' current financial position. The Laws have an investment portfolio consisting of $800,000 in equities and $450,000 in fixed-income instruments. Raye notes that 80% of the equity portfolio consists of shares of WS. The Laws also own real estate valued at $400,000, with $225,000 in mortgage debt. Raye estimates the Laws' pre-retirement earnings from WS have a total present value of $1,025,000. He estimates the Laws' future expected consumption expenditures have a total present value of $750,000.

The Laws express a very strong desire to fund their children's college education expenses, which have an estimated present value of $275,000. The Laws also plan to fund an endowment at their alma mater in 20 years, which has an estimated present value of $500,000. The Laws tell Raye they want a high probability of success funding the endowment. Raye uses this information to prepare an economic balance sheet for the Laws.

In reviewing a financial plan written by the Laws' previous adviser, Raye notices the following asset class specifications.

Equity:	US equities
Debt:	Global investment-grade corporate bonds and real estate
Derivatives:	Primarily large-capitalization foreign equities

The previous adviser's report notes the asset class returns on equity and derivatives are highly correlated. The report also notes the asset class returns on debt have a low correlation with equity and derivative returns.

Raye is concerned that the asset allocation approach followed by the Laws' previous financial adviser resulted in an overlap in risk factors among asset classes for the portfolio. Raye plans to address this by examining the portfolio's sensitivity to various risk factors, such as inflation, liquidity, and volatility, to determine the desired exposure to each factor.

Raye concludes that a portfolio of 75% global equities and 25% bonds reflects an appropriate balance of expected return and risk for the Laws with respect to a 20-year time horizon for most moderately important goals. Raye recommends the Laws follow a goals-based approach to asset allocation and offers three possible portfolios for the Laws to consider. Selected data on the three portfolios are presented in Exhibit 1.

Exhibit 1 Proposed Portfolio Allocations for the Law Family

	Cash	Fixed Income	Global Equities	Diversifying Strategies*
Portfolio 1	35%	55%	10%	0%
Portfolio 2	10%	15%	65%	10%
Portfolio 3	10%	30%	40%	20%

* Diversifying strategies consists of hedge funds

Raye uses a cost–benefit approach to rebalancing and recommends that global equities have a wider rebalancing range than the other asset classes.

1 Using the economic balance sheet approach, the Laws' economic net worth is *closest* to:
   - A $925,000.
   - B $1,425,000.
   - C $1,675,000.

2 Using an economic balance sheet, which of the Laws' current financial assets is *most* concerning from an asset allocation perspective?
   - A Equities
   - B Real estate
   - C Fixed income

3 Raye believes the previous adviser's specification for debt is incorrect given that, for purposes of asset allocation, asset classes should be:
   - A diversifying.
   - B mutually exclusive.
   - C relatively homogeneous.

4 Raye believes the previous adviser's asset class specifications for equity and derivatives are inappropriate given that, for purposes of asset allocation, asset classes should be:
   - A diversifying.
   - B mutually exclusive.
   - C relatively homogeneous.

5 To address his concern regarding the previous adviser's asset allocation approach, Raye should assess the Laws' portfolio using:
   - A a homogeneous and mutually exclusive asset class–based risk analysis.
   - B a multifactor risk model to control systematic risk factors in asset allocation.
   - C an asset class–based asset allocation approach to construct a diversified portfolio.

6 Based on Exhibit 1, which portfolio *best* meets the Laws' education goal for their children?
   - A Portfolio 1
   - B Portfolio 2
   - C Portfolio 3

7 Based on Exhibit 1, which portfolio *best* meets the Laws' goal to fund an endowment for their alma mater?

A Portfolio 1
B Portfolio 2
C Portfolio 3

8 Raye's approach to rebalancing global equities is consistent with:
A the Laws' being risk averse.
B global equities' having higher transaction costs than other asset classes.
C global equities' having lower correlations with other asset classes.

SOLUTIONS

1 A is correct. The Laws' economic net worth is closest to $925,000. An economic balance sheet includes conventional financial assets and liabilities, as well as extended portfolio assets and liabilities that are relevant in making asset allocation decisions. The economic balance sheet for the Law family is shown in the following exhibit.

Assets		**Liabilities and Economic Net Worth**	
Financial Assets		*Financial Liabilities*	
Fixed income	450,000	Mortgage debt	225,000
Real estate	400,000		
Equity	800,000		
Extended Assets		*Extended Liabilities*	
Human capital	1,025,000	Children's education	275,000
		Endowment funding	500,000
		Present value of consumption	750,000
Total Economic Assets	2,675,000	*Total Economic Liabilities*	1,750,000
		Economic Net Worth	925,000

Economic net worth is equal to total economic assets minus total economic liabilities ($2,675,000 – $1,750,000 = $925,000).

2 A is correct. The Laws' equity portfolio is heavily concentrated in WS stock (80% of the equity portfolio), and both Laws work at WS. Should WS encounter difficult economic circumstances, the investment value of WS stock and the Laws' human capital are both likely to be adversely affected. Thus, their investment in WS should be reviewed and their equity portfolio diversified further.

3 C is correct. In order to effectively specify asset classes for the purpose of asset allocation, assets within an asset class should be relatively homogeneous and have similar attributes. The previous adviser's specification of the debt asset class includes global investment-grade corporate bonds and real estate. This definition results in a non-homogeneous asset class.

4 A is correct. For risk control purposes, an asset class should be diversifying and should not have extremely high expected correlations with other classes. Because the returns to the equity and the derivatives asset classes are noted as being highly correlated, inclusion of both asset classes will result in duplication of risk exposures. Including both asset classes is not diversifying to the asset allocation.

5 B is correct. Raye believes the Laws' previous financial adviser followed an asset allocation approach that resulted in an overlap in risk factors among asset classes. A multifactor risk model approach can be used to address potential risk factor overlaps. Risk factor approaches to asset allocation focus on assigning investments to the investor's desired exposures to specified risk factors. These methods are premised on the observation that asset classes often exhibit some overlaps in sources of risk.

6 A is correct. Portfolio 1 best meets the Laws' education goal for their children. The estimated present value of the Laws' expected education expense is $275,000. Given that the children will be starting college soon, and the Laws have a very strong desire to achieve this goal, Portfolio 1, which stresses liquidity and stability, is most appropriate to meet the Laws' short-term education goal.

7 B is correct. Portfolio 2 best meets the Laws' goal to fund an endowment for their alma mater in 20 years. In present value terms, the gift is valued at $500,000, with the Laws desiring a high probability of achieving this goal. Although slightly more conservative than the 75/25 global equity/bond mix, Portfolio 2 has a greater growth emphasis compared with Portfolios 1 and 3. Therefore, Portfolio 2 is best for funding the endowment at their alma mater given the goal's long-term horizon and the Laws' desire for a high probability of achieving it.

8 B is correct. Using the cost–benefit approach, higher transaction costs for an asset class imply wider rebalancing ranges. Raye's recommendation for a wider rebalancing range for global equities is consistent with the presence of higher transaction costs for global equities.

READING

13

Principles of Asset Allocation

by Jean L.P. Brunel, CFA, Thomas M. Idzorek, CFA, and John M. Mulvey, PhD

Jean L.P. Brunel, CFA, is at Brunel Associates LLC (USA). Thomas M. Idzorek, CFA, is at Morningstar (USA). John M. Mulvey, PhD, is at the Bendheim Center for Finance at Princeton University (USA).

LEARNING OUTCOMES

Mastery	*The candidate should be able to:*
☐	**a.** describe and critique the use of mean–variance optimization in asset allocation;
☐	**b.** recommend and justify an asset allocation using mean–variance optimization;
☐	**c.** interpret and critique an asset allocation in relation to an investor's economic balance sheet;
☐	**d.** discuss asset class liquidity considerations in asset allocation;
☐	**e.** explain absolute and relative risk budgets and their use in determining and implementing an asset allocation;
☐	**f.** describe how client needs and preferences regarding investment risks can be incorporated into asset allocation;
☐	**g.** discuss the use of Monte Carlo simulation and scenario analysis to evaluate the robustness of an asset allocation;
☐	**h.** describe the use of investment factors in constructing and analyzing an asset allocation;
☐	**i.** recommend and justify an asset allocation based on the global market portfolio;
☐	**j.** describe and evaluate characteristics of liabilities that are relevant to asset allocation;
☐	**k.** discuss approaches to liability-relative asset allocation;
☐	**l.** recommend and justify a liability-relative asset allocation;

(continued)

LEARNING OUTCOMES	
Mastery	***The candidate should be able to:***
☐	**m.** recommend and justify an asset allocation using a goals-based approach;
☐	**n.** describe and critique heuristic and other approaches to asset allocation;
☐	**o.** discuss factors affecting rebalancing policy.

1 INTRODUCTION

Determining a strategic asset allocation is arguably the most important aspect of the investment process. This reading builds on the "Introduction to Asset Allocation" reading and focuses on several of the primary frameworks for developing an asset allocation, including asset-only mean–variance optimization, various liability-relative asset allocation techniques, and goals-based investing. Additionally, it touches on various other asset allocation techniques used by practitioners, as well as important related topics, such as rebalancing.

The process of creating a diversified, multi-asset class portfolio typically involves two separate steps. The first step is the asset allocation decision, which can refer to both the process and the result of determining long-term (strategic) exposures to the available asset classes (or risk factors) that make up the investor's opportunity set. Asset allocation is the first and primary step in translating the client's circumstances, objectives, and constraints into an appropriate portfolio (or, for some approaches, multiple portfolios) for achieving the client's goals within the client's tolerance for risk. The second step in creating a diversified, multi-asset-class portfolio involves implementation decisions that determine the specific investments (individual securities, pooled investment vehicles, and separate accounts) that will be used to implement the targeted allocations.

Although it is possible to carry out the asset allocation process and the implementation process simultaneously, in practice, these two steps are often separated for two reasons. First, the frameworks for simultaneously determining an asset allocation and its implementation are often complex. Second, in practice, many investors prefer to revisit their strategic asset allocation policy somewhat infrequently (e.g., annually or less frequently) in a dedicated asset allocation study, while most of these same investors prefer to revisit/monitor implementation vehicles (actual investments) far more frequently (e.g., monthly or quarterly).

Section 2 covers the traditional mean–variance optimization (MVO) approach to asset allocation. We apply this approach in what is referred to as an "asset-only" setting, in which the goal is to create the most efficient mixes of asset classes in the absence of any liabilities. We highlight key criticisms of mean–variance optimization and methods used to address them. This section also covers risk budgeting in relation to asset allocation, factor-based asset allocation, and asset allocation with illiquid assets. The observation that almost all portfolios exist to help pay for what can be characterized as a "liability" leads to the next subject.

Section 3 introduces liability-relative asset allocation—including a straightforward extension of mean–variance optimization known as surplus optimization. Surplus optimization is an economic balance sheet approach extended to the liability side of the balance sheet that finds the most efficient asset class mixes in the presence of liabilities. Liability-relative optimization is simultaneously concerned with the return of the assets, the change in value of the liabilities, and how assets and liabilities interact to determine the overall value or health of the total portfolio.

Section 4 covers an increasingly popular approach to asset allocation called goals-based asset allocation. Conceptually, goals-based approaches are similar to liability-relative asset allocation in viewing risk in relation to specific needs or objectives associated with different time horizons and degrees of urgency.

Section 5 introduces some informal (heuristic) ways that asset allocations have been determined and other approaches to asset allocation that emphasize specific objectives.

Section 6 addresses the factors affecting choices that are made in developing specific policies relating to rebalancing to the strategic asset allocation. Factors discussed include transaction costs, correlations, volatility, and risk aversion.[1]

Section 7 summarizes important points and concludes the reading.

DEVELOPING ASSET-ONLY ASSET ALLOCATIONS

2

In this section, we discuss several of the primary techniques and considerations involved in developing strategic asset allocations, leaving the issue of considering the liabilities to Section 3 and the issue of tailoring the strategic asset allocation to meet specific goals to Section 4.

We start by introducing mean–variance optimization, beginning with unconstrained optimization, prior to moving on to the more common mean–variance optimization problem in which the weights, in addition to summing to 1, are constrained to be positive (no shorting allowed). We present a detailed example, along with several variations, highlighting some of the important considerations in this approach. We also identify several criticisms of mean–variance optimization and the major ways these criticisms have been addressed in practice.

2.1 Mean–Variance Optimization: Overview

Mean–variance optimization (MVO), as introduced by Markowitz (1952, 1959), is perhaps the most common approach used in practice to develop and set asset allocation policy. Widely used on its own, MVO is also often the basis for more sophisticated approaches that overcome some of the limitations or weaknesses of MVO.

Markowitz recognized that whenever the returns of two assets are not perfectly correlated, the assets can be combined to form a portfolio whose risk (as measured by standard deviation or variance) is less than the weighted-average risk of the assets themselves. An additional and equally important observation is that as one adds assets to the portfolio, one should focus not on the individual risk characteristics of the additional assets but rather on those assets' effect on the risk characteristics of the entire portfolio. Mean–variance optimization provides us with a framework for determining how much to allocate to each asset in order to maximize the *expected* return of the portfolio for an *expected* level of risk. In this sense, mean–variance optimization is a risk-budgeting tool that helps investors to spend their risk budget—the amount of risk they are willing to assume—wisely. We emphasize the word "expected" because the inputs to mean–variance optimization are necessarily forward-looking estimates, and the resulting portfolios reflect the quality of the inputs.

1 In this reading, "volatility" is often used synonymously with "standard deviation."

Mean–variance optimization requires three sets of inputs: returns, risks (standard deviations), and pair-wise correlations for the assets in the opportunity set. The objective function is often expressed as follows:

$$U_m = E(R_m) - 0.005\lambda\sigma_m^2 \quad (1)$$

where

U_m = the investor's utility for asset mix (allocation) m
R_m = the return for asset mix m
λ = the investor's risk aversion coefficient
σ_m^2 = the expected variance of return for asset mix m

The risk aversion coefficient (λ) characterizes the investor's risk–return trade-off; in this context, it is the rate at which an investor will forgo expected return for less variance. The value of 0.005 in Equation 1 is based on the assumption that $E(R_m)$ and σ_m are expressed as percentages rather than as decimals. (In using Equation 1, omit % signs.) If those quantities were expressed as decimals, the 0.005 would change to 0.5. For example, if $E(R_m) = 0.10$, $\lambda = 2$, and $\sigma = 0.20$ (variance is 0.04), then U_m is 0.06, or 6% [= 0.10 – 0.5(2)(0.04)]. In this case, U_m can be interpreted as a certainty-equivalent return—that is, the utility value of the risky return offered by the asset mix, stated in terms of the risk-free return that the investor would value equally. In Equation 1, 0.005 merely scales the second term appropriately.

In words, the objective function says that the value of an asset mix for an investor is equal to the expected return of the asset mix minus a penalty that is equal to one-half of the expected variance of the asset mix scaled by the investor's risk aversion coefficient. Optimization involves selecting the asset mix with the highest such value (certainty equivalent). Smaller risk aversion coefficients result in relatively small penalties for risk, leading to aggressive asset mixes. Conversely, larger risk aversion coefficients result in relatively large penalties for risk, leading to conservative asset mixes. A value of $\lambda = 0$ corresponds to a risk-neutral investor because it implies indifference to volatility. Most investors' risk aversion is consistent with λ between 1 and 10.[2] Empirically, $\lambda = 4$ can be taken to represent a moderately risk-averse investor, although the specific value is sensitive to the opportunity set in question and to market volatility.

In the absence of constraints, there is a closed-form solution that calculates, for a given set of inputs, the single set of weights (allocation) to the assets in the opportunity set that maximizes the investor's utility. Typically, this single set of weights is relatively extreme, with very large long and short positions in each asset class. Except in the special case in which the expected returns are derived using the reverse-optimization process of Sharpe (1974), the expected-utility-maximizing weights will not add up to 100%. We elaborate on reverse optimization in Section 2.4.1.

In most real-world applications, asset allocation weights must add up to 100%, reflecting a fully invested, non-leveraged portfolio. From an optimization perspective, when seeking the asset allocation weights that maximize the investor's utility, one must constrain the asset allocation weights to sum to 1 (100%). This constraint that weights sum to 100% is referred to as the "budget constraint" or "unity constraint." The inclusion of this constraint, or any other constraint, moves us from a problem that has a closed-form solution to a problem that must be solved numerically using optimization techniques.

In contrast to the single solution (single set of weights) that is often associated with unconstrained optimization (one could create an efficient frontier using unconstrained weights, but it is seldom done in practice), Markowitz's mean–variance optimization paradigm is most often identified with an efficient frontier that plots all

2 See Ang (2014, p. 44).

potential efficient asset mixes subject to some common constraints. In addition to a typical budget constraint that the weights must sum to 1 (100% in percentage terms), the next most common constraint allows only positive weights or allocations (i.e., no negative or short positions).

Efficient asset mixes are combinations of the assets in the opportunity set that maximize expected return per unit of expected risk or, alternatively (and equivalently), minimize expected risk for a given level of expected return. To find all possible efficient mixes that collectively form the efficient frontier, *conceptually* the optimizer iterates through all the possible values of the risk aversion coefficient (λ) and for each value finds the combination of assets that maximizes expected utility. We have used the word *conceptually* because there are different techniques for carrying out the optimization that may vary slightly from our description, even though the solution (efficient frontier and efficient mixes) is the same. The efficient mix at the far left of the frontier with the lowest risk is referred to as the global minimum variance portfolio, while the portfolio at the far right of the frontier is the maximum expected return portfolio. In the absence of constraints beyond the budget and non-negativity constraints, the maximum expected return portfolio consists of a 100% allocation to the single asset with the highest expected return (which is not necessarily the asset with the highest level of risk).

Risk Aversion

Unfortunately, it is extremely difficult to precisely estimate a given investor's risk aversion coefficient (λ). Best practices suggest that when estimating risk aversion (or, conversely, risk tolerance), one should examine both the investor's *preference* for risk (willingness to take risk) and the investor's *capacity* for taking risk. Risk preference is a subjective measure and typically focuses on how an investor feels about and potentially reacts to the ups and downs of portfolio value. The level of return an investor hopes to earn can influence the investor's willingness to take risk, but investors must be realistic when setting such objectives. Risk capacity is an objective measure of the investor's ability to tolerate portfolio losses and the potential decrease in future consumption associated with those losses.[3] The psychometric literature has developed validated questionnaires, such as that of Grable and Joo (2004), to approximately locate an investor's risk preference, although this result then needs to be blended with risk capacity to determine risk tolerance. For individuals, risk capacity is affected by factors such as net worth, income, the size of an emergency fund in relation to consumption needs, and the rate at which the individual saves out of gross income, according to the practice of financial planners noted in Grable (2008).

With this guidance in mind, we move forward with a relatively global opportunity set, in this case defined from the point of view of an investor from the United Kingdom with an approximate 10-year time horizon. The analysis is carried out in British pounds (GBP), and none of the currency exposure is hedged. Exhibit 1 identifies 12 asset classes within the universe of available investments and a set of plausible forward-looking capital market assumptions: expected returns, standard deviations,

3 *Risk preference* and *risk capacity* are sometimes referred to as the willingness and the ability to take risk, respectively.

and correlations. The reading on capital market expectations covers how such inputs may be developed.[4] In the exhibit, three significant digits at most are shown, but the subsequent analysis is based on full precision.

Time Horizon

Mean–variance optimization is a "single-period" framework in which the single period could be a week, a month, a year, or some other time period. When working in a "strategic" setting, many practitioners typically find it most intuitive to work with annual capital market assumptions, even though the investment time horizon could be considerably longer (e.g., 10 years). If the strategic asset allocation will not be re-evaluated within a long time frame, capital market assumptions should reflect the average annual distributions of returns expected over the entire investment time horizon. In most cases, investors revisit the strategic asset allocation decision more frequently, such as annually or every three years, rerunning the analysis and making adjustments to the asset allocation; thus, the annual capital market assumption often reflects the expectations associated with the evaluation horizon (e.g., one year or three years).

Exhibit 1 Hypothetical UK-Based Investor's Opportunity Set with Expected Returns, Standard Deviations, and Correlations

Panel A: Expected Returns and Standard Deviations

Asset Class	Expected Return (%)	Standard Deviation (%)
UK large cap	6.6	14.8
UK mid cap	6.9	16.7
UK small cap	7.1	19.6
US equities	7.8	15.7
Europe ex UK equities	8.6	19.6
Asia Pacific ex Japan equities	8.5	20.9
Japan equities	6.4	15.2
Emerging market equities	9.0	23.0
Global REITs	9.0	22.5
Global ex UK bonds	4.0	10.4
UK bonds	2.9	6.1
Cash	2.5	0.7

4 The standard deviations and correlations in Exhibit 1 are based on historical numbers, while expected returns come from reverse optimization (described later).

Exhibit 1 (Continued)

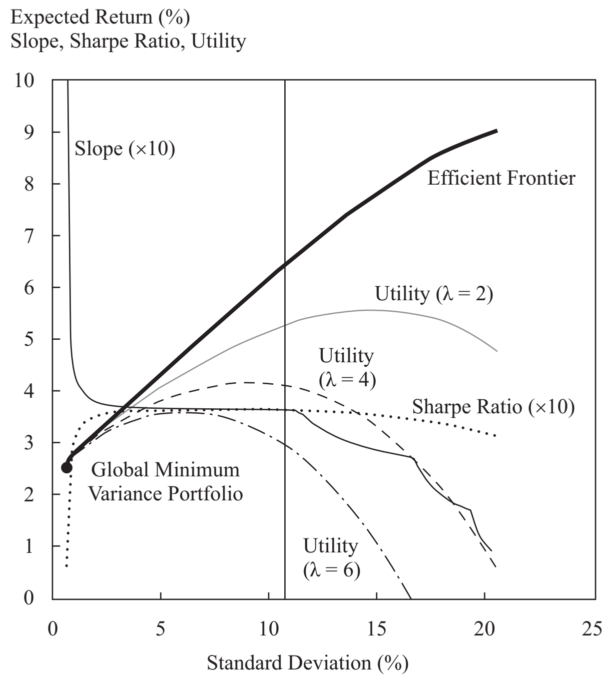
Panel B: Correlations

	UK Large Cap	UK Mid Cap	UK Small Cap	US Equities	Europe ex UK Equities	Asia Pacific ex Japan Equities	Japan Equities	Emerging Market Equities	Global REITs	Global ex UK Bonds	UK Bonds	Cash
UK large cap	1.00	0.86	0.79	0.76	0.88	0.82	0.55	0.78	0.64	–0.12	–0.12	–0.06
UK mid cap	0.86	1.00	0.95	0.76	0.84	0.75	0.51	0.74	0.67	–0.16	–0.10	–0.17
UK small cap	0.79	0.95	1.00	0.67	0.79	0.70	0.49	0.71	0.61	–0.22	–0.15	–0.17
US equities	0.76	0.76	0.67	1.00	0.81	0.72	0.62	0.69	0.77	0.14	0.00	–0.12
Europe ex UK equities	0.88	0.84	0.79	0.81	1.00	0.82	0.60	0.80	0.72	0.04	–0.04	–0.03
Asia Pacific ex Japan equities	0.82	0.75	0.70	0.72	0.82	1.00	0.54	0.94	0.67	0.00	–0.02	0.02
Japan equities	0.55	0.51	0.49	0.62	0.60	0.54	1.00	0.56	0.52	0.18	0.07	–0.01
Emerging market equities	0.78	0.74	0.71	0.69	0.80	0.94	0.56	1.00	0.62	–0.02	–0.03	0.04
Global REITs	0.64	0.67	0.61	0.77	0.72	0.67	0.52	0.62	1.00	0.16	0.18	–0.15
Global ex UK bonds	–0.12	–0.16	–0.22	0.14	0.04	0.00	0.18	–0.02	0.16	1.00	0.62	0.24
UK bonds	–0.12	–0.10	–0.15	0.00	–0.04	–0.02	0.07	–0.03	0.18	0.62	1.00	0.07
Cash	–0.06	–0.17	–0.17	–0.12	–0.03	0.02	–0.01	0.04	–0.15	0.24	0.07	1.00

The classification of asset classes in the universe of available investments may vary according to local practices. For example, in the United States and some other larger markets, it is common to classify equities by market capitalization, whereas the practice of classifying equities by valuation ("growth" versus "value") is less common outside of the United States. Similarly, with regard to fixed income, some asset allocators may classify bonds based on various attributes—nominal versus inflation linked, corporate versus government issued, investment grade versus non-investment grade (high yield)—and/or by maturity/duration (short, intermediate, and long). By means of the non-negativity constraint and using a reverse-optimization procedure (to be explained later) based on asset class market values to generate expected return estimates, we control the typically high sensitivity of the composition of efficient portfolios to expected return estimates (discussed further in Section 2.4). Without such precautions, we would often find that efficient portfolios are highly concentrated in a subset of the available asset classes.

Running this set of capital market assumptions through a mean–variance optimizer with the traditional non-negativity and unity constraints produces the efficient frontier depicted in Exhibit 2. We have augmented this efficient frontier with some non-traditional information that will assist with the understanding of some key concepts related to the efficient frontier. A risk-free return of 2.5% is used in calculating the reserve-optimized expected returns as well as the Sharpe ratios in Exhibit 2.

Exhibit 2 Efficient Frontier—Base Case



The slope of the efficient frontier is greatest at the far left of the efficient frontier, at the point representing the global minimum variance portfolio. Slope represents the rate at which expected return increases per increase in risk. As one moves to the right, in the direction of increasing risk, the slope decreases; it is lowest at the point representing the maximum return portfolio. Thus, as one moves from left to right along the efficient frontier, the investor takes on larger and larger amounts of risk for smaller and smaller increases in expected return. The "kinks" in the line representing the slope (times 10) of the efficient frontier correspond to portfolios (known as corner portfolios) in which an asset either enters or leaves the efficient mix.

For most investors, at the far left of the efficient frontier, the increases in expected return associated with small increases in expected risk represent a desirable trade-off. The risk aversion coefficient identifies the specific point on the efficient frontier at which the investor refuses to take on additional risk because he or she feels the associated increase in expected return is not high enough to compensate for the increase in risk. Of course, each investor makes this trade-off differently.

For this particular efficient frontier, the three expected utility curves plot the solution to Equation 1 for three different risk aversion coefficients: 2.0, 4.0, and 6.0, respectively.[5] For a given risk aversion coefficient, the appropriate efficient mix from the efficient frontier is simply the mix in which expected utility is highest (i.e.,

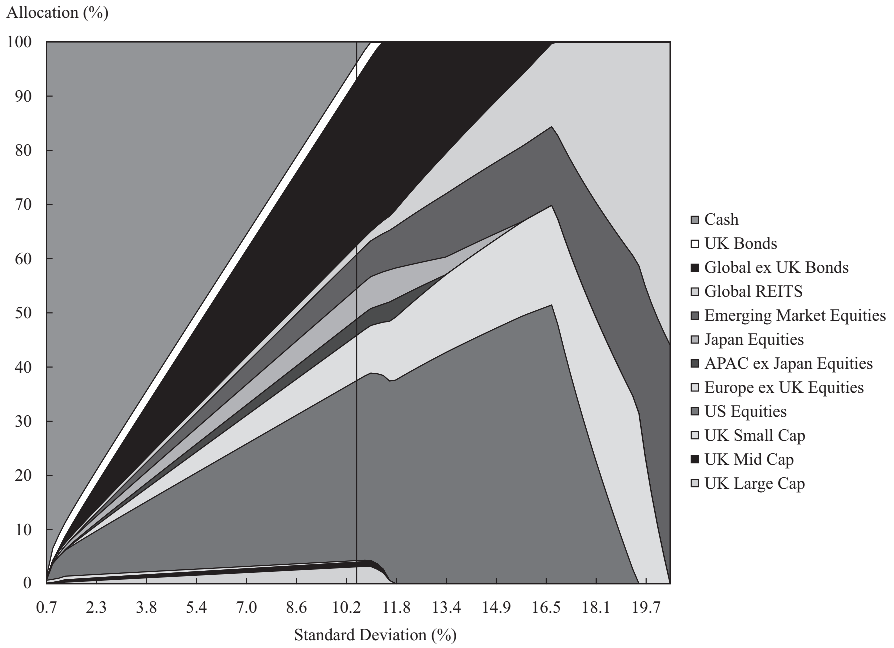
5 Numbers have been rounded to increase readability.

maximized). As illustrated in Exhibit 2, a lower risk aversion coefficient leads to a riskier (higher) point on the efficient frontier, while a higher risk aversion coefficient leads to a more conservative (lower) point on the efficient frontier.

The vertical line (at volatility of 10.88%) identifies the asset mix with the highest Sharpe ratio; it intersects the Sharpe ratio line at a value of 3.7 (an unscaled value of 0.37). This portfolio is also represented by the intersection of the slope line and the Sharpe ratio line.

Exhibit 3 is an efficient frontier asset allocation area graph. Each vertical cross section identifies the asset allocation at a point along the efficient frontier; thus, the vertical cross section at the far left, with nearly 100% cash, is the asset allocation of the minimum variance portfolio, and the vertical cross section at the far right, with 45% in emerging markets and 55% in global REITs, is the optimal asset allocation for a standard deviation of 20.5%, the highest level of portfolio volatility shown. In this example, cash is treated as a risky asset; although its return volatility is very low, because it is less than perfectly correlated with the other asset classes, mixing it with small amounts of other asset classes reduces risk further. The vertical line identifies the asset mix with the highest Sharpe ratio and corresponds to the similar line shown on the original efficient frontier graph (Exhibit 2). The asset allocation mixes are well diversified for most of the first half of the efficient frontier, and in fact, for a large portion of the efficient frontier, all 12 asset classes in our opportunity set receive a positive allocation.[6]

Exhibit 3 Efficient Frontier Asset Allocation Area Graph—Base Case



6 Studying Exhibit 3 closely, one notices distinct regime shifts where the rate at which allocations are made to asset classes changes so that a line segment with a different slope begins. These regime shifts occur at what are called *corner portfolios*. The efficient mixes between two adjacent corner portfolios are simply linear combinations of those portfolios. The efficient frontier asset allocation area graph helps to clarify this result. More formally, corner portfolios are points on the efficient frontier at which an asset class either enters or leaves the efficient mix or a constraint either becomes binding or is no longer binding.

The investment characteristics of potential asset mixes based on mean–variance theory are often further investigated by means of Monte Carlo simulation, as discussed in Section 2.2. Several observations from theory and practice are relevant to narrowing the choices.

Equation 1 indicates that the basic approach to asset allocation involves estimating the investor's risk aversion parameter and then finding the efficient mix that maximizes expected utility. When the risk aversion coefficient has not been estimated, the investor may be able to identify the maximum tolerable level of portfolio return volatility. If that level is 10% per annum, for example, only the part of the efficient frontier associated with volatility less than or equal to 10% is relevant. This approach is justifiable because for a given efficient frontier, every value of the risk aversion coefficient can be associated with a value of volatility that identifies the best point on the efficient frontier for the investor; the investor may also have experience with thinking in terms of volatility. In addition, when the investor has a numerical return objective, he or she can further narrow the range of potential efficient mixes by identifying the efficient portfolios expected to meet that return objective. For example, if the return objective is 5%, one can select the asset allocation with a 5% expected return.

Example 1 illustrates the use of Equation 1 and shows the adaptability of MVO by introducing the choice problem in the context of an investor who also has a shortfall risk concern.

EXAMPLE 1

Mean–Variance-Efficient Portfolio Choice 1

An investment adviser is counseling Aimée Goddard, a client who recently inherited €1,200,000 and who has above-average risk tolerance ($\lambda = 2$). Because Goddard is young and one of her goals is to fund a comfortable retirement, she wants to earn returns that will outpace inflation in the long term. Goddard expects to liquidate €60,000 of the inherited portfolio in 12 months to fund the down payment on a house. She states that it is important for her to be able to take out the €60,000 without invading the initial capital of €1,200,000. Exhibit 4 shows three alternative strategic asset allocations.

Exhibit 4 Strategic Asset Allocation Choices for Goddard

	Investor's Forecasts	
Asset Allocation	**Expected Return**	**Standard Deviation of Return**
A	10.00%	20%
B	7.00	10
C	5.25	5

1 Based only on Goddard's risk-adjusted expected returns for the asset allocations, which asset allocation would she prefer?

2 Recommend and justify a strategic asset allocation for Goddard.

Note: In addressing 2, calculate the minimum return, R_L, that needs to be achieved to meet the investor's objective not to invade capital, using the expression ratio $[E(R_P) - R_L]/\sigma_P$, which reflects the probability of exceeding the minimum given a normal return distribution assumption in a safety-first approach.[7]

Solution to 1:

Using Equation 1,

$$\begin{aligned} U_m &= E(R_m) - 0.005\lambda\sigma_m^2 \\ &= E(R_m) - 0.005(2)\sigma_m^2 \\ &= E(R_m) - 0.01\sigma_m^2 \end{aligned}$$

So Goddard's utility for Asset Allocations A, B, and C are as follows:

$$\begin{aligned} U_A &= E(R_A) - 0.01\,\sigma_A^2 \\ &= 10.0 - 0.01(20)^2 \\ &= 10.0 - 4.0 \\ &= 6.0 \text{ or } 6.0\% \\ U_B &= E(R_B) - 0.01\,\sigma_B^2 \\ &= 7.0 - 0.01(10)^2 \\ &= 7.0 - 1.0 \\ &= 6.0 \text{ or } 6.0\% \\ U_C &= E(R_C) - 0.01\,\sigma_C^2 \\ &= 5.25 - 0.01(5)^2 \\ &= 5.25 - 0.25 \\ &= 5.0 \text{ or } 5.0\% \end{aligned}$$

Goddard would be indifferent between A and B based only on their common perceived certainty-equivalent return of 6%.

Solution to 2:

Because €60,000/€1,200,000 is 5.0%, for any return less than 5.0%, Goddard will need to invade principal when she liquidates €60,000. So 5% is a threshold return level.

To decide which of the three allocations is best for Goddard, we calculate the ratio $[E(R_P) - R_L]/\sigma_P$:

Allocation A	(10% – 5%)/20% = 0.25
Allocation B	(7% – 5%)/10% = 0.20
Allocation C	(5.25% – 5%)/5% = 0.05

Both Allocations A and B have the same expected utility, but Allocation A has a higher probability of meeting the threshold 5% return than Allocation B. Therefore, A would be the recommended strategic asset allocation.

There are several different approaches to determining an allocation to cash and cash equivalents, such as government bills. Exhibit 1 included cash among the assets for which we conducted an optimization to trace out an efficient frontier. The return to cash over a short time horizon is essentially certain in nominal terms. One approach

7 See the Level I CFA Program reading "Common Probability Distributions" for coverage of Roy's safety-first criterion.

to asset allocation separates out cash and cash equivalents as a (nominally) risk-free asset and calculates an efficient frontier of risky assets. Alternatively, a ray from the risk-free rate (a point on the return axis) tangent to the risky-asset efficient frontier (with cash excluded) then defines a linear efficient frontier. The efficient frontier then consists of combinations of the risk-free asset with the tangency portfolio (which has the highest Sharpe ratio among portfolios on the risky-asset efficient frontier).

A number of standard finance models (including Tobin two-fund separation) adopt this treatment of cash. According to two-fund separation, if investors can borrow or lend at the risk-free rate, they will choose the tangency portfolio for the risky-asset holdings and borrow at the risk-free rate to leverage the position in that portfolio to achieve a higher expected return, or they will split money between the tangency portfolio and the risk-free asset to reach a position with lower risk and lower expected return than that represented by the tangency portfolio. Since over horizons that are longer than the maturity of a money market instrument, the return earned would not be known, another approach that is well established in practice and reflected in Exhibit 1 is to include cash in the optimization. The amount of cash indicated by an optimization may be adjusted in light of short-term liquidity needs; for example, some financial advisers advocate that individuals hold an amount of cash equivalent to six months of expenses. All of these approaches are reasonable alternatives in practice.

Although we will treat cash as a risky asset in the following discussions, in Example 2, we stop to show the application of the alternative approach based on distinguishing a risk-free asset.

EXAMPLE 2

A Strategic Asset Allocation Based on Distinguishing a Nominal Risk-Free Asset

The Caflandia Foundation for the Fine Arts (CFFA) is a hypothetical charitable organization established to provide funding to Caflandia museums for their art acquisition programs.

CFFA's overall investment objective is to maintain its portfolio's real purchasing power after distributions. CFFA targets a 4% annual distribution of assets. CFFA has the following current specific investment policies.

Return objective

CFFA's assets shall be invested with the objective of earning an average nominal 6.5% annual return. This level reflects a spending rate of 4%, an expected inflation rate of 2%, and a 40 bp cost of earning investment returns. The calculation is (1.04)(1.02)(1.004) – 1 = 0.065, or 6.5%.

Risk considerations

CFFA's assets shall be invested to minimize the level of standard deviation of return subject to satisfying the expected return objective.

The investment office of CFFA distinguishes a nominally risk-free asset. As of the date of the optimization, the risk-free rate is determined to be 2.2%.

Exhibit 5 gives key outputs from a mean–variance optimization in which asset class weights are constrained to be non-negative.

Exhibit 5 Corner Portfolios Defining the Risky-Asset Efficient Frontier

Portfolio Number	Expected Nominal Returns	Standard Deviation	Sharpe Ratio
1	9.50%	18.00%	0.406
2	8.90	15.98	0.419
3	8.61	15.20	0.422
4	7.24	11.65	0.433
5	5.61	7.89	0.432
6	5.49	7.65	0.430
7	3.61	5.39	0.262

The portfolios shown are corner portfolios (see footnote 6), which as a group define the risky-asset efficient frontier in the sense that any portfolio on the frontier is a combination of the two corner portfolios that bracket it in terms of expected return.

Based only on the facts given, determine the most appropriate strategic asset allocation for CFFA given its stated investment policies.

Solution:

An 85%/15% combination of Portfolio 4 and the risk-free asset is the most appropriate asset allocation. This combination has the required 6.5% expected return with the minimum level of risk. Stated another way, this combination defines the efficient portfolio at a 6.5% level of expected return based on the linear efficient frontier created by the introduction of a risk-free asset.

Note that Portfolio 4 has the highest Sharpe ratio and is the tangency portfolio. With an expected return of 7.24%, it can be combined with the risk-free asset, with a return of 2.2%, to achieve an expected return of 6.5%:

$$6.50 = 7.24w + 2.2(1 - w)$$
$$w = 0.853$$

Placing about 85% of assets in Portfolio 4 and 15% in the risk-free asset achieves an efficient portfolio with expected return of 6.4 with a volatility of 0.853(11.65) = 9.94%. (The risk-free asset has no return volatility by assumption and, also by assumption, zero correlation with any risky portfolio return.) This portfolio lies on a linear efficient frontier formed by a ray from the risk-free rate to the tangency portfolio and can be shown to have the same Sharpe ratio as the tangency portfolio, 0.433. The combination of Portfolio 4 with Portfolio 5 to achieve a 6.5% expected return would have a lower Sharpe ratio and would not lie on the efficient frontier.

Asset allocation decisions have traditionally been made considering only the investor's investment portfolio (and financial liabilities) and not the total picture that includes human capital and other non-traded assets (and liabilities), which are missing in a traditional balance sheet. Taking such extended assets and liabilities into account can lead to improved asset allocation decisions, however.

Depending on the nature of an individual's career, human capital can provide relatively stable cash flows similar to bond payments. At the other extreme, the cash flows from human capital can be much more volatile and uncertain, reflecting a lumpy, commission-based pay structure or perhaps a career in a seasonal business. For many individuals working in stable job markets, the cash flows associated with their human capital are somewhat like those of an inflation-linked bond, relatively consistent and tending to increase with inflation. If human capital is a relatively large component of the individual's total economic worth, accounting for this type of hidden asset in an asset allocation setting is extremely important and would presumably increase the individual's capacity to take on risk.

Let us look at a hypothetical example. Emma Beel is a 45-year-old tenured university professor in London. Capital market assumptions are as before (see Exhibit 1). Beel has GBP 1,500,000 in liquid financial assets, largely due to a best-selling book. Her employment as a tenured university professor is viewed as very secure and produces cash flows that resemble those of a very large, inflation-adjusted, long-duration bond portfolio. The net present value of her human capital is estimated at GBP 500,000. Beel inherited her grandmother's home on the edge of the city, valued at GBP 750,000. The results of a risk tolerance questionnaire that considers both risk preference and risk capacity suggest that Beel should have an asset allocation involving moderate risk. Furthermore, given our earlier assumption that the collective market risk aversion coefficient is 4.0, we assume that the risk aversion coefficient of a moderately risk-averse investor is approximately 4.0, from a total wealth perspective.

To account for Beel's human capital and residential real estate, these two asset classes were modeled and added to the optimization. Beel's human capital of GBP 500,000 was modeled as 70% UK long-duration inflation-linked bonds, 15% UK corporate bonds, and 15% UK equities.[8] Residential real estate was modeled based on a de-smoothed residential property index for London. (We will leave the complexities of modeling liabilities to Section 3.) Beel's assets include those shown in Exhibit 6.

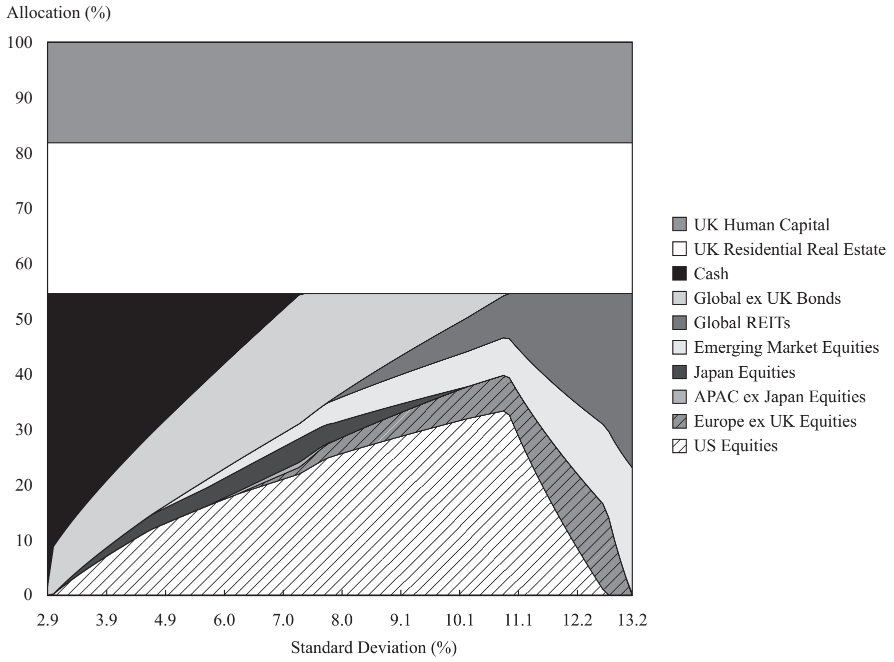
Exhibit 6 Emma Beel's Assets

Asset	Value (GBP)	Percentage
Liquid financial assets	1,500,000	54.55
UK residential real estate	750,000	27.27
Human capital	500,000	18.18
	2,750,000	100

Beel's UK residential real estate (representing the London house) and human capital were added to the optimization opportunity set. Additionally, working under the assumption that Beel's house and human capital are non-tradable assets, the optimizer was forced to allocate 27.27% or more to UK residential real estate and 18.18% to human capital and then determined the optimal asset allocation based on a risk aversion coefficient of 4. Beel's expected utility is maximized by an efficient asset allocation with volatility of approximately 8.2%. Exhibit 7 displays the resulting asset allocation area graph.

8 These weights were used to create the return composite representing Beel's human capital that was used in the asset allocation optimization.

Exhibit 7 Efficient Frontier Asset Allocation Area Graph—Balance Sheet Approach



Looking past the constrained allocations to human capital and UK residential real estate, the remaining allocations associated with Beel's liquid financial assets do not include UK equities, UK fixed income, or global REITs. Each of these three asset classes is relatively highly correlated with either UK residential real estate or UK human capital.[9]

2.2 Monte Carlo Simulation

Monte Carlo simulation complements MVO by addressing the limitations of MVO as a single-period framework. Additionally, in the case in which the investor's risk tolerance is either unknown or in need of further validation, Monte Carlo simulation can help paint a realistic picture of potential future outcomes, including the likelihood of meeting various goals, the distribution of the portfolio's expected value through time, and potential maximum drawdowns. Simulation also provides a tool for investigating the effects of trading/rebalancing costs and taxes and the interaction of evolving financial markets with asset allocation. It is important to note that not all Monte Carlo simulation tools are the same: They vary significantly in their ability to model non-normal multivariate returns, serial and cross-correlations, tax rates, distribution requirements, an evolving asset allocation schedule (target-date glide path), non-traditional investments (e.g., annuities), and human capital (based on age, geography, education, and/or occupation).

Using Monte Carlo simulation, an investment adviser can effectively grapple with a range of practical issues that are difficult or impossible to formulate analytically. Consider rebalancing to a strategic asset allocation for a taxable investor. We can readily calculate the impact of taxes during a single time period. Also, in a single-period

9 For additional information on applying a total balance sheet approach, see, for example, Blanchett and Straehl (2015) or Rudd and Siegel (2013).

setting, as assumed by MVO, rebalancing is irrelevant. In the multi-period world of most investment problems, however, the portfolio will predictably be rebalanced, triggering the realization of capital gains and losses. Given a specific rebalancing rule, different strategic asset allocations will result in different patterns of tax payments (and different transaction costs too). Formulating the multi-period problem mathematically would be a daunting challenge. We could more easily incorporate the interaction between rebalancing and taxes in a Monte Carlo simulation.

We will examine a simple multi-period problem to illustrate the use of Monte Carlo simulation, evaluating the range of outcomes for wealth that may result from a strategic asset allocation (and not incorporating taxes).

The value of wealth at the terminal point of an investor's time horizon is a possible criterion for choosing among asset allocations. Future wealth incorporates the interaction of risk and return. The need for Monte Carlo simulation in evaluating an asset allocation depends on whether there are cash flows into or out of the portfolio over time. For a given asset allocation with no cash flows, the sequence of returns is irrelevant; ending wealth will be path independent (unaffected by the sequence or path of returns through time). With cash flows, the sequence is also irrelevant if simulated returns are independent, identically distributed random variables. We could find expected terminal wealth and percentiles of terminal wealth analytically.[10] Investors save/deposit money in and spend money out of their portfolios; thus, in the more typical case, terminal wealth is path dependent (the sequence of returns matters) because of the interaction of cash flows and returns. When terminal wealth is path dependent, an analytical approach is not feasible but Monte Carlo simulation is. Example 3 applies Monte Carlo simulation to evaluate the strategic asset allocation of an investor who regularly withdraws from the portfolio.

EXAMPLE 3

Monte Carlo Simulation for a Retirement Portfolio with a Proposed Asset Allocation

Malala Ali, a resident of the hypothetical country of Caflandia, has sought the advice of an investment adviser concerning her retirement portfolio. At the end of 2017, she is 65 years old and holds a portfolio valued at CAF$1 million. Ali would like to withdraw CAF$40,000 a year to supplement the corporate pension she has begun to receive. Given her health and family history, Ali believes she should plan for a retirement lasting 25 years. She is also concerned about passing along a portion of her portfolio to the families of her three children; she hopes that at least the portfolio's current real value can go to them. Consulting with her adviser, Ali has expressed this desire quantitatively: She wants the median value of her bequest to her children to be no less than her portfolio's current value of CAF$1 million in real terms. The median is the 50th percentile outcome. The asset allocation of her retirement portfolio is currently 50/50 Caflandia equities/Caflandia intermediate-term government bonds. Ali and her adviser have decided on the following set of capital market expectations (Exhibit 8):

10 Making a plausible statistical assumption, such as a lognormal distribution, for ending wealth.

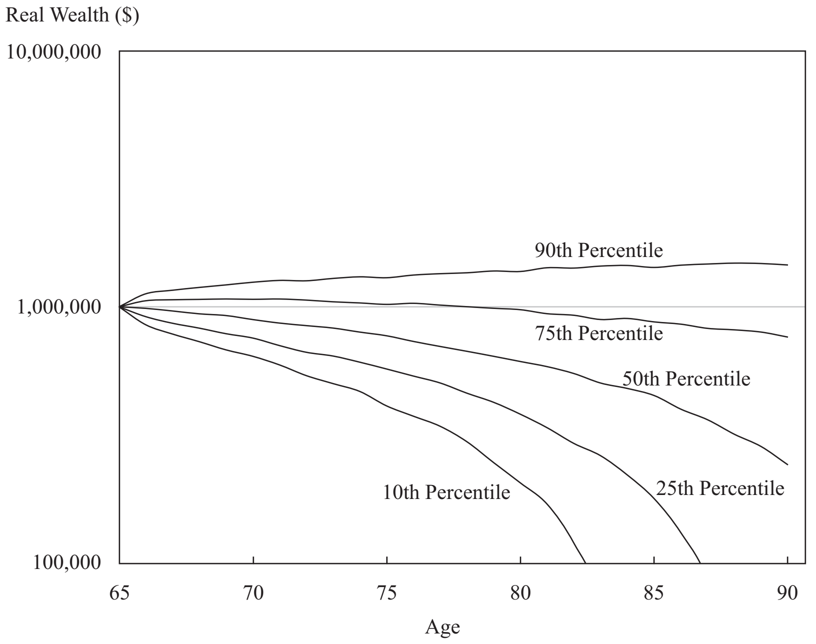
Exhibit 8 Caflandia Capital Market Expectations

	Investor's Forecasts	
Asset Class	**Expected Return**	**Standard Deviation of Return**
Caflandia equities	9.4%	20.4%
Caflandia bonds	5.6%	4.1%
Inflation	2.6%	

The predicted correlation between returns of Caflandia equities and Caflandia intermediate-term government bonds is 0.15.

With the current asset allocation, the expected nominal return on Ali's retirement portfolio is 7.5% with a standard deviation of 11%. Exhibit 9 gives the results of the Monte Carlo simulation.[11] In Exhibit 9, the lowest curve represents, at various ages, levels of real wealth at or below which the 10% of worst real wealth outcomes lie (i.e., the 10th percentile for real wealth); curves above that represent, respectively, 25th, 50th, 75th, and 90th percentiles for real wealth.

Exhibit 9 Monte Carlo Simulation of Ending Real Wealth with Annual Cash Outflows



11 Note that the y-axis in this exhibit is specified using a logarithmic scale. The quantity CAF$1 million is the same distance from CAF$100,000 as CAF$10 million is from CAF$1 million because CAF$1 million is 10 times CAF$100,000, just as CAF$10 million is 10 times CAF$1 million. CAF$100,000 is 10^5, and CAF $1 million is 10^6. In Exhibit 9, a distance halfway between the CAF$100,000 and CAF$1 million hatch marks is $10^{5.5}$ = CAF$316,228.

Based on the information given, address the following:

1 Justify the presentation of ending wealth in terms of real rather than nominal wealth in Exhibit 9.

2 Is the current asset allocation expected to satisfy Ali's investment objectives?

Solution to 1:

Ali wants the median real value of her bequest to her children to be "no less than her portfolio's current value of CAF$1 million." We need to state future amounts in terms of today's values (i.e., in real dollars) to assess the purchasing power of those amounts relative to CAF$1 million today. Exhibit 9 thus gives the results of the Monte Carlo simulation in real dollar terms. The median real wealth at age 90 is clearly well below the target ending wealth of real CAF$1 million.

Solution to 2:

From Exhibit 9, we see that the median terminal (at age 90) value of the retirement portfolio in real dollars is less than the stated bequest goal of CAF$1 million. Therefore, the most likely bequest is less than the amount Ali has said she wants. The current asset allocation is not expected to satisfy all her investment objectives. Although one potential lever would be to invest more aggressively, given Ali's age and risk tolerance, this approach seems imprudent. An adviser may need to counsel that the desired size of the bequest may be unrealistic given Ali's desired income to support her expenditures. Ali will likely need to make a relatively tough choice between her living standard (spending less) and her desire to leave a CAF$1 million bequest in real terms. A third alternative would be to delay retirement, which may or may not be feasible.

2.3 Criticisms of Mean–Variance Optimization

With this initial understanding of mean–variance optimization, we can now elaborate on some of the most common criticisms of it. The following criticisms and the ways they have been addressed motivate the balance of the coverage of MVO:

1 The outputs (asset allocations) are highly sensitive to small changes in the inputs.

2 The asset allocations tend to be highly concentrated in a subset of the available asset classes.

3 Many investors are concerned about more than the mean and variance of returns, the focus of MVO.

4 Although the asset allocations may appear diversified across assets, the sources of risk may not be diversified.

5 Most portfolios exist to pay for a liability or consumption series, and MVO allocations are not directly connected to what influences the value of the liability or the consumption series.

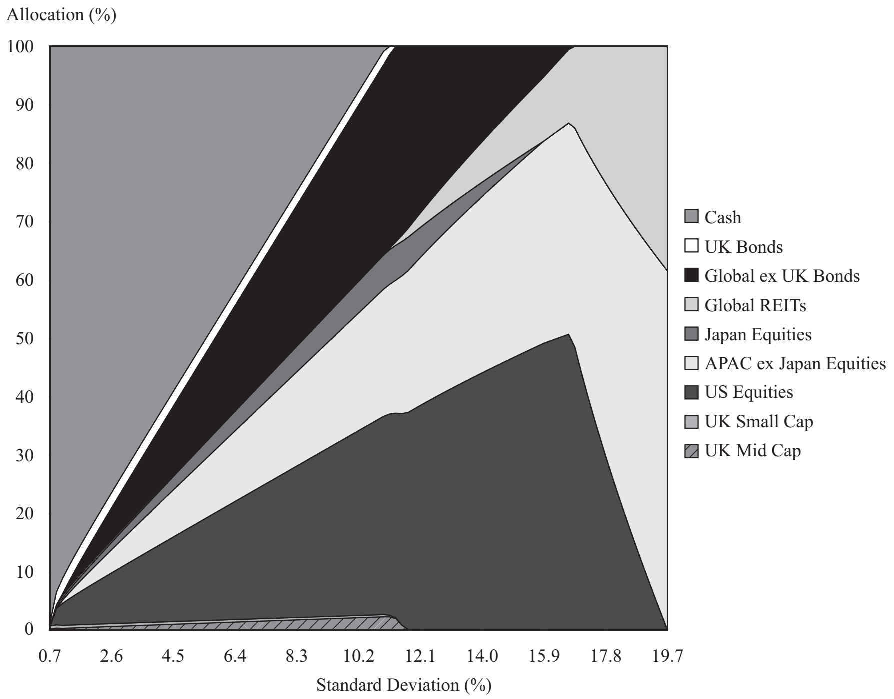
6 MVO is a single-period framework that does not take account of trading/rebalancing costs and taxes.

In the rest of Section 2, we look at various approaches to addressing criticisms 1 and 2, giving some attention also to criticisms 3 and 4. Sections 3 and 4 present approaches to addressing criticism 5. "Asset Allocation with Real World Constraints" addresses some aspects of criticism 6.

It is important to understand that the first criticism above is not unique to MVO. Any optimization model that uses forward-looking quantities as inputs faces similar consequences of treating input values as capable of being determined with certainty. Sensitivity to errors in inputs is a problem that cannot be fully solved because it is inherent in the structure of optimization models that use as inputs forecasts of uncertain quantities.

To illustrate the importance of the quality of inputs, the sensitivity of asset weights in efficient portfolios to small changes in inputs, and the propensity of mean–variance optimization to allocate to a relatively small subset of the available asset classes, we made changes to the expected return of two asset classes in our base-case UK-centric opportunity set in Exhibit 1. We increased the expected return of Asia Pacific ex Japan equities from 8.5% to 9.0% and decreased the expected return of Europe ex UK equities from 8.6% to 8.1% (both changes are approximately 50 bps). We left all of the other inputs unchanged and reran the optimization. The efficient frontier as depicted in mean–variance space appears virtually unchanged (not shown); however, the efficient asset mixes of this new efficient frontier are dramatically different. Exhibit 10 displays the efficient frontier asset allocation area graph based on the slightly changed capital market assumptions. Notice the dramatic difference between Exhibit 10 and Exhibit 3. The small change in return assumptions has driven UK large cap, Europe ex-UK equities, and emerging market equities out of the efficient mixes, and the efficient mixes are now highly concentrated in a smaller subset of the available asset classes. Given that the expected returns of UK large cap and emerging market equities were unchanged, their disappearance from the efficient frontier is not intuitive.

Exhibit 10 Efficient Frontier Asset Allocation Area Graph—Changed Expected Returns



To aid with the comparison of Exhibit 10 with Exhibit 3, we identified three specific efficient asset allocation mixes and compared the version based on the ad hoc modification of expected returns to that of the base case. This comparison is shown in Exhibit 11.

Exhibit 11 Comparison of Select Efficient Asset Allocations—Ad Hoc Return Modification Allocations vs. Base-Case Allocations

	Modified 25/75	Base Case 25/75	Difference	Modified 50/50	Base Case 50/50	Difference	Modified 75/25	Base Case 75/25	Difference
UK large cap	0.0%	1.2%	−1.2%	0.0%	2.5%	−2.5%	0.0%	0.0%	0.0%
UK mid cap	0.8%	0.6%	0.3%	1.7%	0.8%	0.9%	0.0%	0.0%	0.0%
UK small cap	0.5%	0.5%	−0.1%	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%
US equities	13.7%	13.8%	−0.1%	26.6%	26.8%	−0.2%	40.1%	40.5%	−0.4%
Europe ex UK equities	0.0%	2.7%	−2.7%	0.0%	6.5%	−6.5%	0.0%	13.2%	−13.2%
Asia Pacific ex Japan equities	7.5%	1.0%	6.5%	16.6%	2.3%	14.2%	26.8%	1.5%	25.3%
Japan equities	2.2%	2.3%	−0.1%	4.5%	4.5%	0.0%	4.4%	4.3%	0.1%
Emerging market equities	0.0%	2.0%	−2.0%	0.0%	4.9%	−4.9%	0.0%	10.0%	−10.0%
Global REITs	0.3%	0.9%	−0.6%	0.2%	1.4%	−1.3%	3.8%	5.6%	−1.8%
Global ex UK bonds	10.9%	10.6%	0.3%	24.7%	23.9%	0.7%	25.0%	25.0%	0.0%
UK bonds	2.5%	2.7%	−0.2%	2.4%	3.0%	−0.6%	0.0%	0.0%	0.0%
Cash	61.6%	61.7%	−0.1%	22.9%	23.1%	−0.1%	0.0%	0.0%	0.0%
Subtotal equities	25.0%	25.0%		50.0%	50.0%		75.0%	75.0%	
Subtotal fixed income	75.0%	75.0%		50.0%	50.0%		25.0%	25.0%	

2.4 Addressing the Criticisms of Mean–Variance Optimization

In this section, we explore several methods for overcoming some of the potential short-comings of mean–variance optimization. Techniques that address the first two criticisms mostly take three approaches: improving the quality of inputs, constraining the optimization, and treating the efficient frontier as a statistical construct. These approaches are treated in the following three subsections.

In MVO, the composition of efficient portfolios is typically more sensitive to expected return estimates than it is to estimates of volatilities and correlations. Furthermore, expected returns are generally more difficult to estimate accurately than are volatilities and correlations. Thus, in addressing the first criticism of MVO—that outputs are highly sensitive to small changes in inputs—the reading will focus on expected return inputs. However, volatility and correlation inputs are also sources of potential error.

2.4.1 *Reverse Optimization*

Reverse optimization is a powerful tool that helps explain the implied returns associated with any portfolio. It can be used to estimate expected returns for use in a forward-looking optimization. MVO solves for optimal asset weights based on expected returns, covariances, and a risk aversion coefficient. Based on predetermined inputs, an optimizer solves for the optimal asset allocation weights. As the name implies, *reverse* optimization works in the opposite direction. Reverse optimization takes as its inputs a set of asset allocation weights *that are assumed to be optimal* and, with the additional inputs of covariances and the risk aversion coefficient, solves for expected returns. These reverse-optimized returns are sometimes referred to as implied or imputed returns.

When using reverse optimization to estimate a set of expected returns for use in a forward-looking optimization, the most common set of starting weights is the observed market-capitalization value of the assets or asset classes that form the opportunity set. The market capitalization of a given asset or asset classes should reflect the collective information of market participants. In representing the world market portfolio, the use of non-overlapping asset classes representing the majority of the world's investable assets is most consistent with theory.

Some practitioners will find the link between reverse optimization and CAPM equilibrium elegant, while others will see it as a shortcoming. For those who truly object to the use of market-capitalization weights in estimating inputs, the mechanics of reverse optimization can work with any set of starting weights—such as those of an existing policy portfolio, the average asset allocation policy of a peer group, or a fundamental weighting scheme. For those with more minor objections, we will shortly introduce the Black–Litterman model, which allows the expression of alternative forecasts or views.

In order to apply reverse optimization, one must create a working version of the all-inclusive market portfolio based on the constituents of the opportunity set. The market size or capitalization for most of the traditional stock and bond asset classes can be easily inferred from the various indexes that are used as asset class proxies. Many broad market-capitalization-weighted indexes report that they comprise over 95% of the securities, by market capitalization, of the asset classes they are attempting to represent. Exhibit 12 lists approximate values and weights for the 12 asset classes in our opportunity set, uses the weights associated with the asset classes to form a working version of the global market portfolio, and then uses the beta of each asset relative to our working version of the global market portfolio to infer what expected returns would be if all assets were priced by the CAPM according to their market beta. We assume a risk-free rate of 2.5% and a global market risk premium of 4%. Note that expected returns are rounded to one decimal place from the more precise values shown later (in Exhibit 13); expected returns cannot in every case be exactly reproduced based on Exhibit 12 alone because of the approximations mentioned. Also, notice in the final row of Exhibit 12 that the weighted average return and beta of the assets are 6.5% and 1, respectively.

Exhibit 12 Reverse-Optimization Example (Market Capitalization in £ billions)

Asset Class	Mkt Cap	Weight	Return $E[R_i]$		Risk-Free Rate r_f		Beta $\beta_{i,mkt}$	Market Risk Premium
UK large cap	£1,354.06	3.2%	6.62%	=	2.5%	+	1.03	(4%)
UK mid cap	£369.61	0.9%	6.92%	=	2.5%	+	1.11	(4%)
UK small cap	£108.24	0.3%	7.07%	=	2.5%	+	1.14	(4%)
US equities	£14,411.66	34.4%	7.84%	=	2.5%	+	1.33	(4%)
Europe ex UK equities	£3,640.48	8.7%	8.63%	=	2.5%	+	1.53	(4%)
Asia Pacific ex Japan equities	£1,304.81	3.1%	8.51%	=	2.5%	+	1.50	(4%)
Japan equities	£2,747.63	6.6%	6.43%	=	2.5%	+	0.98	(4%)
Emerging market equities	£2,448.60	5.9%	8.94%	=	2.5%	+	1.61	(4%)
Global REITs	£732.65	1.8%	9.04%	=	2.5%	+	1.64	(4%)

(continued)

Exhibit 12 (Continued)

Asset Class	Mkt Cap	Weight	Return $E[R_i]$		Risk-Free Rate r_f		Beta $\beta_{i,mkt}$	Market Risk Premium
Global ex UK bonds	£13,318.58	31.8%	4.05%	=	2.5%	+	0.39	(4%)
UK bonds	£1,320.71	3.2%	2.95%	=	2.5%	+	0.112	(4%)
Cash	£83.00	0.2%	2.50%	=	2.5%	+	0.00	(4%)
	£41,840.04	100.0%	6.50%				1	

Notes: For the Mkt Cap and Weight columns, the final row is the simple sum. For the Return and Beta columns, the final row is the weighted average.

Looking back at our original asset allocation area graph (Exhibit 3), the reason for the well-behaved and well-diversified asset allocation mixes is now clear. By using reverse optimization, we are consistently relating assets' expected returns to their systematic risk. If there isn't a consistent relationship between the expected return and systematic risk, the optimizer will see this inconsistency as an opportunity and seek to take advantage of the more attractive attributes. This effect was clearly visible in our second asset allocation area graph after we altered the expected returns of Asia Pacific ex Japan equities and Europe ex UK equities.

As alluded to earlier, some practitioners find that the reverse-optimization process leads to a nice starting point, but they often have alternative forecasts or views regarding the expected return of one or more of the asset classes that differ from the returns implied by reverse optimization based on market-capitalization weights. One example of having views that differ from the reverse-optimized returns has already been illustrated, when we altered the returns of Asia Pacific ex Japan equities and Europe ex UK equities by approximately 50 bps. Unfortunately, due to the sensitivity of mean–variance optimization to small changes in inputs, directly altering the expected returns caused relatively extreme and unintuitive changes in the resulting asset allocations. If one has strong views on expected returns that differ from the reverse-optimized returns, an alternative or additional approach is needed; the next section presents one alternative.

2.4.2 *Black–Litterman Model*

A complementary addition to reverse optimization is the Black–Litterman model, created by Fischer Black and Robert Litterman (see Black and Litterman 1990, 1991, 1992). Although the Black–Litterman model is often characterized as an asset allocation model, it is really a model for deriving a set of expected returns that can be used in an unconstrained or constrained optimization setting. The Black–Litterman model starts with excess returns (in excess of the risk-free rate) produced from reverse optimization and then provides a technique for altering reverse-optimized expected returns in such a way that they reflect an investor's own distinctive views yet still behave well in an optimizer.

The Black–Litterman model has helped make the mean–variance optimization framework more useful. It enables investors to combine their unique forecasts of expected returns with reverse-optimized returns in an elegant manner. When coupled with a mean–variance or related framework, the resulting Black–Litterman expected returns often lead to well-diversified asset allocations by improving the consistency between each asset class's expected return and its contribution to systematic risk. These asset allocations are grounded in economic reality—via the market capitalization of the assets typically used in the reverse-optimization process—but still reflect the information contained in the investor's unique forecasts (or views) of expected return.

The mathematical details of the Black–Litterman model are beyond the scope of this reading, but many practitioners have access to asset allocation software that includes the Black–Litterman model.[12] To assist with an intuitive understanding of the model and to show the model's ability to blend new information (views) with reverse-optimized returns, we present an example based on the earlier views regarding the expected returns of Asia Pacific ex Japan equities and Europe ex UK equities. The Black–Litterman model has two methods for accepting views: one in which an absolute return forecast is associated with a given asset class and one in which the return differential of an asset (or group of assets) is expressed relative to another asset (or group of assets). Using the relative view format of the Black–Litterman model, we expressed the view that we believe Asia Pacific ex Japan equities will outperform Europe ex UK equities by 100 bps. We placed this view into the Black–Litterman model, which blends reverse-optimized returns with such views to create a new, mixed estimate.

Exhibit 13 compares the Black–Litterman model returns to the original reverse-optimized returns (as in Exhibit 12 but showing returns to the second decimal place based on calculations with full precision). The model accounts for the correlations of the assets with each other, and as one might expect, all of the returns change slightly (the change in return on cash was extremely small).

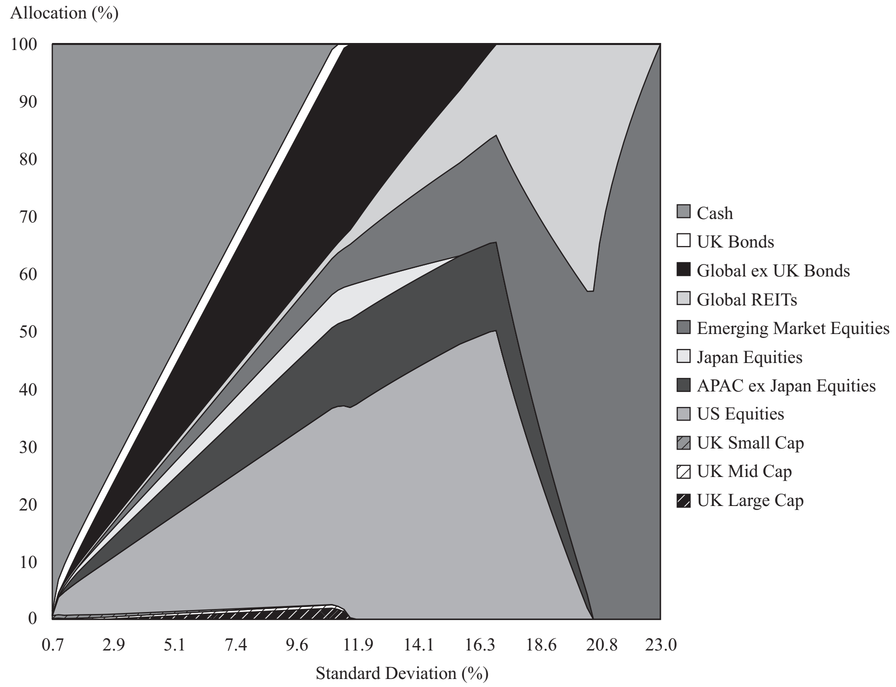
Exhibit 13 Comparison of Black–Litterman and Reverse-Optimized Returns

Asset Class	Reverse-Optimized Returns	Black–Litterman Returns	Difference
UK large cap	6.62%	6.60%	–0.02%
UK mid cap	6.92	6.87	–0.05
UK small cap	7.08	7.03	–0.05
US equities	7.81	7.76	–0.05
Europe ex UK equities	8.62	8.44	–0.18
Asia Pacific ex Japan equities	8.53	8.90	0.37
Japan equities	6.39	6.37	–0.02
Emerging market equities	8.96	9.30	0.33
Global REITs	9.02	9.00	–0.01
Global ex UK bonds	4.03	4.00	–0.03
UK bonds	2.94	2.95	0.01
Cash	2.50	2.50	0.00

Next, we created another efficient frontier asset allocation area graph based on these new returns from the Black–Litterman model, as shown in Exhibit 14. The allocations look relatively similar to those depicted in Exhibit 3. However, if you compare the allocations to Asia Pacific ex Japan equities and Europe ex UK equities to their allocations in the original efficient frontier asset allocation graph, you will notice that allocations to Asia Pacific ex Japan equities have increased across the frontier and allocations to Europe ex UK equities have decreased across the frontier with very little impact on the other asset allocations.

12 For those interested in the mathematical details of the Black–Litterman model, see Idzorek (2007); a pre-publication version is available here: http://corporate.morningstar.com/ib/documents/MethodologyDocuments/IBBAssociates/BlackLitterman.pdf).

Exhibit 14 Efficient Frontier Asset Allocation Area Graph, Black–Litterman Returns



As before, to aid in the comparison of Exhibit 14 (Black–Litterman allocations) with Exhibit 3 (the base-case allocations), we identified three specific mixes in Exhibit 14 and compared those efficient asset allocation mixes based on the expected returns from the Black–Litterman model to those of the base case. The results are shown in Exhibit 15.

Exhibit 15 Comparison of Select Efficient Asset Allocations, Black–Litterman Allocations vs. Base-Case Allocations

	Modified 25/75	Base Case 25/75	Difference	Modified 50/50	Base Case 50/50	Difference	Modified 75/25	Base Case 75/25	Difference
UK large cap	0.4%	1.2%	–0.8%	1.4%	2.5%	–1.1%	0.0%	0.0%	0.0%
UK mid cap	0.4	0.6	–0.2	0.5	0.8	–0.3	0.0	0.0	0.0
UK small cap	0.4	0.5	–0.1	0.2	0.4	–0.2	0.0	0.0	0.0
US equities	13.8	13.8	0.0	26.8	26.8	0.0	40.0	40.5	–0.5
Europe ex UK equities	0.0	2.7	–2.7	0.0	6.5	–6.5	0.0	13.2	–13.2
Asia Pacific ex Japan equities	5.2	1.0	4.2	10.8	2.3	8.5	15.4	1.5	14.0
Japan equities	2.2	2.3	0.0	4.5	4.5	0.0	4.2	4.3	–0.1
Emerging market equities	1.8	2.0	–0.1	4.6	4.9	–0.2	9.8	10.0	–0.1
Global REITs	0.8	0.9	–0.1	1.3	1.4	–0.2	5.5	5.6	–0.1
Global ex UK bonds	10.3	10.6	–0.2	23.6	23.9	–0.3	25.0	25.0	0.0

Exhibit 15 (Continued)

	Modified 25/75	Base Case 25/75	Difference	Modified 50/50	Base Case 50/50	Difference	Modified 75/25	Base Case 75/25	Difference
UK bonds	3.1	2.7	0.3	3.5	3.0	0.5	0.0	0.0	0.0
Cash	61.6	61.7	–0.1	22.9	23.1	–0.1	0.0	0.0	0.0
Subtotal equities	25.0%	25.0%		50.0%	50.0%		75.0%	75.0%	
Subtotal fixed income	75.0%	75.0%		50.0%	50.0%		25.0%	25.0%	

2.4.3 *Adding Constraints beyond the Budget Constraints*

When running an optimization, in addition to the typical budget constraint and the non-negativity constraint, one can impose additional constraints. There are two primary reasons practitioners typically apply additional constraints: (1) to incorporate real-world constraints into the optimization problem and (2) to help overcome some of the potential shortcomings of mean–variance optimization elaborated above (input quality, input sensitivity, and highly concentrated allocations).

Most commercial optimizers accommodate a wide range of constraints. Typical constraints include the following:

1 Specify a set allocation to a specific asset—for example, 30% to real estate or 45% to human capital. This kind of constraint is typically used when one wants to include a non-tradable asset in the asset allocation decision and optimize around the non-tradable asset.

2 Specify an asset allocation range for an asset—for example, the emerging market allocation must be between 5% and 20%. This specification could be used to accommodate a constraint created by an investment policy, or it might reflect the user's desire to control the output of the optimization.

3 Specify an upper limit, due to liquidity considerations, on an alternative asset class, such as private equity or hedge funds.

4 Specify the relative allocation of two or more assets—for example, the allocation to emerging market equities must be less than the allocation to developed equities.

5 In a liability-relative (or surplus) optimization setting, one can constrain the optimizer to hold one or more assets representing the systematic characteristics of the liability short. (We elaborate on this scenario in Section 3.)

In general, good constraints are those that model the actual circumstances/context in which one is attempting to set asset allocation policy. In contrast, constraints that are simply intended to control the output of a mean–variance optimization should be used cautiously. A perceived need to add constraints to control the MVO output would suggest a need to revisit one's inputs. If a very large number of constraints are imposed, one is no longer optimizing but rather specifying an asset allocation through a series of binding constraints.

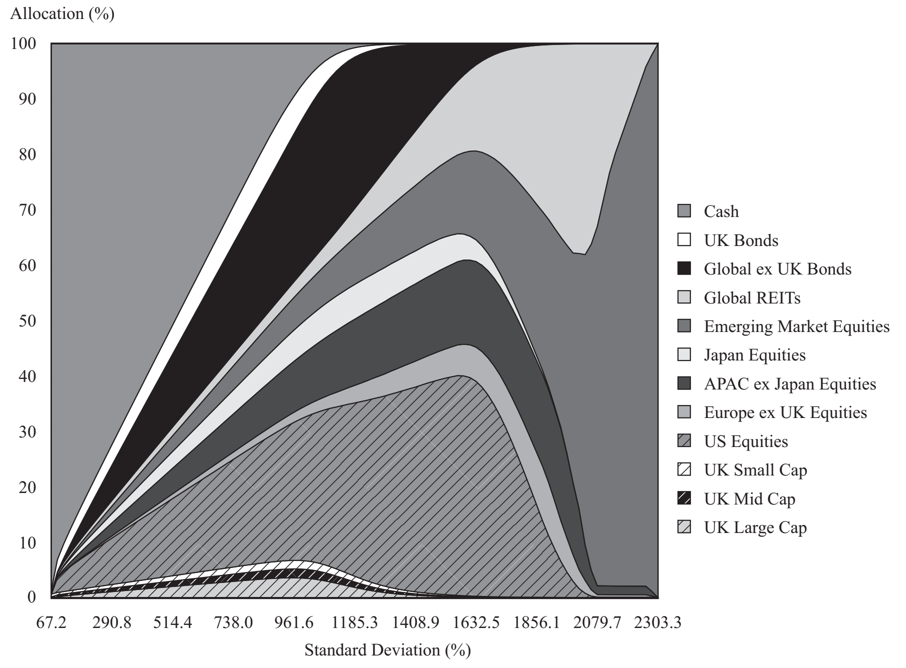
2.4.4 *Resampled Mean–Variance Optimization*

Another technique used by asset allocators is called resampled mean–variance optimization (or sometimes "resampling" for short).[13] Resampled mean–variance optimization combines Markowitz's mean–variance optimization framework with Monte Carlo simulation and, all else equal, leads to more-diversified asset allocations. In contrast to reverse optimization, the Black–Litterman model, and constraints, resampled mean–variance optimization is an attempt to build a better optimizer that recognizes that forward-looking inputs are inherently subject to error.

Resampling uses Monte Carlo simulation to estimate a large number of potential capital market assumptions for mean–variance optimization and, eventually, for the resampled frontier. Conceptually, resampling is a large-scale sensitivity analysis in which hundreds or perhaps thousands of variations on baseline capital market assumptions lead to an equal number of mean–variance optimization frontiers based on the Monte Carlo–generated capital market assumptions. These intermediate frontiers are referred to as simulated frontiers. The resulting asset allocations, or portfolio weights, from these simulated frontiers are saved and averaged (using a variety of methods). To draw the resampled frontier, the averaged asset allocations are coupled with the starting capital market assumptions.

To illustrate how resampling can be used with other techniques, we conducted a resampled mean–variance optimization using the Black–Litterman returns from Exhibit 10, above. Exhibit 16 provides the asset allocation area graph from this optimization. Notice that the resulting asset allocations are smoother than in any of the previous asset allocation area graphs. Additionally, relative to Exhibit 15, based on the same inputs, the smallest allocations have increased in size while the largest allocations have decreased somewhat.

Exhibit 16 Efficient Frontier Asset Allocation Area Graph, Black–Litterman Returns with Resampling



13 The current embodiments of resampling grew out of the work of Jobson and Korkie (1980, 1981); Jorion (1992); DiBartolomeo (1993); and Michaud (1998).

The asset allocations from resampling as depicted in Exhibit 16 are appealing. Criticisms include the following: (1) Some frontiers have concave "bumps" where expected return decreases as expected risk increases; (2) the "riskier" asset allocations are over-diversified; (3) the asset allocations inherit the estimation errors in the original inputs; and (4) the approach lacks a foundation in theory.[14]

2.4.5 *Other Non-Normal Optimization Approaches*

From our list of shortcomings/criticisms of mean–variance optimization, the third is that investor preferences may go beyond the first two moments (mean and variance) of a portfolio's return distribution. The third and fourth moments are, respectively, skewness and kurtosis. Skewness measures the degree to which return distributions are asymmetrical, and kurtosis measures the thickness of the distributions' tails (i.e., how frequently extreme events occur). A normal distribution is fully explained by the first two moments because the skewness and (excess) kurtosis of the normal distribution are both zero.

Returning to the discussion of Equation 1, the mean–variance optimization program involves maximizing expected utility, which is equal to expected return minus a penalty for risk, where risk is measured as variance (standard deviation). Unfortunately, variance or standard deviation is an incomplete measure of risk when returns are not normally distributed. By studying historical return distributions for the major asset classes and comparing those historical distributions to normal distributions, one will quickly see that, historically, asset class returns are not normally distributed. In fact, empirically extreme returns seem to occur approximately 10 times more often than the normal distribution would suggest. Coupling this finding with the asymmetrical risk preferences observed in investors—whereby the pain of a loss is approximately twice as significant as the joy from an equivalent gain (according to Prospect theory)—has led to more complex utility functions and optimizers that expressly account for non-normal returns and asymmetric risk preference.[15] A number of variations of these more sophisticated optimization techniques have been put forth, making them challenging to cover. In general, most of them consider the non-normal return distribution characteristics and use a more sophisticated definition of risk, such as conditional value-at-risk. We view these as important advancements in the toolkit available to practitioners.

Exhibit 17 summarizes selected extensions of quantitative asset allocation approaches outside the sphere of traditional mean–variance optimization.

Exhibit 17 Selected Non-Mean–Variance Developments

Key Non-Normal Frameworks	Research/Recommended Reading
Mean–semivariance optimization	Markowitz (1959)
Mean–conditional value-at-risk optimization	Goldberg, Hayes, and Mahmoud (2013) Rockafellar and Uryasev (2000) Xiong and Idzorek (2011)
Mean–variance-skewness optimization	Briec, Kerstens, and Jokung (2007) Harvey, Liechty, Liechty, and Müller (2010)
Mean–variance-skewness-kurtosis optimization	Athayde and Flôres (2003) Beardsley, Field, and Xiao (2012)

14 For more details, see Scherer (2002).
15 For more on prospect theory, see Kahneman and Tversky (1979) and Tversky and Kahneman (1992).

Long-Term versus Short-Term Inputs

Strategic asset allocation is often described as “long term,” while tactical asset allocation involves short-term movements away from the strategic asset allocation. In this context, “long term” is often defined as 10 or perhaps 20 or more years, yet in practice, very few asset allocators revisit their strategic asset allocation this infrequently. Many asset allocators update their strategic asset allocation annually, which makes it a bit more challenging to distinguish between strategic and tactical asset allocations. This frequent revisiting of the asset allocation policy brings up important questions about the time horizon associated with the inputs. In general, long-term (10-plus-year) capital market assumptions that ignore current market conditions, such as valuation levels, the business cycle, and interest rates, are often thought of as *unconditional* inputs. Unconditional inputs focus on the average capital market assumptions over the 10-plus-year time horizon. In contrast, shorter-term capital market assumptions that explicitly attempt to incorporate current market conditions (i.e., that are “conditioned” on them) are conditional inputs. For example, a practitioner who believes that the market is overvalued and that as a result we are entering a period of low returns, high volatility, and high correlations might prefer to use conditional inputs that reflect these beliefs.[16]

EXAMPLE 4

Problems in Mean–Variance Optimization

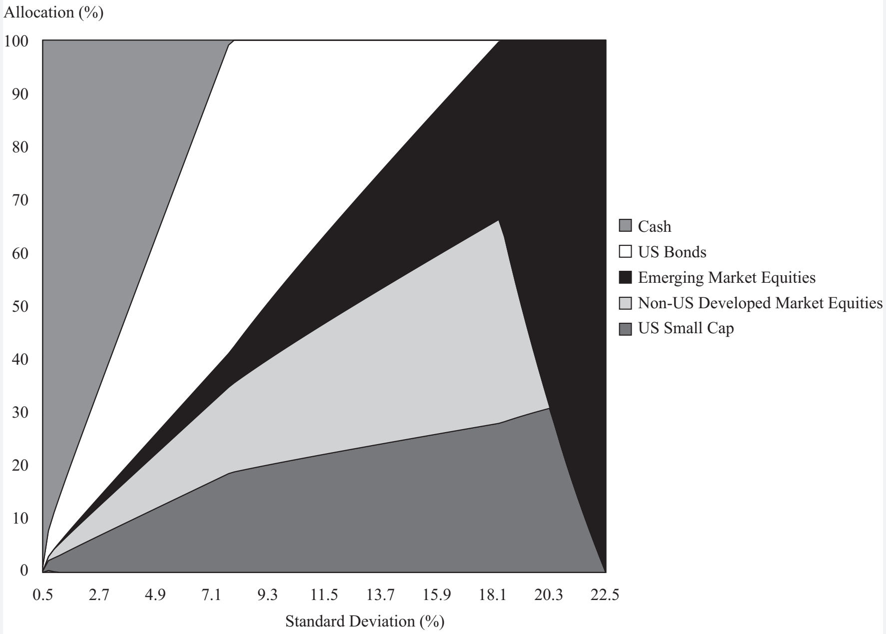
In a presentation to US-based investment clients on asset allocation, the results of two asset allocation exercises are shown, as presented in Exhibit 18.

Exhibit 18 Asset Allocation Choices

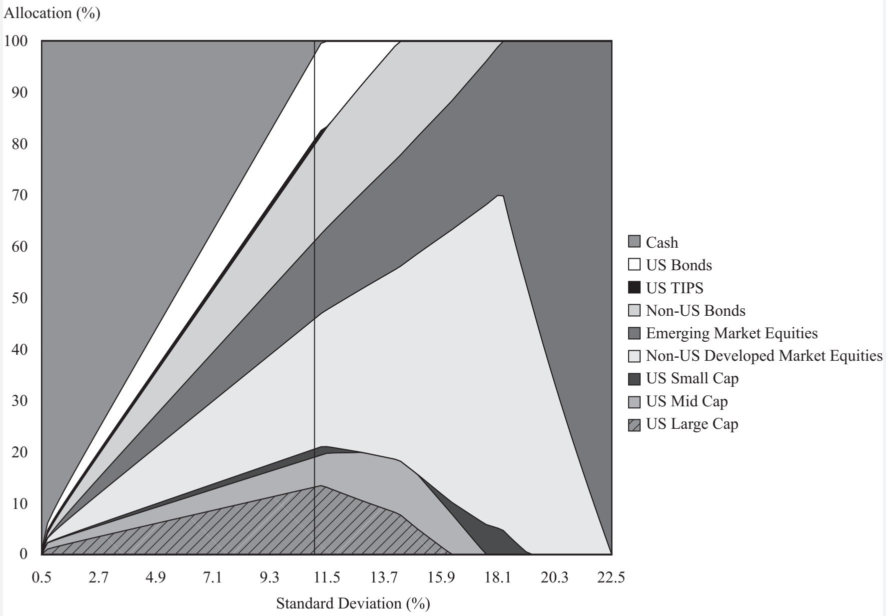
Panel A: Area Graph 1

16 Relatedly, Chow, Jacquier, Kritzman, and Lowry (1999) showed a procedure for blending the optimal portfolios for periods of normal and high return volatility. The approach accounts for the tendency of asset returns to be more highly correlated during times of high volatility.

Exhibit 18 (Continued)



Panel B: Area Graph 2



1 Based on Panel A, address the following:

   A Based on mean–variance analysis, what is the asset allocation that would most likely be selected by a risk-neutral investor?

   B Based only on the information that can be inferred from Panel A, discuss the investment characteristics of non-US developed market equity (NUSD) in efficient portfolios.

   C Critique the efficient asset mixes represented in Panel A.

2 Compare the asset allocations shown in Panel A with the corresponding asset allocations shown in Panel B. (Include a comparison of the panels at the level of risk indicated by the line in Panel B.)

3 **A** Identify three techniques that the asset allocations in Panel B might have incorporated to improve the characteristics relative to those of Panel A.

B Discuss how the techniques described in your answer to 3A address the high input sensitivity of MVO.

Solution to 1A:

For a risk-neutral investor, the optimal asset allocation is 100% invested in emerging market equities. For a risk-neutral investor ($\lambda = 0$), expected utility is simply equal to expected return. The efficient asset allocation that maximizes expected return is the one with the highest level of volatility, as indicated on the x-axis. Panel A shows that that asset allocation consists entirely of emerging market equities.

Solution to 1B:

The weights of NUSD as the efficient frontier moves from its minimum to its maximum risk point suggest NUSD's investment characteristics. This asset class is neither the lowest-volatility asset (which can be inferred to be cash) nor the highest-volatility asset (which is emerging market equity). At the point of the peak of NUSD, when the weight in NUSD is about to begin its decline in higher-risk efficient portfolios, US bonds drop out of the efficient frontier. Further, NUSD leaves the efficient frontier portfolio at a point at which US small cap reaches its highest weight. These observations suggest that NUSD provided diversification benefits in portfolios including US bonds—a relatively low correlation with US bonds can be inferred—that are lost at this point on the efficient frontier. Beyond a volatility level of 20.3%, representing a corner portfolio, NUSD drops out of the efficient frontier.

Solution to 1C:

Of the nine asset classes in the investor's defined opportunity set, five at most are represented by portfolios on the efficient frontier. Thus, a criticism of the efficient frontier associated with Panel A is that the efficient portfolios are highly concentrated in a subset of the available asset classes, which likely reflects the input sensitivity of MVO.

Solution to 2:

The efficient asset mixes in Panels A and B cover a similar risk range: The risk levels of the two minimum-variance portfolios are similar, and the risk levels of the two maximum-return portfolios are similar. Over most of the range of volatility, however, the efficient frontier associated with Panel B is better diversified. For example, at the line in Panel B, representing a moderate level of volatility likely relevant to many investors, the efficient portfolio contains nine asset classes rather than four, as in Panel A. At that point, for example, the allocation to fixed income is spread over US bonds, non-US bonds, and US TIPS in Panel B, as opposed to just US bonds in Panel A.

Solution to 3A:

To achieve the better-diversified efficient frontier shown in Panel B, several methods might have been used, including reverse optimization, the Black–Litterman model, and constrained asset class weights.

Solution to 3B:

Reverse optimization and the Black–Litterman model address the issue of MVO's sensitivity to small differences in expected return estimates by anchoring expected returns to those implied by the asset class weights of a proxy for the global market portfolio. The Black–Litterman framework provides a disciplined way to tilt the expected return inputs in the direction of the investor's own views. These approaches address the problem by improving the balance between risk and return that is implicit in the inputs.

A very direct approach to the problem can be taken by placing constraints on weights in the optimization to force an asset class to appear in a constrained efficient frontier within some desired range of values. For example, non-US bonds did not appear in any efficient portfolio in Panel A. The investor could specify that the weight on non-US bonds be strictly positive. Another approach would be to place a maximum on the weight in US bonds to make the optimizer spread the fixed-income allocation over other fixed-income assets besides US bonds.

2.5 Allocating to Less Liquid Asset Classes

Large institutional investors have the ability to invest in less liquid asset classes, such as direct real estate, infrastructure, and private equity. These less liquid asset classes represent unique challenges to many of the common asset allocation techniques, such as mean–variance optimization.

For traditional, highly liquid asset classes, such as publicly listed equities and bonds, almost all of the major index providers have indexes that do an outstanding job of representing the performance characteristics of the asset class (and its various sub–asset classes). For example, over any reasonably long time period, the risk and return characteristics of a given asset class are nearly identical across the major global equity indexes and the correlations between the returns of the indexes are close to 1. Additionally, in most cases, there are passive, low-cost investment vehicles that allow investors to capture the performance of the asset class with very little tracking error.

Cash, the Risk-Free Asset, and Liquidity Needs

The so called "risk-free asset" has a special and somewhat tricky spot in the world of finance. Asset allocators typically use indexes for either 30-day or 90-day government bills to represent the characteristics associated with holding cash, which they may or may not treat as the risk-free asset. The volatility associated with these total return indexes is extremely low, but it isn't zero. An alternative to using a cash index as a proxy for the risk-free asset is to use a government bond with a duration/maturity that matches the time horizon of the investor. Some asset allocators like to include cash or another asset that could be considered a risk-free asset in the optimization and to allow the optimizer to determine how to mix it with the other asset classes included in the optimization. Other asset allocators prefer to exclude the risk-free asset from the optimization and allow real-world needs, such as liquidity needs, to determine how much to allocate to cash-like assets.

Illiquid assets may offer an expected return premium as compensation for illiquidity as well as diversification benefits. Determining an appropriate allocation to these assets is associated with various challenges, however. Common illiquid asset classes cannot be readily diversified to eliminate idiosyncratic risk, so representing an overall asset class performance is problematic. Furthermore, for less liquid asset classes, such as direct real estate, infrastructure, and private equity, there are, in general, far fewer indexes that attempt to represent aggregate performance. If one were to compare the performance characteristics of multiple indexes representing one of these less liquid asset classes, there would be noticeable risk and return differences, suggesting that it is difficult to accurately measure the risk and return characteristics of these asset classes. Also, due to the illiquid nature of the constituents that make up these asset classes, it is widely believed that the indexes don't accurately reflect their true volatility. In contrast to the more traditional, highly liquid asset classes, there are no low-cost passive investment vehicles that would allow investors to closely track the aggregate performance of these less liquid asset classes.

Thus, the problem is twofold: (1) Due to the lack of accurate indexes, it is more challenging to make capital market assumptions for these less liquid asset classes, and (2) even if there were accurate indexes, there are no low-cost passive investment vehicles to track them.

Compounding the asset allocator's dilemma is the fact that the risk and return characteristics associated with actual investment vehicles, such as direct real estate funds, infrastructure funds, and private equity funds, are typically significantly different from the characteristics of the asset classes themselves. For example, the private equity "asset class" should represent the risk and return characteristics of owning all private equity, just as the MSCI All Country World Index represents the risk and return characteristics of owning all public equity. Purchasing the exchange-traded fund (ETF) that tracks the MSCI All Country World Index completely diversifies public company-specific risk. This scenario is in direct contrast to the typical private equity fund, in which the risk and return characteristics are often dominated by company-specific (idiosyncratic) risk.

In addressing asset allocation involving less liquid asset classes, practical options include the following:

1 Exclude less liquid asset classes (direct real estate, infrastructure, and private equity) from the asset allocation decision and then consider real estate funds, infrastructure funds, and private equity funds as potential implementation vehicles when fulfilling the target strategic asset allocation.

2 Include less liquid asset classes in the asset allocation decision and attempt to model the inputs to represent the *specific risk* characteristics associated with the likely *implementation vehicles*.

3 Include less liquid asset classes in the asset allocation decision and attempt to model the inputs to represent the *highly diversified* characteristics associated with the *true asset classes*.

Related to this last option, some practitioners use listed real estate indexes, listed infrastructure, and public equity indexes that are deemed to have characteristics similar to their private equity counterparts to help estimate the risk of the less liquid asset classes and their correlation with the other asset classes in the opportunity set. It should be noted that the use of listed alternative indexes often violates the recommendation that asset classes be mutually exclusive—the securities in these indexes are likely also included in indexes representing other asset classes—and thus typically results in higher correlations among different asset classes, which has the negative impact of increasing input sensitivity in most optimization settings.

For investors who do not have access to direct real estate funds, infrastructure funds, and private equity funds—for example, small investors—the most common approach is to use one of the indexes based on listed equities to represent the asset class and then to implement the target allocation with a fund that invests similarly. Thus global REITs might be used to represent (approximately) global real estate.

2.6 Risk Budgeting

> [A] risk budget is simply a particular allocation of portfolio risk. An optimal risk budget is simply the allocation of risk such that the first order of conditions for portfolio optimization are satisfied. The risk budgeting process is the process of finding an optimal risk budget.
>
> Kurt Winkelmann (2003, p. 173)

As this quote from Kurt Winkelmann suggests, there are three aspects to risk budgeting:

- The risk budget identifies the total amount of risk and allocates the risk to a portfolio's constituent parts.
- An optimal risk budget allocates risk efficiently.
- The process of finding the optimal risk budget is risk budgeting.

Although its name suggests that risk budgeting is all about risk, risk budgeting is really using risk in relation to seeking return. The goal of risk budgeting is to maximize return per unit of risk—whether overall market risk in an asset allocation setting or active risk in an asset allocation implementation setting.

The ability to determine a position's marginal contribution to portfolio risk is a powerful tool that helps one to better understand the sources of risk. The marginal contribution to a type of risk is the partial derivative of the risk in question (total risk, active risk, or residual risk) with respect to the applicable type of portfolio holding (asset allocation holdings, active holdings, or residual holdings). Knowing a position's marginal contribution to risk allows one to (1) approximate the change in portfolio risk (total risk, active risk, or residual risk) due to a change in an individual holding, (2) determine which positions are optimal, and (3) create a risk budget. *Risk-budgeting tools assist in the optimal use of risk in the pursuit of return.*

Exhibit 19 contains risk-budgeting information for the Sharpe ratio–maximizing asset allocation from our original UK example. The betas are from Exhibit 12. The marginal contribution to total risk (MCTR) identifies the rate at which risk would change with a small (or marginal) change in the current weights. For asset class *i*, it is calculated as MCTR_i = (Beta of asset class *i* with respect to portfolio)(Portfolio return volatility). The absolute contribution to total risk (ACTR) for an asset class measures how much it contributes to portfolio return volatility and can be calculated as the weight of the asset class in the portfolio times its marginal contribution to total risk: $\text{ACTR}_i = (\text{Weight}_i)(\text{MCTR}_i)$. Critically, beta takes account not only of the asset's own volatility but also of the asset's correlations with other portfolio assets.

The sum of the ACTR in Exhibit 19 is approximately 10.88%, which is equal to the expected standard deviation of this asset allocation mix. Dividing each ACTR by the total risk of 10.88% gives the percentage of total risk that each position contributes. Finally, an asset allocation is optimal from a risk-budgeting perspective when the ratio of excess return (over the risk-free rate) to MCTR is the same for all assets and matches the Sharpe ratio of the tangency portfolio. So in this case, which is based on reverse-optimized returns, we have an optimal risk budget.

Exhibit 19 Risk-Budgeting Statistics

Asset Class	Weight	MCTR	ACTR	Percent Contribution to Total Standard Deviation	Ratio of Excess Return to MCTR
UK large cap	3.2%	11.19%	0.36%	3.33%	0.368
UK mid cap	0.9	12.02	0.11	0.98	0.368

(continued)

Exhibit 19 (Continued)

Asset Class	Weight	MCTR	ACTR	Percent Contribution to Total Standard Deviation	Ratio of Excess Return to MCTR
UK small cap	0.3	12.44	0.03	0.30	0.368
US equities	34.4	14.51	5.00	45.94	0.368
Europe ex UK equities	8.7	16.68	1.45	13.34	0.368
Asia Pacific ex Japan equities	3.1	16.35	0.51	4.69	0.368
Japan equities	6.6	10.69	0.70	6.46	0.368
Emerging market equities	5.9	17.51	1.02	9.42	0.368
Global REITs	1.8	17.79	0.31	2.86	0.368
Global ex UK bonds	31.8	4.21	1.34	12.33	0.368
UK bonds	3.2	1.22	0.04	0.35	0.368
Cash	0.2	0.00	0.00	0.00	0.368
	100.0		10.88	100.00	

For additional clarity, the following are the specific calculations used to derive the calculated values for UK large-cap equities (where we show some quantities with an extra decimal place in order to reproduce the values shown in the exhibit):

- Marginal contribution to risk (MCTR):

  Asset beta relative to portfolio × Portfolio standard deviation

  $1.0289 \times 10.876 = 11.19\%$

- ACTR:

  Asset weight in portfolio × MCTR

  $3.2\% \times 11.19\% = 0.36\%$

- Ratio of excess return to MCTR:

  (Expected return – Risk-free rate)/MCTR

  $(6.62\% - 2.5\%)/11.19\% = 0.368$

EXAMPLE 5

Risk Budgeting in Asset Allocation

1. Describe the objective of risk budgeting in asset allocation.
2. Consider two asset classes, A and B. Asset class A has two times the weight of B in the portfolio. Under what condition would B have a larger ACTR than A?
3. When is an asset allocation optimal from a risk-budgeting perspective?

Solution to 1:

The objective of risk budgeting in asset allocation is to use risk efficiently in the pursuit of return. A risk budget specifies the total amount of risk and how much of that risk should be budgeted for each allocation.

Solution to 2:

Because $ACTR_i$ = $(Weight_i)$(Beta with respect to portfolio)$_i$(Portfolio return volatility), the beta of B would have to be more than twice as large as the beta of A for B to contribute more to portfolio risk than A.

Solution to 3:

An asset allocation is optimal when the ratio of excess return (over the risk-free rate) to MCTR is the same for all assets.

2.7 Factor-Based Asset Allocation

Until now, we have primarily focused on the mechanics of asset allocation optimization as applied to an opportunity set consisting of traditional, non-overlapping asset classes. An alternative approach used by some practitioners is to move away from an opportunity set of *asset classes* to an opportunity set consisting of investment *factors*.

In factor-based asset allocation, the factors in question are typically similar to the fundamental (or structural) factors in widely used multi-factor investment models. Factors are typically based on observed market premiums and anomalies. In addition to the all-important market (equity) exposure, typical factors used in asset allocation include size, valuation, momentum, liquidity, duration (term), credit, and volatility. Most of these factors were identified as return drivers that help to explain returns that were not explained by the CAPM. These factors can be constructed in a number of different ways, but with the exception of the market factor, typically, the factor represents what is referred to as a zero (dollar) investment, or self-financing investment, in which the underperforming attribute is sold short to finance an offsetting long position in the better-performing attribute. For example, the size factor is the combined return from shorting large-cap stocks and going long small-cap stocks (Size factor return = Small-cap stock return – Large-cap stock return). Of course, if large-cap stocks outperform small-cap stocks, the realized size return would be negative. Constructing factors in this manner removes most market exposure from the factors (because of the short positions that offset long positions); as a result, the factors generally have low correlations with the market and with one another.

We next present an example of a factor-based asset allocation optimization. Exhibit 20 shows the list of factors, how they were specified, and their historical returns and standard deviations (in excess of the risk-free rate as proxied by the return on three-month Treasury bills). The exhibit also includes historical statistics for three-month Treasury bills.

Thus far, our optimization examples have taken place in "total return space," where the expected return of each asset has equaled the expected return of the risk-free asset plus the amount of expected return in excess of the risk-free rate. In order to stay in this familiar total return space when optimizing with risk factors, the factor return needs to include the return on the assumed collateral (in this example, cash, represented by three-month Treasury bills). This adjustment is also needed if one plans to include both risk factors and some traditional asset classes in the same optimization, so that the inputs for the risk factors and traditional asset classes are similarly specified. Alternatively, one could move in the opposite direction, subtracting the return of the three-month Treasury bills from asset class returns and then conducting the optimization in excess-return space. One way to think about a self-financing allocation to a risk factor is that in order to invest in the risk factor, one must put up an equivalent amount of collateral that is invested in cash.

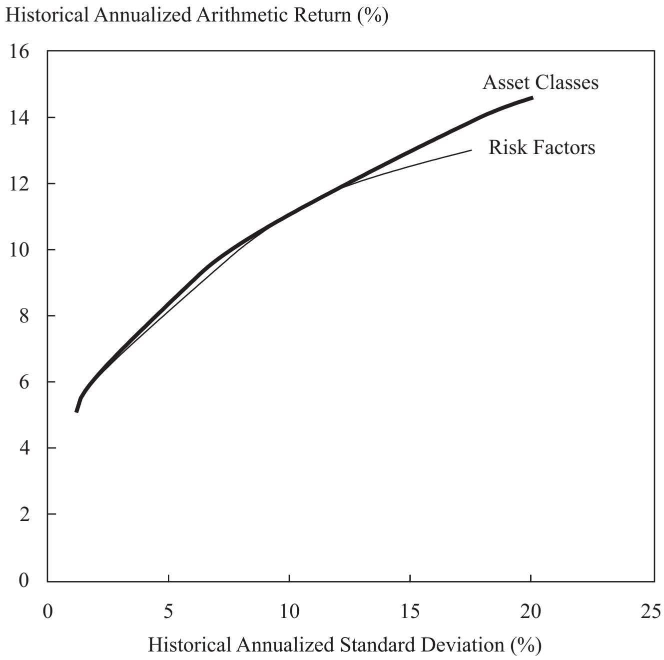
Exhibit 20 Factors/Asset Classes, Factor Definitions, and Historical Statistics (US data, January 1979 to March 2016)

Factor/Asset Class	Factor Definition	Compound Annual Factor Return	Standard Deviation	Total Return	Standard Deviation
Treasury bonds	Long-term Treasury bonds			7.77%	5.66%
Market	Total market return – Cash	7.49%	16.56%	12.97	17.33
Size	Small cap – Large cap	0.41	10.15	5.56	10.65
Valuation	Value – Growth	0.68	9.20	5.84	9.76
Credit	Corporate – Treasury	0.70	3.51	5.87	3.84
Duration	Long Treasury bonds – Treasury bills	4.56	11.29	9.91	11.93
Mortgage	Mortgage-backed – Treasury bonds	0.30	3.38	5.45	3.83
Large growth	—	—	—	12.64	19.27
Large value	—	—	—	13.23	16.52
Small growth	—	—	—	12.30	25.59
Small value	—	—	—	14.54	19.84
Mortgage-backed sec.	—	—	—	8.09	6.98
Corporate bonds	—	—	—	8.52	7.52
Treasury bonds	—	—	—	7.77	5.66
Cash	—	—	—	5.13	1.23

Because of space considerations, we have not included the full correlation matrix, but it is worth noting that the average pair-wise correlation of the risk factor–based opportunity set (in excess of the risk-free rate collateral return) is 0.31, whereas that of the asset class–based opportunity set is 0.57. Given the low pair-wise correlations of the risk factors, there has been some debate among practitioners around whether it is better to optimize using asset classes or risk factors. The issue was clarified by Idzorek and Kowara (2013), who demonstrated that in a proper comparison, neither approach is inherently superior. To help illustrate risk factor optimization and to demonstrate that if the two opportunity sets are constructed with access to similar exposures, neither approach has an inherent advantage, we present two side-by-side optimizations. These optimizations are based on the data given in Exhibit 20.

Exhibit 21 contains the two efficient frontiers. As should be expected, given that the opportunity sets provide access to similar exposures, the two historical efficient frontiers are very similar. This result illustrates that when the same range of potential exposures is available in two opportunity sets, the risk and return possibilities are very similar.

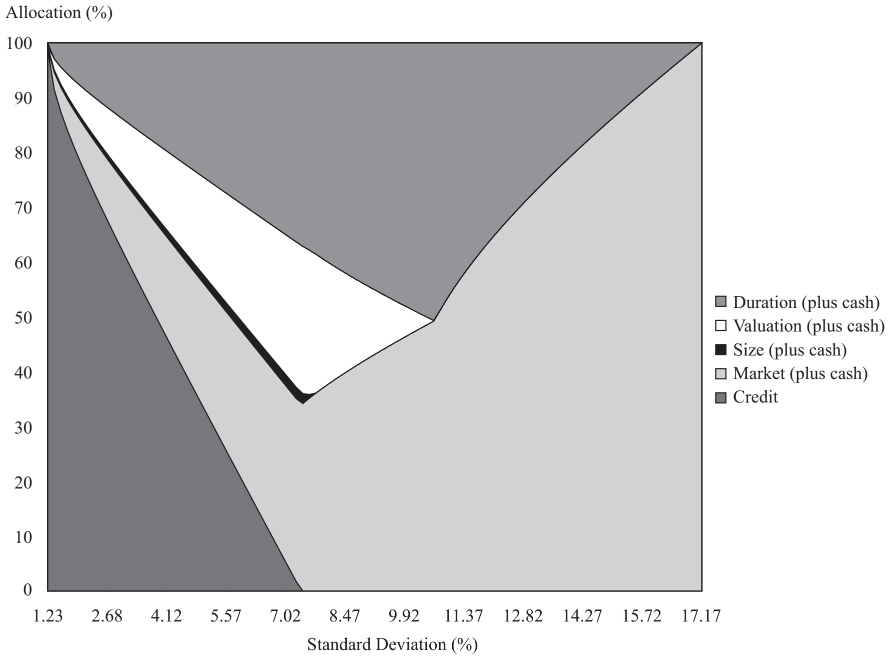
Exhibit 21 Efficient Frontiers Based on Historical Capital Market Assumptions (January 1979 to March 2016)



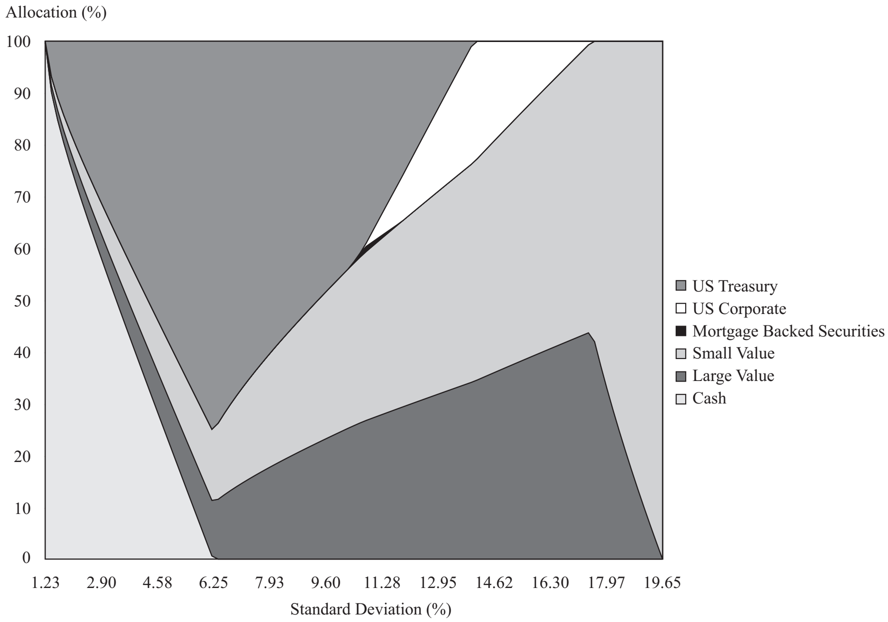
Moving to Exhibit 22, examining the two asset allocation area graphs associated with the two efficient frontiers reveals that the efficient mixes have some relatively clear similarities. For example, in Panel A (risk factors), the market, size, and valuation exposures mirror the pattern (allocations) of Panel B (asset classes) large value and small value exposures, respectively.

Exhibit 22 Asset Allocation Area Graphs—Risk Factors and Asset Classes

Panel A: Risk Factor Asset Allocation Area Graph



Panel B: Asset Class Asset Allocation Area Graph



Practitioners should choose to carry out asset allocation in the particular space—risk factors or asset classes—in which they are most equipped to make capital market assumptions. Regardless of which space a practitioner prefers, expanding one's opportunity set to include new, weakly correlated risk factors or asset classes should improve the potential risk–return trade-offs.

DEVELOPING LIABILITY-RELATIVE ASSET ALLOCATIONS

3

Liability-relative asset allocation is aimed at the general issue of rendering decisions about asset allocation in conjunction with the investor's liabilities. Liability-relative investors view assets as an inventory of capital, sometimes increased by additions, which is available to achieve goals and to pay future liabilities. What is the chance that an institution's capital is sufficient to cover future cash flow liabilities? This type of question is critical for liability-relative asset allocation because many large institutional investors—for example, banks, insurance companies, and pension plans—possess legal liabilities and operate in regulated environments in which an institution's inability to meet its liabilities with current capital has serious consequences. This concern gives rise to unique risk measures, such as the probability of meeting future cash flow requirements, and the restatement of traditional risk metrics, such as volatility, in relation to liabilities.

Liability-relative methods were developed in an institutional investor context, but these ideas have also been applied to individual investors. This section will focus on institutional investors. A later section addresses a thematically similar approach with behavioral finance roots—goals-based asset allocation.

3.1 Characterizing the Liabilities

To be soundly applied, liability-relative asset allocation requires an accurate understanding of the liabilities. A liability is a promise by one party to pay a counterparty based on a prior agreement. Liabilities may be fixed or contingent. When the amounts and timing of payments are fixed in advance by the terms of a contract, the liability is said to be fixed or non-contingent. A corporate bond with a fixed coupon rate is an example.

In many cases relevant to asset allocation, payments depend upon future, uncertain events. In such cases, the liability is a contingent liability.[17] An important example involves the liabilities of a defined benefit (DB) pension plan. The plan sponsor has a legal commitment to pay the beneficiaries of the plan during their retirement years. However, the exact dates of the payments depend on the employees' retirement dates, longevity, and cash payout rules. Insurance companies' liabilities—created by the sale of insurance policies—are also contingent liabilities: The insurance company promises to pay its policyholders a specified amount contingent on the occurrence of a predefined event.

We distinguish legal liabilities from cash payments that are expected to be made in the future and are essential to the mission of an institution but are not legal liabilities. We call these quasi-liabilities. The endowment of a university can fit this category because, in many cases, the endowment contributes a major part of the university's operating budget. The endowment assures its stakeholders that it will continue to support its essential activities through spending from the endowment capital, and failure to provide such support will often lead to changes in how the endowment is managed. Accordingly, the asset allocation decisions are made in conjunction with the university's spending rules and policies. Asset allocation is just one portion of the investment problem. Although we do not explicitly discuss them here, as suggested in Section 2, the spending needs of an individual represent another type of quasi-liability. Exhibit 23 summarizes the characteristics of liabilities that can affect asset allocation.

17 Note that the term "contingent liability" has a specific definition in accounting. We are using the term more broadly here.

Exhibit 23 Characteristics of Liabilities That Can Affect Asset Allocation

1 Fixed versus contingent cash flows
2 Legal versus quasi-liabilities
3 Duration and convexity of liability cash flows
4 Value of liabilities as compared with the size of the sponsoring organization
5 Factors driving future liability cash flows (inflation, economic conditions, interest rates, risk premium)
6 Timing considerations, such as longevity risk
7 Regulations affecting liability cash flow calculations

The above liability characteristics are relevant to liability-relative asset allocation in various ways. For example, they affect the choice of appropriate discount rate(s) to establish the present value of the liabilities and thus the degree to which assets are adequate in relation to those liabilities. Liability characteristics determine the composition of the liability-matching portfolio and that portfolio's basis risk with respect to the liabilities. (Basis risk in this context quantifies the degree of mismatch between the hedging portfolio and the liabilities.)

We will discuss the following case study in detail. It involves a frozen pension plan for LOWTECH, a hypothetical US company. The company has decided to close its defined benefit pension plan and switch to a defined contribution plan. The DB plan has the fixed liabilities (accumulated benefit obligations) shown in Exhibit 24.

Exhibit 24 Projected Liability Cash Flows for Company LOWTECH (US$ billions)

		PV(Liabilities)	
Beginning of Year	Cash Outflow (Liability)	4% Discount Rate	2% Discount Rate
2015	—	$2.261	$3.039
2016	$0.100	2.352	3.10
2017	0.102	2.342	3.06
2018	0.104	2.329	3.02
2019	0.106	2.314	2.97
2020	0.108	2.297	2.92
2021	0.110	2.276	2.87
2022	0.113	2.252	2.82
2023	0.115	2.225	2.76
2024	0.117	2.195	2.69
2025	0.120	2.161	2.63
2026	0.122	2.123	2.56
2027	0.124	2.081	2.49
2028	0.127	2.035	2.41
2029	0.129	1.984	2.33
2030	0.132	1.929	2.24
2031	0.135	1.869	2.15

Exhibit 24 (Continued)

Beginning of Year	Cash Outflow (Liability)	PV(Liabilities) 4% Discount Rate	PV(Liabilities) 2% Discount Rate
2032	0.137	1.804	2.06
2033	0.140	1.733	1.96
2034	0.143	1.657	1.86
2035	0.146	1.575	1.75
2036	0.149	1.486	1.63
2037	0.152	1.391	1.52
2038	0.155	1.289	1.39
2039	0.158	1.180	1.26
2040	0.161	1.063	1.13
2041	0.164	0.938	0.98
2042	0.167	0.805	0.84
2043	0.171	0.663	0.68
2044	0.174	0.512	0.52
2045	0.178	0.352	0.36
2046	0.181	0.181	0.181

In the Cash Outflow (Liability) column, the assumption is made that payments for a given year are made at the beginning of the year (in the exhibit, outflows have a positive sign). As of the beginning of 2015, the present value of these liabilities, given a 4% discount rate for high-quality corporate bonds (required in the United States by the Pension Protection Act of 2006, which applies to private DB pension plans), is US$2.261 billion. The current market value of the assets is assumed to equal US$2.5 billion, for a surplus of US$0.239 billion. On the other hand, if the discount rate is equal to the long-term government bond rate at 2% (required before the 2006 US legislation), the surplus becomes a deficit at –$0.539 billion. In many cases, regulations set the appropriate discount rates; these rates have an impact on the determination of surplus or deficit and thus on future contribution rules.

Like other institutions with legal liabilities, the LOWTECH company must analyze its legal future cash flows under its DB pension system and evaluate them in conjunction with the current market value of its assets on an annual basis. The following steps of the valuation exercise for a DB pension plan occur on a fixed annual date:

1 Calculate the market value of assets.

2 Project liability cash flows (via actuarial principles and rules).

3 Determine an appropriate discount rate for liability cash flows.

4 Compute the present value of liabilities, the surplus value, and the funding ratio.

Surplus = Market value (assets) – Present value (liabilities).

The surplus for the LOWTECH company is US$2.500 billion – US$2.261 billion = US$0.239 billion, given the 4% discount rate assumption.

The funding ratio is another significant measure: Funding ratio = Market value (assets)/Present value (liabilities). We say that an investor is fully funded if the investor's funding ratio equals 1 (or the surplus is 0). A state of overfunding occurs when the funding ratio is greater than 1, and a state of underfunding takes place when the funding ratio is less than 1. Based on a discount rate of 4%, the funding ratio for LOWTECH = US$2.5 billion/US$2.261 billion = 1.1057, so that the company is about 10.6% overfunded.

The surplus value and the funding ratio are highly dependent upon the discount rate assumption. For example, if the discount rate is equal to 2.0% (close to the 10-year US Treasury bond rate in early 2016), the surplus drops to –US$0.539 billion and the funding ratio equals 0.8226. The company's status changes from overfunded to underfunded. The choice of discount rate is generally set by regulations and tradition. Rate assumptions are different across industries, countries, and domains. From the standpoint of economic theory, if the liability cash flows can be hedged perfectly by a set of market-priced assets, the discount rate can be determined by reference to the discount rate for the assets. For example, if the pension plan liabilities are fixed (without any uncertainty), the discount rate should be the risk-free rate with reference to the duration of the liability cash flows—for example, a five-year zero-coupon bond yield for a liability with a (modified) duration of 5. In other cases, it can be difficult to find a fully hedged portfolio because an ongoing DB pension plan's liabilities will depend upon future economic growth and inflation, which are clearly uncertain. Even a frozen pension plan can possess uncertainty due to the changing longevity of the retirees over the long-term future.

3.2 Approaches to Liability-Relative Asset Allocation

Various approaches to liability-relative asset allocation exist. These methods are influenced by tradition, regulations, and the ability of the stakeholders to understand and extend portfolio models that come from the asset-only domain.

There are several guiding principles. The first is to gain an understanding of the make-up of the investor's liabilities and especially the factors that affect the amount and timing of the cash outflows. Given this understanding, the present value of the liabilities is calculated, along with the surplus and funding ratio. These measures are used to track the results of ongoing investment and funding policies and for other tasks. Next come the decisions regarding the asset allocation taking account of the liabilities. There are a number of ways to proceed. We will discuss three major approaches:

- *Surplus optimization*. This approach involves applying mean–variance optimization (MVO) to an efficient frontier based on the volatility of the surplus ("surplus volatility," or "surplus risk") as the measure of risk. Surplus optimization is thus an extension of MVO based on asset volatility.[18] Depending on context, surplus risk may be stated in money or percentage terms ("surplus return volatility" is then another, more precise term for this measure).
- *Hedging/return-seeking portfolios approach*. This approach involves separating assets into two groups: a hedging portfolio and a return-seeking portfolio. The reading also refers to this as the two-portfolio approach. The concept of allocating assets to two distinct portfolios can be applied for various funding ratios, but the reading distinguishes as the basic approach the case in which there is a positive surplus available to allocate to the return-seeking portfolio.
- *Integrated asset–liability approach*. For some institutional investors, such as banks and insurance companies and long–short hedge funds, asset and liability decisions can be integrated and jointly optimized.

We cover these three approaches in turn.

18 Among the papers that discuss the surplus optimization model are Leibowitz and Henriksson (1988); Mulvey (1989, 1994); Sharpe and Tint (1990); Elton and Gruber (1992).

3.2.1 *Surplus Optimization*

Surplus optimization involves adapting asset-only mean–variance optimization by substituting surplus return for asset return over any given time horizon. The quadratic optimization program involves choosing the asset allocation (mix) that maximizes expected surplus return net of a penalty for surplus return volatility at the chosen time horizon. The objective function is

$$U_m^{LR} = E\left(R_{s,m}\right) - 0.005\lambda\sigma^2\left(R_{s,m}\right) \quad (2)$$

where U_m^{LR} is the surplus objective function's expected value for a particular asset mix m; $E(R_{s,m})$ is the expected surplus return for asset mix m, with surplus return defined as (Change in asset value – Change in liability value)/(Initial asset value); and the parameter λ (lambda) indicates the investor's risk aversion. The more risk averse the investor, the greater the penalty for surplus return volatility. Note that the change in liability value (liability return) measures the time value of money for the liabilities plus any expected changes in the discount rate and future cash flows over the planning horizon.

This surplus efficient frontier approach is a straightforward extension of the asset-only portfolio model. Surplus optimization assumes that the relationship between the value of liabilities and the value of assets can be approximated through a correlation coefficient. Surplus optimization exploits natural hedges that may exist between assets and liabilities as a result of their systematic risk characteristics.

The following steps describe the surplus optimization approach:

1 Select asset categories and determine the planning horizon. One year is often chosen for the planning exercise, although funding status analysis is based on an analysis of all cash flows.

2 Estimate expected returns and volatilities for the asset categories and estimate liability returns (expanded matrix).

3 Determine any constraints on the investment mix.

4 Estimate the expanded correlation matrix (asset categories and liabilities) and the volatilities.[19]

5 Compute the surplus efficient frontier and compare it with the asset-only efficient frontier.

6 Select a recommended portfolio mix.

Exhibit 25 lists LOWTECH's asset categories and current allocation for a one-year planning horizon. The current allocation for other asset categories, such as cash, is zero. LOWTECH has been following an asset-only approach but has decided to adopt a liability-relative approach. The company is exploring several liability-relative approaches. With respect to surplus optimization, the trustees want to maintain surplus return volatility at a level that tightly controls the risk that the plan will become underfunded, and they would like to keep volatility of surplus below US$0.25 billion (10%).

19 A covariance matrix is computed by combining the correlation matrix and the volatilities.

Exhibit 25 Asset Categories and Current Allocation for LOWTECH

	Private Equity	Real Estate	Hedge Funds	Real Assets	US Equities	Non-US Equities (Developed Markets)	Non-US Equities (Emerging Markets)	US Corporate Bonds
Allocation	20.0%	12.0%	18.0%	7.0%	15.0%	12.0%	8.0%	8.0%

The second step is to estimate future expected asset and liability returns, the expected present value of liabilities, and the volatility of both assets and PV(liabilities). The capital market projections can be made in several ways—based on historical data, economic analysis, or expert judgment, for example. The plan sponsor and its advisers are responsible for employing one or a blend of these approaches. Exhibit 26 shows the plan sponsor's capital market assumptions over a three- to five-year horizon. Note the inclusion of the present value of liabilities in Exhibit 26.

Exhibit 26 LOWTECH's Capital Market Assumptions: Expected Annual Compound Returns and Volatilities

	Private Equity	Real Estate	Hedge Funds	Real Assets	US Equities	Non-US Equities (Developed Markets)	Emerging Markets	US Corporate Bonds	Cash	PV (Liabilities)
Expected returns	8.50%	7.50%	7.00%	6.00%	7.50%	7.20%	7.80%	4.90%	1.00%	4.90%
Volatilities	14.20%	9.80%	7.70%	6.10%	18.00%	19.50%	26.30%	5.60%	1.00%	5.60%

Typically, in the third step, the investor imposes constraints on the composition of the asset mix, including policy and legal limits on the amount of capital invested in individual assets or asset categories (e.g., a constraint that an allocation to equities must not exceed 50%). In our example, we simply constrain portfolio weights to be non-negative and to sum to 1.

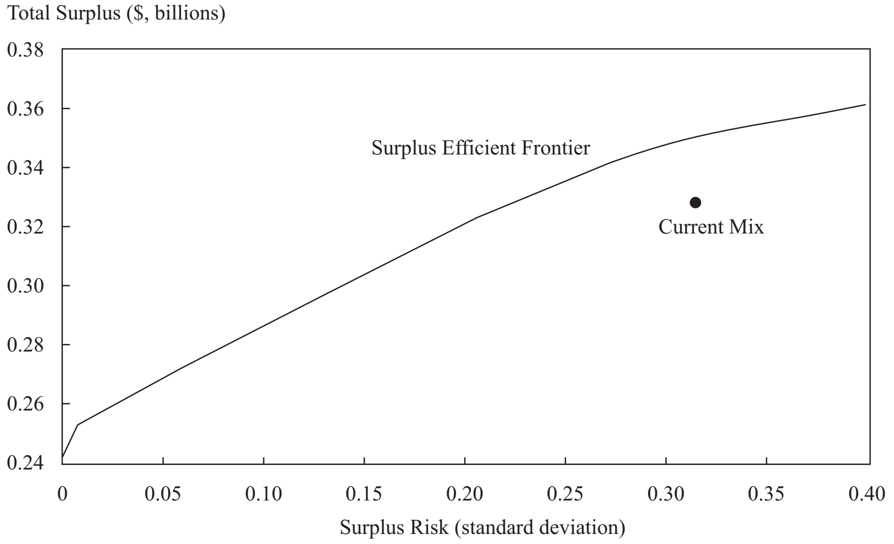
The fourth step is to estimate the correlation matrix and volatilities. We assume that the liabilities have the same expected returns and volatilities as US corporate bonds; thus, the expanded matrix has a column and a row for liabilities with values equal to the corporate bond values. For simplicity, the investor may employ historical performance. Exhibit 27 shows the correlation matrix of asset categories based on historical quarterly returns. Recall that we assume that liability returns (changes in liabilities) are driven by changes in the returns of US corporate bonds. An alternative approach is to deploy a set of underlying factors that drive the returns of the assets. Factors include changes in nominal and real interest rates, changes in economic activity (such as employment levels), and risk premiums. This type of factor investment model can be applied in an asset-only or a liability-relative asset allocation context.

Exhibit 27 Correlation Matrix of Returns

	Private Equity	Real Estate	Hedge Funds	Real Assets	US Equities	Non-US Equities (Developed Markets)	Non-US Equities (Emerging Markets)	US Corporate Bonds	Cash	PV (Liabilities)
Private equity	1	0.41	0.57	0.32	0.67	0.59	0.49	–0.27	0	–0.27
Real estate	0.41	1	0.45	0.41	0.31	0.33	0.17	–0.08	0	–0.08
Hedge funds	0.57	0.45	1	0.11	0.68	0.61	0.54	–0.23	0	–0.23
Real assets	0.32	0.41	0.11	1	0.04	0.06	–0.06	0.34	0	0.34
US equities	0.67	0.31	0.68	0.04	1	0.88	0.73	–0.38	0	–0.38
Non-US equities (developed)	0.59	0.33	0.61	0.06	0.88	1	0.81	–0.39	0	–0.39
Non-US equities (emerging)	0.49	0.17	0.54	–0.06	0.73	0.81	1	–0.44	0	–0.44
US corporate bonds	–0.27	–0.08	–0.23	0.34	–0.38	–0.39	–0.44	1	0	1
Cash	0	0	0	0	0	0	0	0	1	0
PV(liabilities)	–0.27	–0.08	–0.23	0.34	–0.38	–0.39	–0.44	1	0	1

Exhibit 28 shows a surplus efficient frontier that results from the optimization program based on the inputs from Exhibits 26 and 27. Surplus risk (i.e., volatility of surplus) in money terms (US$ billions) is on the *x*-axis, and expected surplus in money terms (US$ billions) is on the *y*-axis. By presenting the efficient frontier in money terms, we can associate the level of risk with the level of plan surplus, US$0.239 billion. Like the asset-only efficient frontier, the surplus efficient frontier has a concave shape.

Exhibit 28 Surplus Efficient Frontier



The first observation is that the current mix in Exhibit 28 lies below the surplus efficient frontier and is thus suboptimal.[20] We can attain the same expected total surplus as that of the current mix at a lower level of surplus volatility by choosing the portfolio on the efficient frontier at the current mix's level of expected total surplus. Another observation is that by uncovering the implications of asset mixes for surplus and surplus volatility, this approach allows the deliberate choice of an asset allocation in terms of the tolerable level of risk in relation to liabilities. It may be the case, for example, that neither the surplus volatility of the current mix nor that of the efficient mix with equal expected surplus is the appropriate level of surplus risk for the pension.

The surplus efficient frontier in Exhibit 28 shows efficient reward–risk combinations but does not indicate the asset class composition of the combinations. Exhibit 29 shows the asset class weights for surplus efficient portfolios.

Exhibit 29 Surplus Efficient Frontier Asset Allocation Area Graph

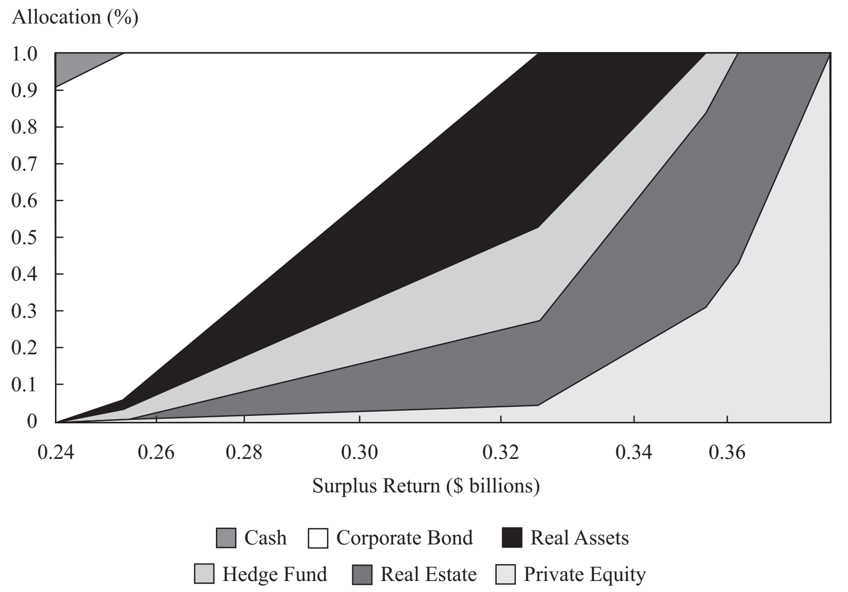
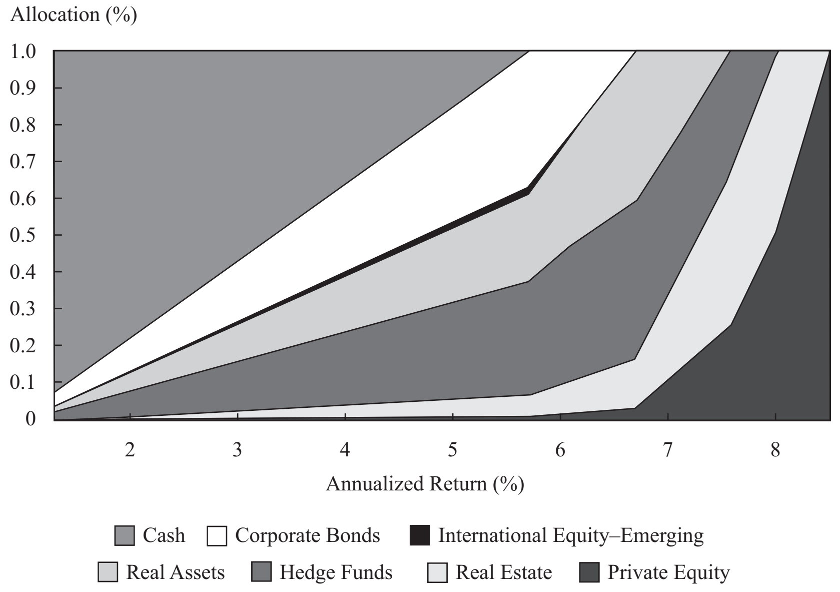


Exhibit 30, showing weights for portfolios on the usual *asset-only* efficient frontier based on the same capital market assumptions reflected in Exhibit 29, makes the point that efficient portfolios from the two perspectives are meaningfully different.[21]

20 The current mix can also be shown to lie below the asset-only mean–variance frontier.

21 In Exhibit 30, the annualized percentage returns can be equated to monetary surplus returns by multiplying by the asset value, US$2.5 billion.

Exhibit 30 Asset-Only Efficient Frontier Asset Allocation Area Graph



The asset mixes are very different on the conservative side of the two frontiers. The most conservative mix for the surplus efficient frontier (in Exhibit 29) consists mostly of the US corporate bond index (the hedging asset) because it results in the lowest volatility of surplus over the one-year horizon. Bonds are inversely correlated with changes in the present value of the frozen liability cash flows (because the liabilities indicate negative cash flows). In contrast, the most conservative mix for the asset-only efficient frontier (in Exhibit 30) consists chiefly of cash. As long as there is a hedging asset and adequate asset value, the investor can achieve a very low volatility of surplus, and for conservative investors, the asset value at the horizon will be uncertain but the surplus will be constant (or as constant as possible).

The two asset mixes (asset-only and surplus) become similar as the degree of risk aversion decreases, and they are identical for the most aggressive portfolio (private equity). Bonds disappear from the frontier about halfway between the most conservative and the most aggressive mixes, as shown in Exhibits 29 and 30.

To summarize, the current asset mix is moderately aggressive and below the surplus efficient frontier. Thus, a mean–variance improvement is possible: either higher expected surplus with the same surplus risk or lower surplus risk for the same expected surplus. The current portfolio is also poorly hedged with regard to surplus volatility; the hedging asset (long bonds in this case) has a low commitment.

The LOWTECH plan has been frozen, and the investment committee is interested in lowering the volatility of the surplus. Accordingly, it seems appropriate to choose an asset allocation toward the left-hand side of the surplus efficient frontier. For instance, a surplus efficient portfolio with about 60% bonds and the remainder in other assets (as can be approximately identified from Exhibit 29) will drop surplus volatility by about 50%.

In the end, the investment committee for the plan sponsor and its advisers and stakeholders are responsible for rendering the best decision, taking into account all of the above considerations. And as always, the recommendations of a portfolio-modeling exercise are only as good as the input data and assumptions.

Multi-Period Portfolio Models

The traditional mean–variance model assumes that the investor follows a buy-and-hold strategy over the planning horizon. Thus, the portfolio is not rebalanced at intermediate dates. A portfolio investment model requires multiple time periods if rebalancing decisions are to be directly incorporated into the model. Mulvey, Pauling, and Madey (2003) discuss the pros and cons of building and implementing multi-period portfolio models. Applicable to both asset-only and liability-relative asset allocation, multi-period portfolio models are more comprehensive than single-period models but are more complex to implement. These models are generally implemented by means of the integrated asset–liability methods discussed in Section 3.2.1

EXAMPLE 6

Surplus Optimization

1. Explain how surplus optimization solutions differ from mean–variance optimizations based on asset class risk alone.
2. What is a liability return?
3. Compare the composition of a surplus optimal portfolio at two points on the surplus efficient frontier. In particular, take one point at the lower left of the surplus frontier (surplus return = US$0.26 billion) and the other point higher on the surplus efficient frontier (surplus return = US$0.32 billion). Refer to Exhibit 29. Explain the observed relationship in terms of the use of corporate bonds as the hedging asset for the liabilities.

Solution to 1:

The surplus optimization model considers the impact of asset decisions on the (Market value of assets – Present value of liabilities) at the planning horizon.

Solution to 2:

Liability returns measure the time value of money for the liabilities plus any expected changes in the discount rate over the planning horizon.

Solution to 3:

Whereas the portfolio at the US$0.26 billion surplus return point on the efficient frontier has a substantial position in corporate bonds, the efficient mix with US$0.32 billion surplus return does not include them. The observed relationship that the allocation to corporate bonds declines with increasing surplus return can be explained by the positive correlation of bond price with the present value of liabilities. The hedging asset (corporate bonds) is employed to a greater degree at the low end of the surplus efficient frontier.

3.2.2 *Hedging/Return-Seeking Portfolio Approach*

In this approach, the liability-relative asset allocation task is divided into two parts. We distinguish as "basic" the two-portfolio approach in the case in which there is a surplus available to allocate to a return-seeking portfolio and as "variants" the approach as applied when there is not a positive surplus. In the basic case, the first part of the asset allocation task consists of hedging the liabilities through a hedging portfolio.

In the second part, the surplus (or some part of it) is allocated to a return-seeking portfolio, which can be managed independently of the hedging portfolio (for example, using mean–variance optimization or another method). An essential issue involves the composition of the hedging portfolio. In some cases, such as the LOWTECH frozen DB pension plan, the hedging portfolio is straightforward to identify. The designated cash flows can be hedged via cash flow matching, duration matching, or immunization (as explained in the fixed-income readings). This hedge will support the future cash flows with little or no risk.

In LOWTECH's application of the basic two-portfolio approach, the small surplus causes the pension plan to invest most of its capital in the hedging portfolio. The hedging portfolio can be approximated by the long-bond indexed investment as a first cut. Thus, given a 4% discount rate, US$2.261 billion is placed in long bonds. The remaining US$0.239 billion is invested in a portfolio of higher expected return assets, such as stocks, real estate, and hedge funds. This approach guarantees that the capital is adequate to pay future liabilities, as long as the hedging portfolio does not experience defaults.

Note that if the discount rate were 2% rather than 4%, the pension plan would be underfunded even if all assets were placed in a hedging portfolio. In such a case, the pension plan sponsor would either develop a strategy to increase the funding ratio so that the liabilities would be eventually paid or apply a variant of the two-portfolio approach. An underfunded plan will require higher contributions from the sponsor than a plan that is fully funded or overfunded.

The basic two-portfolio approach is most appropriate for conservative investors, such as insurance companies, and for overfunded pension plans that wish to reduce or eliminate the risk of not being able to pay future liabilities.

Several variants of the two-portfolio approach are possible. These include a partial hedge, whereby capital allocated to the hedging portfolio is reduced in order to generate higher expected returns, and dynamic versions whereby the investor increases the allotment to the hedging portfolio as the funding ratio increases. The specification of this allotment is often referred to as the liability glide path. These variants do not hedge the liabilities to the full extent possible given the assets and thus are less conservative than the basic approach discussed above. Still, there can be benefits to a partial hedge when the sponsor is able to increase contributions if the funding ratio does not increase in the future to 1 or above.

In the following discussion, we focus on determining the hedging portfolio.

Forming the Hedging Portfolio The hedging portfolio must include assets whose returns are driven by the same factor(s) that drive the returns of the liabilities. Otherwise, even if the assets and liabilities start with equal values, the assets and liabilities will likely become inconsistent over time. One example involves promises (cash outflows) that are dependent upon future inflation. The hedging portfolio in this situation would often include index-linked (inflation-linked) Treasury bonds, again cash matched to the liabilities or immunized to the degree possible.

If there is an active market for the hedging portfolio (securities) in question, the present value of future cash flows is equal to a market value of the assets contained in the hedging portfolio. In this case, the date of valuation for the assets must be the same as the date of valuation for the liabilities. Absent market values, some form of appraised value is used.

The task of forming the hedging portfolio is complicated by the discount rate assumption and by the need to identify assets that are driven by the same factors that affect the liabilities. For example, if the discount rate is set by reference to a marketable instrument, such as the long government bond index, but the liability cash flows are driven by a factor such as inflation, the hedging task may require the use of instruments beyond nominal bonds (perhaps multiple instruments, such as interest rate swaps, inflation-linked bonds, and real assets). And in many applications, the hedge cannot be fully accomplished due to the nature of the driving factors (e.g., if they are non-marketable factors, such as economic growth).

If the uncertainties in the cash flows are related to non-market factors, such as future salary increases, the discount rate will depend upon regulations and tradition. Clearly, high discount rates lead to high funding ratios and in most cases require lower contributions from the sponsoring organization (at least in the short run). Conversely, lower discount rates give rise to lower funding ratios and thereby higher contributions. In the former case, investors with high discount rates will need to generate higher asset returns to achieve their promises if the pension plan sponsor wishes to avoid future contributions. A more conservative route is to designate a lower discount rate, as is the case in much of Europe and Asia. In all cases, it is the regulator's responsibility to set the guidelines, rules, and penalties involved in determining contribution policy.

Several issues complicate the valuation of liability cash flows. In many situations, investors must satisfy their promises without being able to go to a market and purchase a security with positive cash flows equal in magnitude to the liability cash flows.

At times, uncertain liabilities can be made more certain through the law of large numbers. For example, life insurance companies promise to pay beneficiaries when a policyholder dies. The life insurance company can minimize the risk of unexpected losses by insuring large numbers of individuals. Then, valuation of liabilities will use present value of expected cash flows based on a low (or even zero) risk premium in the discount rate. The field of application of the law of large numbers can be limited. For example, averages do not eliminate longevity risk.

Limitations The basic two-portfolio approach cannot be directly applied under several circumstances. First, if the funding ratio is less than 1, the investor cannot create a fully hedging portfolio unless there is a sufficiently large positive cash flow (contribution). In this case, the sponsor might increase contributions enough to generate a positive surplus. As an alternative, there are conditional strategies that might help improve the investor's funding ratio, such as the glide path rules.[22]

A second barrier occurs when a true hedging portfolio is unavailable. An example involves losses due to weather-related causes, such as hurricanes or earthquakes. In these cases, the investor might be able to partially hedge the portfolio with instruments that share some of the same risks. The investor has "basis risk" when imperfect hedges are employed. (As an aside, the investor might be able to set up a contract with someone who, for a fee, will take on the liability risk that cannot be hedged. Insurance contracts have this defining characteristic.)

EXAMPLE 7

The Hedging/Return-Seeking Portfolios Approach

1 Compare how surplus optimization and the hedging/return-seeking portfolio approach take account of liabilities.

2 How does funding status affect the use of the basic hedging/return-seeking portfolio approach?

22 See Gannon and Collins (2009).

Solution to 1:

The surplus optimization approach links assets and the present value of liabilities through a correlation coefficient. The two-portfolio model does not require this input. Surplus optimization considers the asset allocation problem in one step; the hedging/return-seeking portfolio approach divides asset allocation into two steps.

Solution to 2:

Implementation of the basic two-portfolio approach depends on having an overfunded plan. A variant of the two-portfolio approach might be applied, however. Surplus optimization does not require an overfunded status. Both approaches address the present value of liabilities, but in different ways.

3.2.3 *Integrated Asset–Liability Approach*

The previous two approaches are most appropriate when asset allocation decisions are made after, and relatively independently of, decisions regarding the portfolio of liabilities. However, there are numerous applications of the liability-relative perspective in which the institution must render significant decisions regarding the composition of its liabilities *in conjunction with the asset allocation*. Banks, long–short hedge funds (for which short positions constitute liabilities), insurance companies, and re-insurance companies routinely fall into this situation. Within this category, the liability-relative approaches have several names, including asset–liability management (ALM) for banks and some other investors and dynamic financial analysis (DFA) for insurance companies. These approaches are often implemented in the context of multi-period models. Using the following two cases, we review the major issues.

Integrated Asset–Liability Approach for Property/Casualty Insurance Companies

A property/casualty insurance company must make asset investment decisions in conjunction with business decisions about the portfolio of insured properties, its liabilities. To that end, asset and liability decisions are frequently integrated in an enterprise risk management system. In fact, the liability portfolio is essential to the company's long-term viability. For example, a particular property/casualty (PC) insurance company might engage (accept) liabilities for catastrophic risks such as earthquakes and hurricanes. In this case, the liabilities depend upon rare events and thus are most difficult to hedge against. Specialized firms calculate insured losses for a chosen set of properties for property/casualty insurance companies, and these firms provide liability cash flows on a probabilistic (scenario) basis. In this way information is gathered about the probability of losses over the planning horizon and the estimated losses for each loss event. An important issue involves the amount of capital needed to support the indicated liabilities. This issue is addressed by evaluating the tail risks, such as the 1% Value-at-Risk or Conditional-Value-at-Risk amount. To reduce this risk, there are major advantages to forming a diversified global portfolio of liabilities and rendering asset allocation decisions in conjunction with the liability portfolio decisions. The hedging portfolio in this case is not well defined. Therefore, it is difficult to hedge liabilities for a book of catastrophic risk policies. Liabilities might be addressed via customized products or by purchasing re-insurance. The assets and liabilities are integrated so that the worst-case events can be analyzed with regard to both sides of the balance sheet.

Integrated Asset–Liability Approach for Banks

Large global banks are often required to analyze their ability to withstand stress scenarios, in accordance with the Basel III framework. These institutions must be able to show that their current capital is adequate to withstand losses in their business units, such as asset trading, in conjunction with increases in liabilities. The chief risk officer evaluates these scenarios by means of integrated asset–liability approaches. The asset and liability decisions are linked in an enterprise manner. Both the portfolio of assets and the portfolio of liabilities have major impacts on the organization's risk. Thus, decisions to take on new products or expand an existing product—thereby generating liabilities—must take into account the associated decisions on the asset side. The integrated asset–liability management system provides a mechanism for discovering the optimal mix of assets and liabilities (products). These applications often employ multi-period models via a set of projected scenarios.

Decisions about asset allocation will affect the amount of business available to a financial intermediary, such as a bank or insurance company. Similarly, decisions about the portfolio of liabilities and concentration risks will feed back to the asset allocation decisions. Accordingly, we can set up a linked portfolio model. In a similar fashion, the performance of the assets of an institution possessing quasi-liabilities, such as a university endowment, will affect the spending rules for the institution. We can reduce worst-case outcomes by adjusting spending during crash periods, for example. Portfolio models linked to liabilities can provide significant information, helping the institution make the best compromise decisions for both the assets and the liabilities under its control. The twin goals are to maximize the growth of surplus over time subject to constraints on worst-case and other risk measures relative to the institution's surplus.

3.2.4 *Comparing the Approaches*

We have introduced three approaches for addressing asset allocation decisions in the context of liability issues; Exhibit 31 summarizes their characteristics. Each of these approaches has been applied in practice. The surplus optimization approach is a straightforward extension of the traditional (asset-only) mean–variance model. Surplus optimization demonstrates the importance of the hedging asset for risk-averse investors and provides choices for investors who are less risk averse in the asset mixes located on the middle and the right-hand side of the efficient frontier. The assumptions are similar to those of the traditional Markowitz model, where the inputs are expected returns and a covariance matrix. Thus, the assets and liabilities are linked through correlation conditions. The second approach, separating assets into two buckets, has the advantage of simplicity. The basic approach is most appropriate for conservative investors, such as life insurance companies, and for overfunded/fully funded institutional investors that can fully hedge their liabilities. Another advantage of this approach is a focus on the hedging portfolio and its composition. The hedging portfolio can be constructed using a factor model and then linked to the assets via the same factors. Unfortunately, underfunded investors do not have the luxury of fully hedging their liabilities and investing the surplus in the risky portion; they must apply variants of the two-portfolio approach. The third approach, integrating the liability portfolio with the asset portfolio, is the most comprehensive of the three. It requires a formal method for selecting liabilities and for linking the asset performance with changes in the liability values. This approach can be implemented in a factor-based model, linking the assets and liabilities to the underlying driving factors. It has the potential to improve the institution's overall surplus. It does not require the linear correlation assumption and is capable of modeling transaction costs, turnover constraints, and other real-world constraints. The capital required for this approach is often determined by reference to the output of integrated asset–liability systems in banks and property/casualty insurance and re-insurance companies.

Exhibit 31 Characteristics of the Three Liability-Relative Asset Allocation Approaches

Surplus Optimization	Hedging/Return-Seeking Portfolios	Integrated Asset–Liability Portfolios
Simplicity	Simplicity	Increased complexity
Linear correlation	Linear or non-linear correlation	Linear or non-linear correlation
All levels of risk	Conservative level of risk	All levels of risk
Any funded ratio	Positive funded ratio for basic approach	Any funded ratio
Single period	Single period	Multiple periods

EXAMPLE 8

Liability-Relative Asset Allocation: Major Approaches

1. Discuss how the probability of not being able to pay future liabilities when they come due is or is not addressed by each of the major approaches to liability-relative asset allocation.
2. What are the advantages of the three approaches for investors who are more interested in protecting the surplus than growing their assets? Assume that the investor has a positive surplus.

Solution to 1:

Such issues are best addressed by means of multi-period integrated asset–liability models. Surplus optimization and the two-portfolio approach, being single-period models, have difficulty estimating the probability of meeting future obligations.

Solution to 2:

The three liability-relative approaches are appropriate for conservative investors (investors who are more interested in protecting the surplus than growing their assets). All of the three approaches force investors to understand the nature of their liabilities. This type of information can help inform the decision-making process.

3.3 Examining the Robustness of Asset Allocation Alternatives

As part of a liability-relative asset allocation study, the institutional investor can evaluate performance over selected events and "simulated" historical time periods. Each of the selected events can be interpreted as a "what if" sensitivity analysis. For example, we might wish to consider the effect of a 100 bp increase in interest rates across all maturities—that is, a parallel shift in the yield curve. This event would have a significant impact on the value of government bonds, clearly. Also, there would be a corresponding positive impact on the present discounted value of liabilities that are discounted at the government bond rate. The effect on other liability-relative asset allocation elements is less direct, and assumptions must be made. Suppose, for example, that the investor must discount at the high-quality corporate rate. In that case, we need to estimate the effect of changing government rates on corporate rates. These designated studies are part of the stress tests required by banking and other regulators.

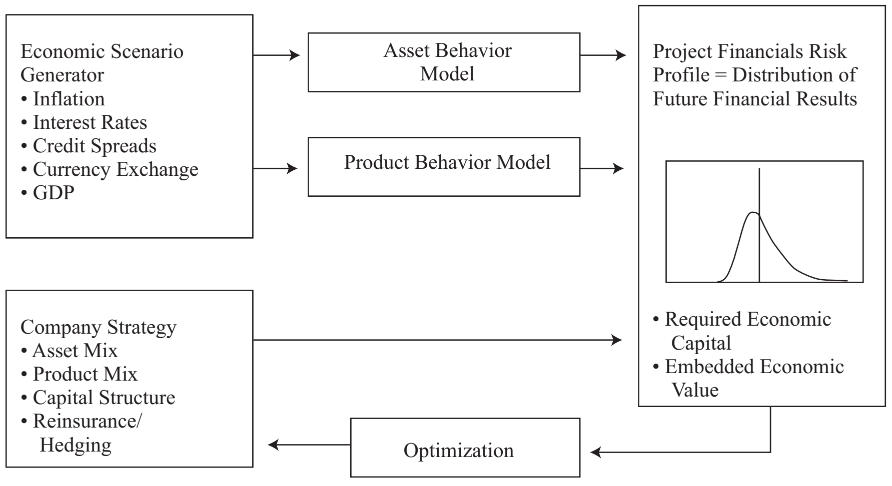
Another type of event study is the construction of scenarios based on carefully selected historical time periods. For example, we might select late 2008 as a reference point. In such a scenario, we are interested in the changes in the economic factors and the associated changes in the values of the institution's assets and liabilities. What would be the impact on our current (or projected) portfolio—assets and PV(liabilities)—if the conditions seen in late 2008 occurred again?

A more comprehensive method for examining robustness involves setting up a multi-stage simulation analysis. Here, we use scenarios to model uncertainty and replace decisions with "rules." The process begins with a set of scenarios for the underlying driving economic factors. Each scenario designates a path for the asset returns and the liability values at each stage of the planning horizon. The result is a set of probabilistic outcomes for the institutional investor's asset portfolio and the cash flows for its liabilities. In such modeling, one must take care to be consistent between asset returns and corresponding liabilities within a scenario; for example, if interest rates are a common factor driving both asset performance and the PV (liabilities), the interest rate effects should be based on the same assumptions.

Through the scenario analysis, the probability of both good and bad outcomes can be estimated. For example, we can measure the probability that an institutional investor will make a capital contribution in the future. Exhibit 32 shows the decision structure for the simulation of an insurance company over several periods, including modeling of the company's business strategy and the required capital rules.

To evaluate robustness, we can apply the simulation system with different assumptions. For instance, if we change the expected return of US equities, what is the effect on the probability of meeting the liabilities over an extended horizon, such as 10 years? This type of sensitivity analysis is routinely done in conjunction with the modeling exercise.

Exhibit 32 Simulation Analysis



3.4 Factor Modeling in Liability-Relative Approaches

A factor-based approach for liability-relative asset allocation has gained interest and credibility for several reasons. First, in many applications, the liability cash flows are dependent on multiple uncertainties. The two primary macro factors are future economic conditions and inflation. Many pension payments to beneficiaries will be based on inflation and salary changes over the employees' work span. A fully hedged portfolio cannot be constructed when the liabilities are impacted by these uncertain factors. Recall that a hedged portfolio can be constructed for a frozen plan with fixed liabilities. For ongoing pension schemes, the best that can be done is to add asset categories to the portfolio that are positively correlated with the underlying driving risk factors, such as inflation-linked bonds. A factor-based approach can be implemented with any of the three liability-relative asset allocation methods discussed above.

EXAMPLE 9

Robustness and Risk Assessment in Liability-Relative Asset Allocation

What types of sensitivity analysis can be evaluated with a multi-period ALM simulation system?

Solution:

To provide estimates of the probability of meeting future obligations and the distribution of outcomes, several types of sensitivity analysis are likely to be performed.

- For example, the expected returns could be increased or decreased to evaluate the impact on future contributions to the plan.
- Likewise, by analyzing historical events, the investor can estimate the size of losses during crash periods and make decisions about the best asset allocation to protect against these worst-case events. Multiple risk measures over time (temporal risk measures) can be readily included in a simulation system.

4 DEVELOPING GOALS-BASED ASSET ALLOCATIONS

In this section, we review the concept of goals-based asset allocation, focusing first on the rationale behind this different approach and its investment implications. We then discuss the major elements of the process, illustrating them with specific, simplified examples when necessary. We conclude with a discussion of the applicability of the approach and its major shortcomings.

A goals-based asset allocation process disaggregates the investor's portfolio into a number of sub-portfolios, each of which is designed to fund an individual goal (or "mental account") with its own time horizon and required probability of success. The literature behind the development of this approach is very rich. Initially, goals-based wealth management was specifically proposed by a small group of practitioners,[23] each of whom offered his own solution for taking into account the tendency of individuals

23 See Brunel (2003, 2005); Nevins (2004); Pompian and Longo (2004); Chhabra (2005).

to classify money into non-fungible mental accounts. Shefrin and Statman (2000) developed the concept of the behavioral portfolio, which can be related to the Maslow (1943) hierarchy of needs. Das, Markowitz, Scheid, and Statman (2010, 2011) showed that traditional and behavioral finance could be viewed as equivalent if one were prepared to change the definition of risk from volatility of returns to the probability of not achieving a goal.[24] The essential point is that optimality requires both a suitably structured portfolio that can meet the given need *and* the correct capital allocation based on an appropriate discount rate, reflecting considerations of time horizon and the required probability of success.

Individuals have needs that are different from those of institutions. The most important difference is that individuals often have multiple goals, each with its own time horizon and its own "urgency," which can be expressed as a specific required probability of success. Exhibit 33 summarizes differences in institutional and individual investor definitions of goals. An individual's goals are not necessarily mutually compatible in two senses: The investor may not be able to address them all given the financial assets available, and there may be internal contradictions among the goals. An alternative process using one set of overall investment objectives—and thus effectively ignoring or "averaging" the different time horizons and required probabilities of success of individual goals—ostensibly loses the granular nature of client goals; as a result, the inherent complexities of the investment problem are less likely to be addressed fully. An approach that breaks the problem into sub-portfolios carries a higher chance of fully addressing an investor's goals, although it may require several iterations to ensure that the investor's portfolio is internally consistent and satisfactory.

Exhibit 33 Institutional and Individual Ways of Defining Goals

	Institutions	Individuals
Goals	Single	Multiple
Time horizon	Single	Multiple
Risk measure	Volatility (return or surplus)	Probability of missing goal
Return determination	Mathematical expectations[a]	Minimum expectations
Risk determination	Top-down/bottom-up	Bottom-up
Tax status	Single, often tax-exempt	Mostly taxable

[a] "Mathematical expectations" here means the weighted expected return of portfolio components.

The characteristics of individuals' goals have three major implications for an investment process that attempts to address the characteristics directly:

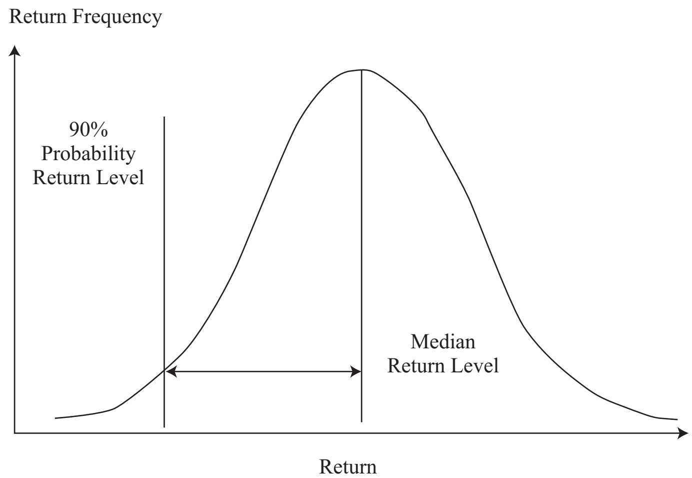
- The overall portfolio needs to be divided into sub-portfolios to permit each goal to be addressed individually.
- Both taxable and tax-exempt investments are important.
- Probability- and horizon-adjusted expectations (called "minimum expectations" in Exhibit 33) replace the typical use of mathematically expected average returns in determining the appropriate funding cost for the goal (or "discount rate" for future cash flows).

24 We apologize to these authors for grossly oversimplifying their work, but our aim is to make their insights more readily available without going into excruciating detail.

Compared with average return expectations—the median or average return anticipated for a combination of assets that is appropriate to address a goal—minimum expectations reflect a more complex concept. Minimum expectations are defined as the minimum return expected to be earned over the given time horizon with a given minimum required probability of success.

To illustrate, assume that a portfolio associated with a goal has an expected return of 7% with 10% expected volatility and the investor has indicated that the goal is to be met over the next five years with at least 90% confidence. Over the next five years, that portfolio is expected to produce returns of 35% with a volatility of 22.4%.[25] In short, this portfolio is expected to experience an average compound return of only 1.3% per year over five years with a probability of 90%; this result is quite a bit lower than the portfolio's average 7% expected return (see Exhibit 34). Thus, rather than discounting expected cash outflows by 7% to compute the dollar amount needed to defease the goal over that five-year horizon, one must use a considerably lower discount rate and by implication reserve a higher level of capital to meet that goal. Under moderate simplifying assumptions, that computation is valid whether or not return and volatility numbers are pretax or after-tax. Exhibit 34 shows, for the case of a normal distribution of returns, a return level that is expected to be exceeded 90% of the time (the 40% of the probability that lies between the vertical lines plus the 50% to the right of the median).

Exhibit 34 Probability-Weighted Return vs. Expected (= Median) Return

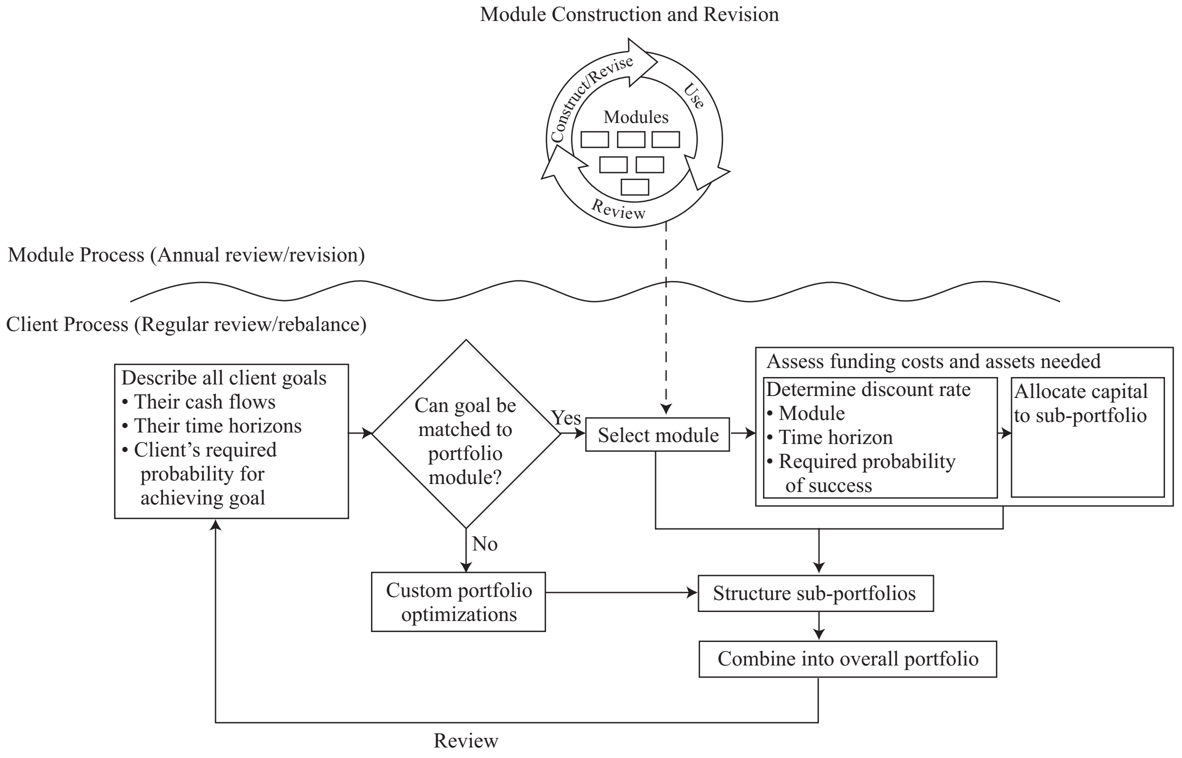


4.1 The Goals-Based Asset Allocation Process

Investment advisers taking a goals-based approach to investing client assets may implement this approach in a variety of ways. Exhibit 35 illustrates the major elements of the goals-based asset allocation process described in this reading. Ostensibly, there are two fundamental parts to this process. The first centers on the creation of portfolio modules, while the second involves identifying client goals and matching each of these goals to the appropriate sub-portfolio of a suitable asset size.

25 The return is the product of the annual return times the number of years, while the volatility is the product of the annual volatility times the square root of the number of years (under the assumption of independently and identically distributed returns).

Exhibit 35 A Stylized Representation of the Goals-Based Asset Allocation Process



Determining the lowest-cost funding for any given goal requires the formulation of an optimized portfolio that will be used to defease that goal optimally in the sense that risks are not taken for which the investor is not fairly compensated. Note that this process is most often generic and internal to the adviser and his or her firm. The adviser will typically not create a specific sub-portfolio for each goal of each client but rather will select, from a pre-established set, one of a few modules—or model portfolios—that best meet each goal.[26] As discussed above, adjusting the expected return on that portfolio to account for the time horizon and the required probability of success allows one to formulate the relevant discount rate which, when applied to the expected cash flows, will help determine the capital required at the outset. That capital will then be invested in the optimized portfolio asset allocation, where the balance will decline until the end of the horizon, when it runs out.[27] Note that the process is somewhat iterative because individual investors may describe a certain horizon as set when in fact they view it as "the next *x* years," with the horizon rolling by one year every year. Note also that discounting needs based on probability- and

26 See the next paragraph for a discussion of when it makes sense to create specific optimal sub-portfolios.
27 An important reason for the use of a declining-balance portfolio relates to the need for individuals and families to plan for the transfer of assets at death. In order for the income from assets to be used by an individual, these assets must be in the individual's name, or at least in a structure of which he or she is a beneficiary. Such assets would then be a part of the estate of the individual. Using a declining-balance portfolio allows the individual to receive the income—and some of the principal liquidated every year—while still ensuring that the amount of assets kept in the individual's name remains as low as appropriate given the individual's goals. An exception to this scenario would be the case of families whose income needs are so modest in relation to total assets that there is no need to provide income in planning for generational transfers or families that have such large eventual philanthropic intentions that assets kept in some beneficiaries' names are meant to be transferred to charity at death.

horizon-adjusted minimum expectations naturally means that these expectations will be exceeded under "normal circumstances." Thus, it is not unusual for the funding for a goal to seem excessive with the benefit of hindsight.

Although the great majority of advisers will likely create individual client portfolios using model portfolios—precisely, pre-optimized modules—a greater degree of customization is possible. Such customization involves creating specific sub-portfolios for each goal of each client. Indeed, it is conceivable, and mathematically possible, to create an optimal sub-portfolio for each goal. In fact, in practice, one would often proceed in this way when dealing with complex situations and with clients who have highly differentiated needs and constraints.[28] The adviser may find it impossible to use pre-optimized modules if the investment constraints imposed by the client are incompatible with those used in the creation of the module set. These might include, for instance, geographical or credit emphases—or de-emphases—that conflict with the market portfolio concept. Other restrictions might concern base currency, the use of alternative strategies, or the acceptability of illiquid investments, for example. Thus, although it is feasible for advisers to create client-specific modules, this approach can become prohibitively expensive. In short, one would likely use standardized modules for most individuals, except for those whose situation is so complex as to require a fully customized approach.

Many multi-client advisers may prefer to create a set of "goal modules" whose purpose is, collectively, to cover a full range of capital market opportunities and, individually, to represent a series of return–risk trade-offs that are sufficiently differentiated to offer adequate but not excessive choices to meet all the goals they expect their clients to express. These modules should therefore collectively appear to create a form of efficient frontier, though the frontier they depict in fact does not exist because the modules may well be based on substantially different sets of optimization constraints.

The two most significant differences from one module to the next, besides the implied return–risk trade-offs, are liquidity requirements and the eligibility of certain asset classes or strategies. Additionally, while intra–asset class allocation to individual sub–asset classes or strategies may typically be guided by the market portfolio for that asset class, one can conceive of instances where the selection of a specific sub–asset class or strategy is justified, even though the asset class per se may seem inappropriate. For instance, one might agree to hold high-yield bonds in an equity-dominated portfolio because of the equity risk factor exposure inherent in lower-credit fixed income. Conversely, the fixed-income market portfolio might be limited to investment-grade bonds and possibly the base-currency-hedged variant of non-domestic investment-grade bonds. We will return to the construction of these modules in Section 4.5.

4.2 Describing Client Goals

At this point, it is important to note that individual investors do not always consider all goals as being equal and similarly well-formulated in their own minds. Thus, while certain investors will have a well-thought-out set of goals—which may at times not be simultaneously achievable given the financial assets available—others will focus only on a few "urgent" goals and keep other requirements in the background.

Thus, a first step is to distinguish between goals for which anticipated cash flows are available—whether regularly or irregularly timed across the horizon or represented by a bullet payment at some future point—and those we call "labeled goals," for which details are considerably less precise. The term "labeled" here simply means that the individual has certain "investment features" in mind—such as minimal risk, capital

28 Note that such an approach, being more complex, is also costlier. It would therefore be more likely to be economically feasible for those advisory clients who also have the ability to pay a higher fee.

preservation, purchasing power preservation, and long-term growth—but has not articulated the actual need that stands behind each label. The individual may already have mentally allocated some portion of his or her assets, in currency or percentage terms, to one or several of these labels. For cash flow–based goals,[29] the time horizon over which the goal is to be met is usually not difficult to ascertain: It is either the period over which cash outflows are expected to be made or the point in time at which a bullet payment is expected. More complex, however, is the issue of the urgency of the goal and thus of the required minimum probability of success.

By working to preserve a human (as opposed to a technical) tone in the advisory conversations, the adviser can serve the client without forcing him or her to come up with a quantified probability of success. The adviser may start with the simple observation that there are two fundamental types of goals: those that one seeks to achieve and those whose consequences one seeks to avoid. Dividing the goals the investor seeks to achieve into "needs, wants, wishes, and dreams" provides the adviser with an initial sense of the urgency of each goal. A need typically must be met and so should command a 90%–99% probability of success, while at the other end of the spectrum, it is an unfortunate fact that we all live with unfulfilled dreams, whose required probabilities of success probably fall below 60%. A parallel—and analogous—structure can be created to deal with goals one seeks to avoid:[30] "nightmares, fears, worries, and concerns," with similar implications in terms of required probabilities of success. In short, while some discussion of probability level may well take place, it can be informed and guided by the use of commonly accepted everyday words that will ensure that the outcome is internally consistent. The adviser avoids the use of jargon, which many clients dislike, and yet is able to provide professional advice.[31]

The simplest way to bring this concept to life is to work with a basic case study. Imagine a family, the Smiths, with financial assets of US$25 million. (For the sake of simplicity, we are assuming that they do not pay taxes and that all assets are owned in a single structure.) The parents are in their mid-fifties, and the household spends about US$500,000 a year. They expect that inflation will average about 2% per year for the foreseeable future. They express four important goals and are concerned that they may not be able to meet all of them:

1 They *need* a 95% chance of being able to maintain their current expenditures over the next five years.
2 They *want* an 85% chance of being able to maintain their current expenditures over the ensuing 25 years, which they see as a reasonable estimate of their joint life expectancy.
3 They *need* a 90% chance of being able to transfer US$10 million to their children in 10 years.
4 They *wish* to have a 75% chance to be able to create a family foundation, which they wish to fund with US$10 million in 20 years.

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29 Note that all cash flows do not have to be negative (i.e., outflows). One can easily imagine circumstances where certain future inflows are anticipated and yet are not seen, individually, as sufficient to meet the specified goal.

30 Although negative goals may sound surprising, they do exist and play a double role. First, when a negative goal is explicitly stated, it can be "replaced" by a specific positive goal: Avoiding the nightmare of running out of capital, for example, can be turned into the need to meet a certain expense budget. Second, negative goals serve as a useful feedback loop to check the internal consistency of the investor's goal set.

31 Note that the adviser can also identify a series of "secondary" words to help determine whether a need, for instance, means that the required probability of success should be set at 99%, 95%, or 90%. An *indispensable* need could require a 99% probability of being met, while an *urgent* need might require only a 95% probability of success, and a *serious* need a 90% probability.

EXAMPLE 10

Understanding Client Goals

1 A client describes a desire to have a reserve of €2 million for business opportunities that may develop when he retires in five years. What are the important features of this goal?

2 A 70-year-old client discusses the need to be able to maintain her lifestyle for the balance of her life and wishes to leave US$3 million to be split among her three grandchildren at her death. What are the important features of this situation?

Solution to 1:

The time horizon is five years. Words such as "desire" in describing a goal, compared with expressions indicating "need," indicate that there is room for "error" in the event that capital markets are not supportive. The portfolio required to meet the goal described as a desire will likely be able to involve a riskier profile. One would want to verify this assumption by comparing the size of that goal compared with the total financial assets available to the client.

Solution to 2:

The key takeaway is that although the two goals have the same time horizon, the two portfolios designed to defease them will have potentially significantly different risk profiles. The time horizon is approximately 20 years. The first goal relates to maintaining the client's lifestyle and must be defeased with an appropriately structured portfolio. The second goal, relating to the wish to leave some money to grandchildren, will allow more room for risk taking.

4.3 Constructing Sub-Portfolios

Having defined the needs of the investor in as much detail as possible, the next step in the process is to identify the amount of money that needs to be allocated to each goal and the asset allocation that will apply to that sum. For most advisers, the process will start with a set of sub-portfolio modules (such as those we briefly discussed in Section 4.1 and will study in more depth in Section 4.5). When using a set of pre-optimized modules, the adviser will then need to identify the module best suited to each of the specific goals of the client. That process is always driven by the client's time horizon and required probability of success, and it involves identifying the module that offers the highest possible return given the investor's risk tolerance as characterized by a given required probability of success over a given time horizon.

To illustrate, consider the set of six modules shown in Exhibit 36;[32] these modules result from an optimization process that will be explained later.[33] In the exhibit, the entries for minimum expected return are shown rounded to one decimal place; subsequent calculations for required capital are based on full precision.

32 The different ranges of required probabilities of success for various time horizons reflect the fact that the differentiation across modules can occur more or less rapidly, reflecting the different ratios of return per unit of risk.

33 Exhibit 38 presents the details of the asset allocation of these modules and the constraints underpinning their optimization.

Exhibit 36 "Highest Probability- and Horizon-Adjusted Return" Sub-Portfolio Module under Different Horizon and Probability Scenarios

	A	B	C	D	E	F
Portfolio Characteristics						
Expected return	4.3%	5.5%	6.4%	7.2%	8.0%	8.7%
Expected volatility	2.7%	4.5%	6.0%	7.5%	10.0%	12.5%

	Annualized Minimum Expectation Returns					
Time Horizon (years)			5			
Required Success						
99%	1.5%	0.9%	0.2%	–0.6%	–2.4%	–4.3%
95	2.3	2.2	2.0	1.7	0.7	–0.5
90	2.7	3.0	3.0	2.9	2.3	1.5
75	3.5	4.2	4.6	4.9	5.0	4.9
Time Horizon (years)			10			
Required Success						
99%	2.3%	2.2%	2.0%	1.7%	0.7%	–0.5%
90	3.2	3.7	4.0	4.1	4.0	3.6
75	3.7	4.6	5.1	5.6	5.9	6.0%
60	4.1	5.2	5.9	6.6	7.2	7.7
Time Horizon (years)			20			
Required Success						
95%	3.3%	3.9%	4.2%	4.4%	4.4%	4.1%
90	3.5	4.3	4.7	5.0	5.2	5.1
85	3.7	4.5	5.0	5.4	5.7	5.8
75	3.9	4.9	5.5	6.0	6.5	6.8
Time Horizon (years)			25			
Required Success						
95%	3.4%	4.1%	4.4%	4.7%	4.7%	4.6%
90	3.6	4.4	4.9	5.2	5.5	5.5
85	3.7	4.6	5.2	5.6	6.0	6.1
75	3.9	4.9	5.6	6.2	6.7	7.0

In Exhibit 36, the top section, on portfolio characteristics, presents the expected return and expected volatility of each module. Below that are four sections, one for each of four time horizons: 5, 10, 20, and 25 years. In a given section, the entries are the returns that are expected for a given required probability of achieving success. For example, at a 10-year horizon and a 90% required probability of success, Modules A, B, C, D, E, and F are expected to return, respectively, 3.2%, 3.7%, 4.0%, 4.1%, 4.0%, and 3.6%. In this case, Module D would be selected to address a goal with this time horizon and required probability of success because its 4.1% expected return is higher than those of all the other modules. Thus, Module D offers the lowest "funding cost" for the given goal. The highest expected return translates to the lowest initially required capital when the expected cash flows associated with the goal are discounted using that expected return.

EXAMPLE 11

Selecting a Module

Address the following module selection problems using Exhibit 36:

1 A client describes a desire to have a reserve of €2 million for business opportunities that may develop when he retires in five years. Assume that the word "desire" points to a wish to which the adviser will ascribe a probability of 75%.

2 A 70-year-old client with a 20-year life expectancy discusses the need to be able to maintain her lifestyle for the balance of her life and wishes to leave US$3 million to be split among her three grandchildren at her death.

Solution to 1:

The time horizon is five years. Exhibit 36 shows that Module E has the highest expected return (5.0%) over the five-year period and with the assumed 75% required probability of success.

Solution to 2:

The time horizon is 20 years. The first goal is a need, while the second is a wish. We assume a required probability of success of 95% for a need and 75% for a wish. Exhibit 36 shows that Module D provides the highest horizon- and required-probability-adjusted return (4.4%) for the first goal. Module F is better suited to the second goal because, even though the second goal has the same time horizon, it involves only a 75% required probability of success; the appropriately adjusted return is 6.8%, markedly the highest, which means the initially required capital is lower.

Returning to the Smiths, let us use that same set of modules to look at their four specific goals. The results of our analysis are presented in Exhibit 37.

1 The first goal is a need, with a five-year time horizon and a 95% required probability of success. Looking at the 95% required probability line in the five-year time horizon section of Exhibit 36, we can see that the module with the highest expected return on a time horizon- and required probability-adjusted basis is Module A and that the appropriately adjusted expected return for that module is 2.3%. Discounting a US$500,000 annual cash flow, inflated by 2% a year from Year 2 onwards, required a US$2,430,000 initial investment. This amount represents 9.7% of the total financial wealth of the Smiths.

2 The second goal is a want, with a 25-year time horizon and an 85% required probability of success. The corresponding line of the table in Exhibit 36 points to Module F and a discount rate of 6.1%. Discounting their current expenses with the same assumption over the 25 years starting in Year 6 with a 6.1% rate points to an initially required capital of US$4,978,000, representing 19.9% of the Smiths' wealth.

3 The third goal is another need, with a 10-year time horizon and a 90% required probability of success. Module D is the best module, and the US$6,671,000 required capital reflects the discounting of a US$10 million payment in 10 years at the 4.1% indicated in Exhibit 36.

4 Finally, the fourth goal is a wish with a 20-year time horizon and a 75% required probability of success. Module F is again the best module, and the discounting of a US$10 million payment 20 years from now at the 6.8% expected return from Exhibit 36 points to a required capital of US$2,679,000 today.

Note that different goals may, in fact, be optimally addressed using the same module; thus, an individual module may be used more than once in the allocation of the individual's overall financial assets. Here, Goals 2 and 4 can both be met with the riskiest of the six modules, although their time horizons differ, as do the required probabilities of success, with Goal 2 being characterized as a want and Goal 4 as a wish.

Exhibit 37 Module Selection and Dollar Allocations (US$ thousands)

	Total Financial Assets				25,000	
	Goals					Overall Asset
	1	2	3	4	Surplus	Allocation
Horizon (years)	5	25	10	20		
Required probability of success	95%	85%	90%	75%	$E(R_t)$	7.1%
Discount rate	2.3%	6.1%	4.1%	6.8%	$\sigma(R_t)$	7.6%
Module	**A**	**F**	**D**	**F**	**C**	
Required capital						
In currency	2,430	4,978	6,671	2,679	8,242	25,000
As a % of total	9.7%	19.9%	26.7%	10.7%	33.0%	100.0%

Note also that the Smiths' earlier worry, that they might not be able to meet all their goals, can be addressed easily. Our assumptions suggest that, in fact, they have excess capital representing 33% of their total financial wealth. They can either revisit their current goals and bring the timing of payments forward or raise their probability of success. The case suggests that they would rather think of additional goals but will want to give themselves some time to refine their intentions. Their adviser then suggests that a "middle of the road" module be used as a "labeled goal" for that interim period, and they call this module (Module C) "capital preservation."

4.4 The Overall Portfolio

Assuming the same six modules, with their detailed composition shown in Exhibit 38, one can then derive the overall asset allocation by aggregating the individual exposures to the various modules. In short, the overall allocation is simply the weighted average exposure to each of the asset classes or strategies within each module, with the weight being the percentage of financial assets allocated to each module. Exhibit 39 presents these computations and the overall asset allocation, which is given in bold in the right-most column. The overall portfolio's expected return and volatility are also shown. In Exhibit 38, liquidity[34] is measured as one minus the ratio of the average number of days that might be needed to liquidate a position to the number of trading days in a year. (Note that the column B values add up to 101 because of rounding.)

Exhibit 38 Asset Allocation of Each Module

	A	B	C	D	E	F
Portfolio Characteristics						
Expected return	4.3%	5.5%	6.4%	7.2%	8.0%	8.7%
Expected volatility	2.7%	4.5%	6.0%	7.5%	10.0%	12.5%
Expected liquidity	100.0%	96.6%	90.0%	86.1%	83.6%	80.0%
Portfolio Allocations						
Cash	80%	26%	3%	1%	1%	1%
Global investment-grade bonds	20	44	45	25	0	0
Global high-yield bonds	0	5	11	25	34	4
Lower-volatility alternatives	0	9	13	0	0	0
Global developed equities	0	9	13	19	34	64
Global emerging equities	0	2	2	3	6	11
Equity-based alternatives	0	0	0	8	0	0
Illiquid global equities	0	0	5	10	15	20
Trading strategy alternatives	0	1	3	6	7	0
Global real estate	0	5	5	3	3	0
Total	100%	100%	100%	100%	100%	100%

Exhibit 39 Goals-Based Asset Allocation (US$ thousands)

	Total Financial Assets				25,000	
	Goals					Overall Asset
	1	2	3	4	Surplus	Allocation
Horizon	5	25	10	20		
Required success	95%	85%	90%	75%	$E(R_t)$	7.1%
Discount rate	2.3%	6.1%	4.1%	6.8%	$\sigma(R_t)$	7.6%

(continued)

34 Note that we need to incorporate some estimate of liquidity for all asset classes and strategies to ensure that the client's and the goals' liquidity constraints can be met.

Exhibit 39 (Continued)

Module	A	F	D	F	C	
Required capital						
In currency	2,430	4,978	6,671	2,679	8,242	25,000
As a % of total	9.7	19.9	26.7	10.7	33.0	100.0
Cash	80%	1%	1%	1%	3%	**9%**
Global investment-grade bonds	20	0	25	0	45	**24**
Global high-yield bonds	0	4	25	4	11	**12**
Lower-volatility alternatives	0	0	0	0	13	**4**
Global developed equities	0	64	19	64	13	**28**
Global emerging equities	0	11	3	11	2	**5**
Equity-based alternatives	0	0	8	0	0	**2**
Illiquid global equities	0	20	10	20	5	**10**
Trading strategy alternatives[a]	0	0	6	0	3	**3**
Global real estate	0	0	3	0	5	**2**
Total	100	100	100	100	100	**100**

[a] "Trading strategy alternatives" refers to discretionary or systematic trading strategies such as global macro and managed futures.

4.5 Revisiting the Module Process in Detail

Having explained and illustrated the client process in Exhibit 35, we now explore how modules are developed. Creating an appropriate set of optimized modules starts with the formulation of capital market assumptions. Exhibit 40 presents a possible set of forward-looking pretax capital market expectations for expected return, volatility, and liquidity[35] in Panel A and a historical 15-year correlation matrix in Panel B.[36]

35 For clients who might invest in traditional asset classes by means of vehicles such as mutual funds or ETFs, these asset classes can be treated as providing virtually instant liquidity. For clients with particularly large asset pools who might use separately managed accounts, the liquidity factor for high-yield or emerging market bonds, small-capitalization equities, and certain real assets might be adjusted downward.
36 For illiquid equities, data availability reduces the time period to seven years. The correlation matrix is based on the 15 years ending with March 2016.

Exhibit 40 Example of Capital Market Expectations for a Possible Asset Class Universe

Panel A

	Expected Return	Expected Volatility	Expected Liquidity
Cash	4.0%	3.0%	100%
Global investment-grade bonds	5.5	6.5	100
Global high-yield bonds	7.0	10.0	100
Lower-volatility alternatives	5.5	5.0	65
Global developed equities	8.0	16.0	100
Global emerging equities	9.5	22.0	100
Equity-based alternatives	6.0	8.0	65
Illiquid global equities	11.0	30.0	0
Trading strategy alternatives	6.5	10.0	80
Global real estate	7.0	15.0	100

Panel B

	Cash	Global IG Bonds	Global HY Bonds	Lower-Volatility Alts	Global Developed Equities	Global Emerging Equities	Equity-Based Alts	Trading Strategy Alts	Illiquid Equities	Global Real Estate
Cash	**1.00**	0.00	–0.12	0.08	–0.06	–0.04	0.02	0.04	–0.26	–0.01
Global investment-grade bonds	0.00	**1.00**	0.27	0.14	0.28	0.09	0.07	0.16	0.20	0.24
Global high-yield bonds	–0.12	0.27	**1.00**	0.46	0.70	0.17	0.31	–0.08	0.35	0.28
Lower-volatility alternatives	0.08	0.14	0.46	**1.00**	0.44	0.61	0.86	0.12	0.65	0.47
Global developed equities	–0.06	0.28	0.70	0.44	**1.00**	0.17	0.32	–0.03	0.47	0.38
Global emerging equities	–0.04	0.09	0.17	0.61	0.17	**1.00**	0.72	–0.03	0.67	0.49
Equity-based alternatives	0.02	0.07	0.31	0.86	0.32	0.72	**1.00**	0.11	0.72	0.45
Trading strategy alternatives	0.04	0.16	–0.08	0.12	–0.03	–0.03	0.11	**1.00**	–0.09	0.07
Illiquid global equities	–0.26	0.20	0.35	0.65	0.47	0.67	0.72	–0.09	**1.00**	0.88
Global real estate	–0.01	0.24	0.28	0.47	0.38	0.49	0.45	0.07	0.88	**1.00**

Ostensibly, in the real world, the process ought to be associated with a set of after-tax expectations, which usually cannot be limited to broad asset classes or sub–asset classes. Indeed, the tax impact of management processes within individual asset classes or strategies (for instance, index replication, index replication with systematic tax-loss harvesting, broadly diversified portfolios, or concentrated portfolios) requires that each management process within each asset class or strategy be given its own expected return and volatility. We will dispense with that step here for the sake of simplicity, both in absolute terms and with respect to jurisdictional differences.

Exhibit 41 presents a possible set of such modules based on the capital market expectations from Exhibit 40. The optimization uses a mean–variance process and is subject to a variety of constraints that are meant to reflect both market portfolio considerations and reasonable asset class or strategy suitability given the goals that we expect to correspond to various points on the frontier. Note that the frontier is not "efficient" in the traditional sense of the term because the constraints applied to the portfolios differ from one to the next. Three elements within the set of constraints deserve special mention. The first is the need to be concerned with the liquidity of the various strategies: It would make little sense, even if it were appropriate based on other considerations, to include any material exposure to illiquid equities in a declining-balance portfolio expected to "mature" within 10 years, for instance. Any exposure thus selected would be bound to increase through time because portfolio liquidation focuses on more-liquid assets. The second relates to strategies whose return distributions are known not to be "normal." This point applies particularly to a number of alternative strategies that suffer from skew and kurtosis,[37] which a mean–variance optimization process does not take into account (see Section 2.4.4). Finally, the constraints contain a measure of drawdown control to alleviate the problems potentially associated with portfolios that, although apparently optimal, appear too risky in overly challenging market circumstances. Drawdown controls are an important element in that they help deal with the often-observed asymmetric tolerance of investors for volatility: upward volatility is much preferred to downward volatility.

Exhibit 41 Six Possible Sub-Portfolio Modules

	A	B	C	D	E	F
Portfolio Characteristics						
Expected return	4.3%	5.5%	6.4%	7.2%	8.0%	8.7%
Expected volatility	2.7	4.5	6.0	7.5	10.0	12.5
Expected liquidity	100.0	96.6	90.0	86.1	83.6	80.0
Portfolio Allocations						
Cash	80%	26%	3%	1%	1%	1%
Global investment-grade bonds	20	44	45	25	0	0
Global high-yield bonds	0	5	11	25	34	4
Lower-volatility alternatives	0	9	13	0	0	0
Global developed equities	0	9	13	19	34	64
Global emerging equities	0	2	2	3	6	11
Equity-based alternatives	0	0	0	8	0	0
Illiquid global equities	0	0	5	10	15	20
Trading strategy alternatives	0	1	3	6	7	0
Global real estate	0	5	5	3	3	0
Total	100%	100%	100%	100%	100%	100%

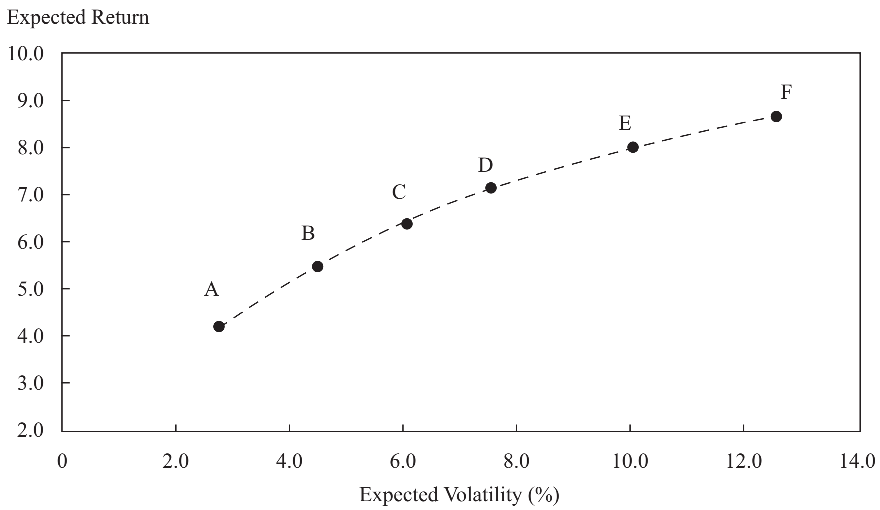
37 Kat (2003) described the challenge, and Davies, Kat, and Lu (2009) presented a solution that involves the use of mean–variance-skew-kurtosis optimization, which is typically too complex for most real-life circumstances.

Exhibit 41 (Continued)

Constraints						
Maximum volatility	3.0%	4.5%	6.0%	7.5%	10.0%	12.5%
Minimum liquidity	100.0	95.0	90.0	85.0	80.0	70.0
Maximum alternatives	0.0	10.0	20.0	30.0	30.0	30.0
Minimum cash	80.0	20.0	0.3	0.5	0.7	1.0
Maximum HY as a percent of total fixed income	0.0	10.0	20.0	50.0	100.0	100.0
Maximum equity spectrum	0.0	10.0	20.0	40.0	75.0	100.0
Maximum EM as a percent of public equities	15.0	15.0	15.0	15.0	15.0	15.0
Maximum illiquid equities	0.0	0.0	5.0	10.0	15.0	20.0
Maximum trading as a percent of equity spectrum	0.0	10.0	15.0	15.0	20.0	25.0
Maximum real estate	0.0	5.0	10.0	15.0	20.0	25.0
Escrow cash as a percent of illiquid equities	5.0	5.0	5.0	5.0	5.0	5.0
Maximum probability of return < drawdown	1.0	1.5	2.0	2.0	2.5	2.5
Drawdown horizon	3	3	3	3	3	3
Drawdown amount	0.0	–5.0	–7.5	–10.0	–15.0	–20.0

The six sub-portfolios shown in Exhibit 41 satisfy two major design goals: First, they cover a wide spectrum of the investment universe, ranging from a nearly all-cash portfolio (Portfolio A) to an all-equity alternative (Portfolio F). Second, they are sufficiently differentiated to avoid creating distinctions without real differences. These portfolios are graphed in Exhibit 42.

Exhibit 42 Sub-Portfolio Modules Cover a Full Range



Returning to an earlier point about "labeled goals," one can easily imagine "aspirations" to describe each of these modules, ranging from "immediate- to short-term lifestyle" for Module A to "aggressive growth" for Module F. Module B might be labeled "long-term lifestyle," while C and D might represent forms of capital preservation and E a form of "balanced growth."

A final point deserves special emphasis: Modules need to be revisited on a periodic basis. While equilibrium assumptions will likely not change much from one year to the next, the need to identify one's position with respect to a "normal" market cycle can lead to modest changes in forward-looking assumptions. It would indeed be foolish to keep using long-term equilibrium assumptions when it becomes clear that one is closer to a market top than to a market bottom. The question of the suitability of revisions becomes moot when using a systematic approach such as the Black–Litterman model. One may also need to review the continued suitability of constraints, not to mention (when applicable) the fact that the make-up of the market portfolio may change in terms of geography or credit distribution.

4.6 Periodically Revisiting the Overall Asset Allocation

Once set, the goals-based allocation must be regularly reviewed. Two considerations dominate:

1. Goals with an initially fixed time horizon are not necessarily one year closer to maturity after a year. Superficially, one would expect that someone who says that his or her need is to meet lifestyle expenditures over the next five years, for instance, means exactly this. Accordingly, next year, the time horizon should shift down to four years. Yet experience suggests that certain horizons are "placeholders": One year on, the time horizon remains five years. This is particularly—and understandably—relevant when the horizon reflects the anticipated death of an individual.
2. The preference for upward rather than downward volatility, combined with perceptions that goals may have higher required probabilities of success than is truly the case, leads to portfolios that typically outperform the discount rate used to compute the required initial capital. Thus, one would expect there to be some need for portfolio rebalancing when the assets allocated to certain goals appear excessive, at least in probability- and horizon-adjusted terms. This situation gives rise to important discussions with taxable clients because any form of portfolio rebalancing is inherently more complex and costly in a taxable environment than when taxes do not come into consideration.

4.7 Issues Related to Goals-Based Asset Allocation

Although goals-based asset allocation offers an elegant and mathematically sound way to deal with the circumstances of individuals, it is not a panacea. By definition, goals-based asset allocation applies best to individuals who have multiple goals, time horizons, and urgency levels. The classic example of the professional who is just starting to save for retirement and who has no other significant goal (as in the case of Aimée Goddard in Example 1) can be easily be handled with the traditional financial tools discussed in the earlier sections of this reading.[38] However, one should always be cautious to ensure that there is no "hidden" goal that should be brought out and that the apparently "single" retirement goal is not in fact an aggregation of several elements with different levels of urgency, if not also different time horizons. Single-goal circumstances may still be helped by the goals-based asset allocation process when there are sustainability or behavioral questions. In that case, one can look at the single goal as being made up of several similar goals over successive time periods with different required probabilities of success. For instance, one might apply a higher sense of urgency—and thus require a lower risk profile—to contributions made in the first few years, on the ground that adverse market circumstances might negatively affect the willingness of the client to stay with the program. In many ways, this approach can be seen as a conceptual analog to the dollar-cost-averaging investment framework.

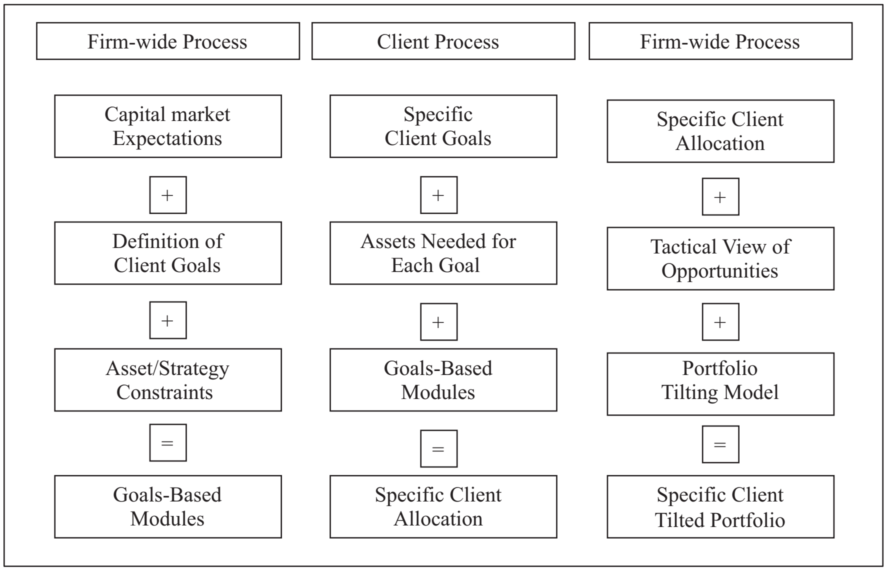
Goals-based asset allocation is ideally suited to situations involving multiple goals, time horizons, and urgency levels, whether the assets are large or more modest. In fact, in cases where "human capital" is considered, a multi-goal approach can help investors understand the various trade-offs they face. Ostensibly, the larger the assets, the more complex the nature of the investment problem, the more diverse the list of investment structures, and the more one should expect a client-focused approach to offer useful benefits. However, the ratio of cash outflows to assets under consideration is a more germane issue than the overall size of the asset pool.

Advisers using goals-based wealth management must contend with a considerably higher level of business management complexity. They will naturally expect to have a different policy for each client and potentially more than one policy per client. Thus, managing these portfolios day to day and satisfying the usual regulatory requirement that all clients be treated in an equivalent manner can appear to be a major quandary.

Typically, the solution would involve developing a systematic approach to decision making such that it remains practical for advisers to formulate truly individual policies that reflect their investment insights. Exhibit 43 offers a graphical overview of advisers' activities, divided into those that involve "firm-wide" processes, defined as areas where no real customization is warranted, and those that must remain "client focused." The result is analogous to a customized racing bicycle, whose parts are mass produced but then combined into a truly unique bike custom-designed for the individual racer.

38 However, an adviser may find it appropriate to help the individual divide the funds he or she believes are needed for retirement into several categories. For instance, there may be some incompressible lifestyle expenditure that represents a minimum required spending level, but there may also be some luxury or at least compressible spending that does not have such a high level of urgency or that applies over a different time frame (say, the early or late years). Thus, one could still describe the problem as involving multiple goals, multiple time horizons, and multiple urgency levels. Then, one could compare the costs associated with the funding of these goals and have the individual weigh potential future satisfaction against the loss of current purchasing power.

Exhibit 43 Goals-Based Wealth Management Advisory Overview



5 HEURISTICS AND OTHER APPROACHES TO ASSET ALLOCATION

In addition to the various asset allocation approaches already covered, a variety of heuristics (rules that provide a reasonable but not necessarily optimal solution) and other techniques deserve mention:

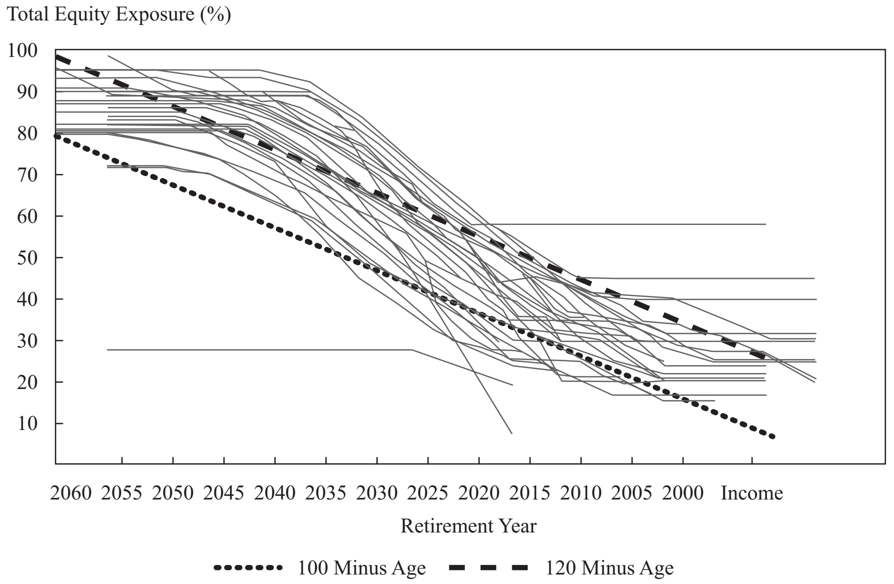
The "120 minus your age" rule. The phrase "120 minus your age" is a heuristic for inferring a hidden, age-driven risk tolerance coefficient that then leads directly to an age-based stock versus fixed income split: 120 – Age = Percentage allocated to stocks. Thus, a 25-year-old man would allocate 95% of his investment portfolio to stocks. Although we are aware of no theoretic basis for this heuristic—or its older and newer cousins, "100 minus your age" and "125 minus your age," respectively—it results in a linear decrease in equity exposure that seems to fit the general equity glide paths associated with target-date funds, including those that are based on a total balance sheet approach that includes human capital. A number of target-date funds (sometimes called life-cycle or age-based funds) and some target-date index providers report that their glide path (the age-based change in equity exposure) is based on the evolution of an individual's human capital. For example, one set of indexes[39] explicitly targets an investable proxy for the world market portfolio in which the glide path is the result of the evolving relationship of financial capital to human capital.[40]

Exhibit 44 displays the glide paths of the 60 largest target-date fund families in the United States. The retirement year (typically part of the fund's name) on the *x*-axis denotes the year in which the investor is expected to retire, which is almost always assumed to be the year the investor turns 65. Thus, as of 2016, the 2060 allocations correspond to a 21-year-old investor (79% equity, using the heuristic), whereas the 2005

39 Morningstar's Lifetime Allocation (target-date) indexes.
40 See Idzorek (2008).

allocation corresponds to a 76-year-old investor (24% equity, using the heuristic).[41] One dashed line represents the equity allocation based on the "100 minus your age" heuristic, while another dashed line represents the "120 minus your age" heuristic. The heuristic lines lack some of the nuances of the various glide path lines, but it would appear that an age-based heuristic leads to asset allocations that are broadly similar to those used by target-date funds.

Exhibit 44 Target-Date Funds and Age Heuristics (as of January 2016)



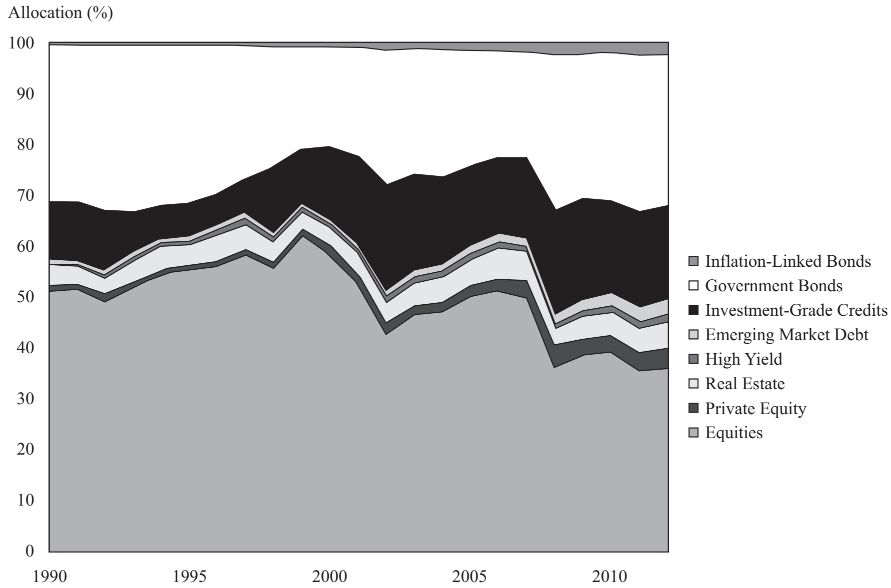
The 60/40 stock/bond heuristic. Some investors choose to skip the various optimization techniques and simply adopt an asset allocation consisting of 60% equities and 40% fixed income.

The equity allocation is viewed as supplying a long-term growth foundation, and the fixed-income allocation as supplying risk reduction benefits. If the stock and bond allocations are themselves diversified, an overall diversified portfolio should result.

There is some evidence that the global financial asset market portfolio is close to this prototypical 60/40 split. Exhibit 45 displays the estimated market value of eight major components of the market portfolio from 1990 to 2012. In approximately 7 of the 23 years, equities, private equity, and real estate account for slightly more than 60%, while for the rest of the time, the combined percentage is slightly less.

41 Many target-date funds continue to offer a "2005" vintage that would have been marketed/sold to people retiring in 2005.

Exhibit 45 Global Market Portfolio, 1990 to 2012



Source: Doeswijk, Lam, and Swinkels (2014).

The endowment model. An approach to asset allocation that emphasizes large allocations to non-traditional investments, including equity-oriented investments driven by investment manager skill (e.g., private equities), has come to be known as the endowment model or Yale model. The label "Yale model" reflects the fact that the Yale University Investments Office under David Swensen pioneered the approach in the 1990s; the label "endowment model" reflects the influence of this approach among US university endowments. Swensen (2009) stated that most investors should not pursue the Yale model but should instead embrace a simpler asset allocation implemented with low-cost funds. Besides high allocations to non-traditional assets and a commitment to active management, the approach characteristically seeks to earn illiquidity premiums, which endowments with long time horizons are well positioned to capture. Exhibit 46, showing the Yale endowment asset allocation, makes these points. In the exhibit, "absolute return" indicates investment in event-driven and value-driven strategies.

Exhibit 46 Yale University Endowment Asset Allocation as of June 2014

	Yale University	US Educational Institution Mean
Absolute return	17.4%	23.3%
Domestic equity	3.9	19.3
Fixed income	4.9	9.3
Foreign equity	11.5	22.0
Natural resources	8.2	8.5
Private equity	33.0	10.0
Real estate	17.6	4.2
Cash	3.5	3.5

Source: Yale University (2014, p. 13).

In almost diametrical contrast to the endowment model is the asset allocation approach of Norway's Government Pension Fund Global (Statens pensjonsfond Utland), often called the Norway model.[42] This model's asset allocation is highly committed to passive investment in publicly traded securities (subject to environmental, social, and governance [ESG] concerns), reflecting a belief in the market's informational efficiency. Since 2009, the asset allocation has followed an approximate 60/40 stock/bond mix.

Risk parity. A risk parity asset allocation is based on the notion that each asset (asset class or risk factor) should contribute equally to the total risk of the portfolio for a portfolio to be well diversified. Recall that in Section 2, we identified various criticisms and potential shortcomings of mean–variance optimization, one of which was that, while the resulting asset allocations may appear diversified across assets, the sources of risk may not be diversified. In the section on risk budgeting, Exhibit 19 contained a risk decomposition of a reverse-optimization-based asset allocation from a United Kingdom–based investor. There, we noted that the overall equity/fixed income split was approximately 54% equities and 46% fixed income, yet of the 10% standard deviation, approximately 74% of the risk came from equities while only 26% came from fixed income.

Risk parity is a relatively controversial approach. Although there are several variants, the most common risk parity approach has the following mathematical form:

$$w_i \times \mathrm{Cov}(r_i, r_P) = \frac{1}{n}\sigma_P^2 \quad (3)$$

where

w_i = the weight of asset i

$\mathrm{Cov}(r_i, r_P)$ = the covariance of asset i with the portfolio

n = the number of assets

σ_P^2 = the variance of the portfolio

In general, there is not a closed-form solution to the problem, and it must be solved using some form of optimization (mathematical programming). Prior to Markowitz's development of mean–variance optimization, which simultaneously considered both risk and return, most asset allocation approaches focused only on return *and ignored risk* (or accounted for it in an ad hoc manner). The primary criticism of risk parity is that it makes the opposite mistake: It *ignores expected returns*. In general, most of the rules-based risk approaches—such as other forms of volatility weighting, minimum volatility, and target volatility—suffer from this shortcoming.

With risk parity, the contribution to risk is highly dependent on the formation of the opportunity set. For example, if the opportunity set consists of seven equity asset classes and three fixed-income asset classes, intuitively, 70% of risk will come from the equities and 30% of risk will come from fixed income. Conversely, if the opportunity set consists of three equity asset classes and seven fixed-income asset classes, intuitively, 70% of risk will come from fixed income and 30% of risk will come from equities. The point is that practitioners of risk parity must be very cognizant of the formation of their opportunity set.

Exhibit 47 gives a US-centric example consisting of five equity asset classes and three fixed-income asset classes. A constrained optimization routine (weights must sum to 100%) was used to determine the weight to each asset class, such that all asset classes contributed the same amount to total risk. In this case, each asset class contributed 0.8%, resulting in an asset allocation with a total standard deviation of 6.41%. In this example, 5/8 of total risk comes from equity asset classes and 3/8 comes from fixed-income asset classes. Earlier, we explained that reverse optimization can be used

42 See Curtis (2012).

to infer the expected return of any set of presumed efficient weights. In Exhibit 47, based on a total market risk premium of 2.13% and a risk-free rate of 3%, we inferred the reverse-optimized total returns (final column). In this case, these seem to be relatively reasonable expected returns.

Exhibit 47 Risk Parity Portfolio Weights and Risk-Budgeting Statistics Based on Reverse-Optimized Returns

Asset Class	Weight	Marginal Contribution to Total Risk (MCTR)	ACTR	Percentage Contribution to Total Standard Deviation	Reverse-Optimized Total Returns
US large-cap equities	7.7%	10.43%	0.80%	12.50%	6.47%
US mid-cap equities	6.1	13.03	0.80	12.50	7.33
US small-cap equities	5.9	13.61	0.80	12.50	7.52
Non-US developed market equities	5.6	14.38	0.80	12.50	7.78
Emerging market equities	4.5	17.74	0.80	12.50	8.89
Non-US bonds	15.5	5.17	0.80	12.50	4.72
US TIPS	23.9	3.36	0.80	12.50	4.12
US bonds	30.8	2.60	0.80	12.50	3.86
Total	100.0%		6.41%	100.00%	5.13%

After deriving a risk parity–based asset allocation, the next step in the process is to borrow (use leverage) or to lend (save a portion of wealth, presumably in cash) so that the overall portfolio corresponds to the investor's risk appetite. Continuing with our example, the market risk premium is 2.13% (above the assumed risk-free rate of 3%) and the market variance is 0.41% (i.e., 6.41% squared); thus, the implied market trade-off of expected return (in excess of the risk-free rate) for risk is 2.13% divided by 0.41%, which equals approximately 5.2. Investors with a greater appetite for risk than the market as a whole would borrow money to lever up the risk parity portfolios, while investors with a lower appetite for risk would invest a portion of their wealth in cash.

Back tests of levered risk parity portfolios have produced promising results, although critics of these back tests argue that they suffer from look-back bias and are very dependent on the ability to use extremely large amounts of leverage at low borrow rates (which may not have been feasible); see, for example, Anderson, Bianchi, and Goldberg (2012). Proponents of risk parity have suggested that the idea of "leverage aversion" contributes to the success of the strategy. Black (1972) suggested that restrictions on leverage and a general aversion to leverage may cause return-seeking investors to pursue higher-returning assets, such as stocks. All else equal, this behavior would reduce the price of bonds, thus allowing the investor to buy bonds at a small discount, hold them to maturity, and realize the full value of the bond. Asness, Frazzini, and Pedersen (2012) have offered this idea as a potential explanation for why a levered (bond-centric) asset allocation might outperform an equity-centric asset allocation with equivalent or similar risk.

The 1/N rule. One of the simplest asset allocation heuristics involves equally weighting allocations to assets. DeMiguel, Garlappi, and Uppal (2009) define an approach in which $1/N$ of wealth is allocated to each of N assets available for investment at each rebalancing date. Calendar rebalancing to equal weighting at quarterly intervals is one common rebalancing discipline used. By treating all assets as indistinguishable in terms of mean returns, volatility, and correlations, in principle, $1/N$ rule portfolios should be dominated by methods that optimize asset class weights to exploit differences in investment characteristics. In empirical studies comparing approaches, however, the $1/N$ rule has been found to perform considerably better, based on Sharpe ratios and certainty equivalents, than theory might suggest. One possible explanation is that the $1/N$ rule sidesteps problems caused by optimizing when there is estimation error in inputs.

PORTFOLIO REBALANCING IN PRACTICE

6

The reading "Introduction to Asset Allocation" provided an introduction to rebalancing, including some detailed comments on strategic considerations. This section aims to present useful additional insight and information.

Meanings of "Rebalancing"

Rebalancing has been defined as the discipline of adjusting portfolio weights to more closely align with the strategic asset allocation. In that sense, rebalancing includes policy regarding the correction of any drift away from strategic asset allocation weights resulting from market price movements and the passage of time for finite-lived assets, such as bonds. In liability-relative asset allocation, adjusting a liability-hedging portfolio to account for changes in net duration exposures from the passage of time, for example, would fall under the rubric of rebalancing.

Some use the term "rebalancing" more expansively, to include the combined effects on asset class weights not only of rebalancing in the above sense but also of active allocation activities. In that sense, rebalancing would include tactical allocations. Although rebalancing policy can be established to accommodate tactical adjustments, tactical asset allocation per se is not covered under "rebalancing" as the term is used here.

Changes in asset allocation weights in response to changes in client circumstances, goals, or other client factors are sometimes also referred to as "rebalancing" (especially if the adjustments are minor). These activities fall under the scope of client monitoring and asset allocation review, as described elsewhere in the CFA curriculum.

An appropriate rebalancing policy involves a weighing of benefits and costs. Benefits depend on the idea that if an investor's strategic asset allocation is optimal, then any divergence in the portfolio from that asset allocation represents an expected utility loss to the investor. Rebalancing benefits the investor by reducing the present value of expected losses from not tracking the optimum. In theory, the basic cost of not rebalancing is this present value of expected utility losses from straying from the optimum.[43]

Apart from the above considerations of trade-offs, disciplined rebalancing has tended to reduce risk while incrementally adding to returns. Several interpretations of this empirical finding have been offered, including the following:

- *Rebalancing earns a diversification return*. The compound growth rate of a portfolio is greater than the weighted average compound growth rates of the component portfolio holdings (given positive expected returns and positive asset

43 See Leland (2000).

weights). Given sufficiently low transaction costs, this effect leads to what has been called a *diversification return* to frequent rebalancing to a well-diversified portfolio.[44]

- *Rebalancing earns a return from being short volatility*. In the case of a portfolio consisting of a risky asset and a risk-free asset, the return to a rebalanced portfolio can be replicated by creating a buy-and-hold position in the portfolio, writing out-of-the-money puts and calls on the risky asset, and investing the premiums in risk-free bonds.[45] As the value of puts and calls is positively related to volatility, such a position is called being short volatility (or being short gamma, by reference to the option Greeks).

Practice appears not to have produced a consensus on the most appropriate rebalancing discipline. Introduction to Asset Allocation defined and discussed calendar rebalancing[46]—sometimes mentioned as common in portfolios managed for individual investors—and percent-range rebalancing. Calendar rebalancing involves lower overhead because of lower monitoring costs. Percent-range rebalancing is a more disciplined risk control policy, however, because it makes rebalancing contingent on market movements. Without weighing costs and benefits in the abstract, Exhibit 48 assumes percent-range rebalancing and summarizes the effects of each of several key factors on the corridor width of an asset class, holding all else equal, except for the factor of the asset class's own volatility.[47] For taxable investors, transactions trigger capital gains in jurisdictions that tax them; therefore, for such investors, higher tax rates on capital gains should also be associated with wider corridors.

Exhibit 48 Factors Affecting the Optimal Corridor Width of an Asset Class

Factor	Effect on Optimal Width of Corridor (All Else Equal)	Intuition
Factors Positively Related to Optimal Corridor Width		
Transaction costs	The higher the transaction costs, the wider the optimal corridor.	High transaction costs set a high hurdle for rebalancing benefits to overcome.
Risk tolerance	The higher the risk tolerance, the wider the optimal corridor.	Higher risk tolerance means less sensitivity to divergences from the target allocation.
Correlation with the rest of the portfolio	The higher the correlation, the wider the optimal corridor.	When asset classes move in sync, further divergence from target weights is less likely.
Factors Inversely Related to Optimal Corridor Width		
Volatility of the rest of the portfolio	The higher the volatility, the narrower the optimal corridor.	Higher volatility makes large divergences from the strategic asset allocation more likely.

Among positive factors, the cases of transaction costs and risk tolerance are obvious. Transaction costs can be reduced to the extent that portfolio cash flows can be used to rebalance. The case of correlation is less obvious. Because of correlations, the rebalancing triggers among different asset classes are linked.

44 See Willenbrock (2011). This phenomenon was called *rebalancing return* by Mulvey and Kim (2009). Luenberger (2013) suggests that the phenomenon could be exploited by a strategy of buying high-volatility assets and rebalancing often, a process he called *volatility pumping*.
45 As shown in Ang (2014, pp. 135–139).
46 Rebalancing a portfolio to target weights on a periodic basis—for example, monthly, quarterly, semi-annually, or annually.
47 See Masters (2003).

Consider correlation in a two–asset class scenario. Suppose one asset class is above its target weight, so the other asset class is below its target weight. A further increase in the value of the overweight asset class implies, on average, a smaller divergence in the asset mix if the asset classes' returns are more highly positively correlated (because the denominator in computing the overweight asset class's weight is the sum of the values of the two asset classes). In a multi-asset-class scenario, all pair-wise asset class correlations would need to be considered, making the interpretation of correlations complex. To expand the application of the two-asset case's intuition, one simplification involves considering the balance of a portfolio to be a single hypothetical asset and computing an asset class's correlation with it.

As indicated in Exhibit 48, the higher the volatility of the rest of the portfolio, excluding the asset class being considered, the more likely a large divergence from the strategic asset allocation becomes. That consideration should point to a narrower optimal corridor, all else being equal.

In the case of an asset class's own volatility, "holding all else equal" is not practically meaningful. If rebalancing did not involve transaction costs, then higher volatility would lead to a narrower corridor, all else equal, for a risk-averse investor.[48] Higher volatility implies that if an asset class is not brought back into the optimal range after a given move away from it, the chance of an even further divergence from optimal is greater. In other words, higher volatility makes large divergence from the strategic asset allocation more likely. However, reducing a corridor's width means more frequent rebalancing and higher transaction costs. Thus, the effect of volatility on optimal corridor width involves a trade-off between controlling transaction costs and controlling risk. Conclusions also depend on the assumptions made about asset price return dynamics.

In practice, corridor width is often specified to be proportionally greater, the higher an asset class's volatility, with a focus on transaction cost control. In *volatility-based rebalancing*, corridor width is set proportionally to the asset class's own volatility. In one variation of *equal probability rebalancing* (McCalla 1997), the manager specifies a corridor for each asset class in terms of a common multiple of the standard deviation of the asset class's returns such that, under a normal probability assumption, each asset class is equally likely to trigger rebalancing.

EXAMPLE 12

Tolerance Bands for an Asset Allocation

An investment committee is reviewing the following strategic asset allocation:

Domestic equities 50% ± 5% (i.e., 45% to 55% of portfolio value)

International equities 15% ± 1.5%

Domestic bonds 35% ± 3.5%

The market for the domestic bonds is relatively illiquid. The committee views the above corridors as appropriate *if* each asset class's risk and transaction cost characteristics remain unchanged. The committee now wants to account for differences among the asset classes in setting the corridors.

Evaluate the implications of the following sets of facts for the stated tolerance bands, given an all-else-equal assumption in each case:

1 Tax rates for international equities increase by 10 percentage points.

48 As in Masters (2003).

2 Transaction costs in international equities increase by 20% relative to domestic equities, but the correlation of international equities with domestic equities and bonds declines. What is the expected effect on the tolerance band for international equities?

3 The volatility of domestic bonds increases. What is the expected effect on their tolerance band? Assume that domestic bonds are relatively illiquid.

Solution to 1:

The tolerance band for international equities should increase if the entity is a taxable investor.

Solution to 2:

Increased transaction costs point to widening the tolerance band for international equities, but declining correlations point to narrowing it. The overall effect is indeterminate.

Solution to 3:

Given that the market for domestic bonds is relatively illiquid, the increase in volatility suggests widening the rebalancing band. Containing transaction costs is more important than the expected utility losses from allowing a larger divergence from the strategic asset allocation.

One decision involved in rebalancing policy is whether to adjust asset class holdings to their target proportions, to the limits of the corridors, or to within the corridors but not to target weights. Compared with rebalancing to target weights, rebalancing to the upper or lower limit of the allowed range results in less close alignment with target proportions but lower transaction costs—an especially important consideration in the case of relatively illiquid assets. The choice among alternatives may be influenced by judgmental tactical considerations.

Because one rebalancing decision affects later rebalancing decisions, the optimal rebalancing decisions at different points in time are linked. However, optimal rebalancing in a multi-period, multi-asset case is an unsolved problem.

The analysis of Dybvig (2005) suggests that fixed transaction costs favor rebalancing to the target weights and variable transaction costs favor rebalancing to the nearest corridor border (the interior of the corridor being therefore a "no trade zone"). A number of studies have contrasted rebalancing to target weights and rebalancing to the allowed range based on particular asset classes, time periods, and measures of the benefits of rebalancing. These studies have reached a variety of conclusions, suggesting that no simple, empirically based advice can be provided.

Rebalancing in a Goals-Based Approach

The use of probability- and horizon-adjusted discount rates to size the various goal-defeasing sub-portfolios means that portfolios will usually produce returns that are higher than assumed. Thus, as time passes, the dollars allocated to the various sub-portfolios—other than labeled-goal portfolios—may be expected to exceed the actual requirements. For example, in average markets, returns should exceed the conservative requirements of a goal associated with a 90% required probability of success. Sub-portfolios with shorter time horizons for goals with high required probabilities of success will tend to contain relatively low-risk assets, whereas riskier assets may have high allocations in longer-horizon portfolios for goals with lower required probabilities of success. Thus, there is a greater chance that the exposure to lower-risk assets will creep up before one experiences the same for riskier assets. Thus, failing to rebalance the portfolio will gradually move it down the risk axis—and the defined efficient frontier—and thus lead the client to take less risk than he or she can bear.

CONCLUSIONS

7

This reading has surveyed how appropriate asset allocations can be determined to meet the needs of a variety of investors. Among the major points made have been the following:

- The objective function of asset-only mean–variance optimization is to maximize the expected return of the asset mix minus a penalty that depends on risk aversion and the expected variance of the asset mix.
- Criticisms of MVO include the following:
  - The outputs (asset allocations) are highly sensitive to small changes in the inputs.
  - The asset allocations are highly concentrated in a subset of the available asset classes.
  - Investors are often concerned with characteristics of asset class returns such as skewness and kurtosis that are not accounted for in MVO.
  - While the asset allocations may appear diversified across assets, the sources of risk may not be diversified.
  - MVO allocations may have no direct connection to the factors affecting any liability or consumption streams.
  - MVO is a single-period framework that tends to ignore trading/rebalancing costs and taxes.
- Deriving expected returns by reverse optimization or by reverse optimization tilted toward an investor's views on asset returns (the Black–Litterman model) is one means of addressing the tendency of MVO to produce efficient portfolios that are not well diversified.
- Placing constraints on asset class weights to prevent extremely concentrated portfolios and resampling inputs are other ways of addressing the same concern.
- For some relatively illiquid asset classes, a satisfactory proxy may not be available; including such asset classes in the optimization may therefore be problematic.
- Risk budgeting is a means of making optimal use of risk in the pursuit of return. A risk budget is optimal when the ratio of excess return to marginal contribution to total risk is the same for all assets in the portfolio.
- Characteristics of liabilities that affect asset allocation in liability-relative asset allocation include the following:
  - Fixed versus contingent cash flows
  - Legal versus quasi-liabilities
  - Duration and convexity of liability cash flows
  - Value of liabilities as compared with the size of the sponsoring organization
  - Factors driving future liability cash flows (inflation, economic conditions, interest rates, risk premium)
  - Timing considerations, such longevity risk

- Regulations affecting liability cash flow calculations

- Approaches to liability-relative asset allocation include surplus optimization, a hedging/return-seeking portfolios approach, and an integrated asset–liability approach.
  - Surplus optimization involves MVO applied to surplus returns.
  - A hedging/return-seeking portfolios approach assigns assets to one of two portfolios. The objective of the hedging portfolio is to hedge the investor's liability stream. Any remaining funds are invested in the return-seeking portfolio.
  - An integrated asset–liability approach integrates and jointly optimizes asset and liability decisions.
- A goals-based asset allocation process combines into an overall portfolio a number of sub-portfolios, each of which is designed to fund an individual goal with its own time horizon and required probability of success.
- In the implementation, there are two fundamental parts to the asset allocation process. The first centers on the creation of portfolio modules, while the second relates to the identification of client goals and the matching of these goals to the appropriate sub-portfolios to which suitable levels of capital are allocated.
- Other approaches to asset allocation include "120 minus your age," 60/40 stocks/bonds, the endowment model, risk parity, and the 1/*N* rule.
- Disciplined rebalancing has tended to reduce risk while incrementally adding to returns. Interpretations of this empirical finding include that rebalancing earns a diversification return, that rebalancing earns a return from being short volatility, and that rebalancing earns a return to supplying liquidity to the market.
- Factors positively related to optimal corridor width include transaction costs, risk tolerance, and an asset class's correlation with the rest of the portfolio. The higher the correlation, the wider the optimal corridor, because when asset classes move in sync, further divergence from target weights is less likely.
- The volatility of the rest of the portfolio (outside of the asset class under consideration) is inversely related to optimal corridor width.
- An asset class's own volatility involves a trade-off between transaction costs and risk control. The width of the optimal tolerance band increases with transaction costs for volatility-based rebalancing.

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PRACTICE PROBLEMS

The following information relates to questions 1–8

Megan Beade and Hanna Müller are senior analysts for a large, multi-divisional money management firm. Beade supports the institutional portfolio managers, and Müller does the same for the private wealth portfolio managers.

Beade reviews the asset allocation in Exhibit 1, derived from a mean–variance optimization (MVO) model for an institutional client, noting that details of the MVO are lacking.

Exhibit 1 Asset Allocation and Market Weights (in percent)

Asset Classes	Asset Allocation	Investable Global Market Weights
Cash	0	—
US bonds	30	17
US TIPS	0	3
Non-US bonds	0	22
Emerging market equity	25	5
Non-US developed equity	20	29
US small- and mid-cap equity	25	4
US large-cap equity	0	20

The firm's policy is to rebalance a portfolio when the asset class weight falls outside of a corridor around the target allocation. The width of each corridor is customized for each client and proportional to the target allocation. Beade recommends wider corridor widths for high-risk asset classes, narrower corridor widths for less liquid asset classes, and narrower corridor widths for taxable clients with high capital gains tax rates.

One client sponsors a defined benefit pension plan where the present value of the liabilities is \$241 million and the market value of plan assets is \$205 million. Beade expects interest rates to rise and both the present value of plan liabilities and the market value of plan assets to decrease by \$25 million, changing the pension plan's funding ratio.

Beade uses a surplus optimization approach to liability-relative asset allocation based on the objective function

$$U_m^{LR} = E\left(R_{s,m}\right) - 0.005\lambda\sigma^2\left(R_{s,m}\right)$$

where $E(R_{s,m})$ is the expected surplus return for portfolio m, λ is the risk aversion coefficient, and $\sigma^2(R_{s,m})$ is the variance of the surplus return. Beade establishes the expected surplus return and surplus variance for three different asset allocations, shown in Exhibit 2. Given $\lambda = 1.50$, she chooses the optimal asset mix.

Exhibit 2 Expected Surplus Return and Volatility for Three Portfolios

	Return	Standard Deviation
Portfolio 1	13.00%	24%
Portfolio 2	12.00%	18%
Portfolio 3	11.00%	19%

Client Haunani Kealoha has a large fixed obligation due in 10 years. Beade assesses that Kealoha has substantially more funds than are required to meet the fixed obligation. The client wants to earn a competitive risk-adjusted rate of return while maintaining a high level of certainty that there will be sufficient assets to meet the fixed obligation.

In the private wealth area, the firm has designed five subportfolios with differing asset allocations that are used to fund different client goals over a five-year horizon. Exhibit 3 shows the expected returns and volatilities of the subportfolios and the probabilities that the subportfolios will exceed an expected minimum return. Client Luis Rodríguez wants to satisfy two goals. Goal 1 requires a conservative portfolio providing the highest possible minimum return that will be met at least 95% of the time. Goal 2 requires a riskier portfolio that provides the highest minimum return that will be exceeded at least 85% of the time.

Exhibit 3 Characteristics of Subportfolios

Subportfolio	A	B	C	D	E
Expected return, in percent	4.60	5.80	7.00	8.20	9.40
Expected volatility, in percent	3.46	5.51	8.08	10.80	13.59
Required Success Rate	**Minimum Expected Return for Success Rate**				
99%	1.00	0.07	–1.40	–3.04	–4.74
95%	2.05	1.75	1.06	0.25	–0.60
90%	2.62	2.64	2.37	2.01	1.61
85%	3.00	3.25	3.26	3.19	3.10
75%	3.56	4.14	4.56	4.94	5.30

Müller uses a risk parity asset allocation approach with a client's four–asset class portfolio. The expected return of the domestic bond asset class is the lowest of the asset classes, and the returns of the domestic bond asset class have the lowest covariance with other asset class returns. Müller estimates the weight that should be placed on domestic bonds.

Müller and a client discuss other approaches to asset allocation that are not based on optimization models or goals-based models. Müller makes the following comments to the client:

Comment 1 An advantage of the "120 minus your age" heuristic over the 60/40 stock/bond heuristic is that it incorporates an age-based stock/bond allocation.

Comment 2 The Yale model emphasizes traditional investments and a commitment to active management.

Comment 3 A client's asset allocation using the 1/*N* rule depends on the investment characteristics of each asset class.

1 The asset allocation in Exhibit 1 *most likely* resulted from a mean–variance optimization using:

A historical data.

B reverse optimization.

C Black–Litterman inputs.

2 For clients concerned about rebalancing-related transactions costs, which of Beade's suggested changes in the corridor width of the rebalancing policy is correct? The change with respect to:

A high-risk asset classes.

B less liquid asset classes.

C taxable clients with high capital gains tax rates.

3 Based on Beade's interest rate expectations, the pension plan's funding ratio will:

A decrease.

B remain unchanged.

C increase.

4 Based on Exhibit 2, which portfolio provides the greatest objective function expected value?

A Portfolio 1

B Portfolio 2

C Portfolio 3

5 The asset allocation approach most appropriate for client Kealoha is *best* described as:

A a surplus optimization approach.

B an integrated asset–liability approach.

C a hedging/return-seeking portfolios approach.

6 Based on Exhibit 3, which subportfolios *best* meet the two goals expressed by client Rodríguez?

A Subportfolio A for Goal 1 and Subportfolio C for Goal 2

B Subportfolio B for Goal 1 and Subportfolio C for Goal 2

C Subportfolio E for Goal 1 and Subportfolio A for Goal 2

7 In the risk parity asset allocation approach that Müller uses, the weight that Müller places on domestic bonds should be:

A less than 25%.

B equal to 25%.

C greater than 25%.

8 Which of Müller's comments about the other approaches to asset allocation is correct?

A Comment 1

B Comment 2

C Comment 3

The following information relates to questions 9–13

Investment adviser Carl Monteo determines client asset allocations using quantitative techniques such as mean–variance optimization (MVO) and risk budgets. Monteo is reviewing the allocations of three clients. Exhibit 1 shows the expected return and standard deviation of returns for three strategic asset allocations that apply to several of Monteo's clients.

Exhibit 1 Strategic Asset Allocation Alternatives

	Adviser's Forecasts	
Asset Allocation	**Expected Return (%)**	**Standard Deviation of Returns (%)**
A	10	12.0
B	8	8.0
C	6	2.0

Monteo interviews client Mary Perkins and develops a detailed assessment of her risk preference and capacity for risk, which is needed to apply MVO to asset allocation. Monteo estimates the risk aversion coefficient (λ) for Perkins to be 8 and uses the following utility function to determine a preferred asset allocation for Perkins:

$$U_m = E(R_m) - 0.005\lambda\sigma_m^2$$

Another client, Lars Velky, represents Velky Partners (VP), a large institutional investor with \$500 million in investable assets. Velky is interested in adding less liquid asset classes, such as direct real estate, infrastructure, and private equity, to VP's portfolio. Velky and Monteo discuss the considerations involved in applying many of the common asset allocation techniques, such as MVO, to these asset classes. Before making any changes to the portfolio, Monteo asks Velky about his knowledge of risk budgeting. Velky makes the following statements:

Statement 1 An optimum risk budget minimizes total risk.

Statement 2 Risk budgeting decomposes total portfolio risk into its constituent parts.

Statement 3 An asset allocation is optimal from a risk-budgeting perspective when the ratio of excess return to marginal contribution to risk is different for all assets in the portfolio.

Monteo meets with a third client, Jayanta Chaterji, an individual investor. Monteo and Chaterji discuss mean–variance optimization. Chaterji expresses concern about using the output of MVOs for two reasons:

Criticism 1: The asset allocations are highly sensitive to changes in the model inputs.

Criticism 2: The asset allocations tend to be highly dispersed across all available asset classes.

Monteo and Chaterji also discuss other approaches to asset allocation. Chaterji tells Monteo that he understands the factor-based approach to asset allocation to have two key characteristics:

Characteristic 1	The factors commonly used in the factor-based approach generally have low correlations with the market and with each other.
Characteristic 2	The factors commonly used in the factor-based approach are typically different from the fundamental or structural factors used in multifactor models.

Monteo concludes the meeting with Chaterji after sharing his views on the factor-based approach.

9 Based on Exhibit 1 and the risk aversion coefficient, the preferred asset allocation for Perkins is:

A Asset Allocation A.

B Asset Allocation B.

C Asset Allocation C.

10 In their discussion of the asset classes that Velky is interested in adding to the VP portfolio, Monteo should tell Velky that:

A these asset classes can be readily diversified to eliminate idiosyncratic risk.

B indexes are available for these asset classes that do an outstanding job of representing the performance characteristics of the asset classes.

C the risk and return characteristics associated with actual investment vehicles for these asset classes are typically significantly different from the characteristics of the asset classes themselves.

11 Which of Velky's statements about risk budgeting is correct?

A Statement 1

B Statement 2

C Statement 3

12 Which of Chaterji's criticisms of MVO is/are valid?

A Only Criticism 1

B Only Criticism 2

C Both Criticism 1 and Criticism 2

13 Which of the characteristics put forth by Chaterji to describe the factor-based approach is/are correct?

A Only Characteristic 1

B Only Characteristic 2

C Both Characteristic 1 and Characteristic 2

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14 John Tomb is an investment advisor at an asset management firm. He is developing an asset allocation for James Youngmall, a client of the firm. Tomb considers two possible allocations for Youngmall. Allocation A consists of four asset classes: cash, US bonds, US equities, and global equities. Allocation B includes these same four asset classes, as well as global bonds.

Youngmall has a relatively low risk tolerance with a risk aversion coefficient (λ) of 7. Tomb runs mean–variance optimization (MVO) to maximize the following utility function to determine the preferred allocation for Youngmall:

$$U_m = E(R_m) - 0.005\lambda\sigma_m^2$$

The resulting MVO statistics for the two asset allocations are presented in Exhibit 1.

Exhibit 1 MVO Portfolio Statistics

	Allocation A	Allocation B
Expected return	6.7%	5.9%
Expected standard deviation	11.9%	10.7%

Determine which allocation in Exhibit 1 Tomb should recommend to Youngmall. **Justify** your response.

Determine which allocation in Exhibit 1 Tomb should recommend to Youngmall. (circle one)	
Allocation A	Allocation B

Justify your response.

15 Walker Patel is a portfolio manager at an investment management firm. After successfully implementing mean–variance optimization (MVO), he wants to apply reverse optimization to his portfolio. For each asset class in the portfolio, Patel obtains market capitalization data, betas computed relative to a global market portfolio, and expected returns. This information, along with the MVO asset allocation results, are presented in Exhibit 1.

Exhibit 1 Asset Class Data and MVO Asset Allocation Results

Asset Class	Market Cap (trillions)	Beta	Expected Returns	MVO Asset Allocation
Cash	$4.2	0.0	2.0%	10%
US bonds	$26.8	0.5	4.5%	20%
US equities	$22.2	1.4	8.6%	35%
Global equities	$27.5	1.7	10.5%	20%
Global bonds	$27.1	0.6	4.7%	15%
Total	$107.8			

The risk-free rate is 2.0%, and the global market risk premium is 5.5%.

Contrast, using the information provided above, the results of a reverse optimization approach with that of the MVO approach for each of the following:

i. The asset allocation mix

ii. The values of the expected returns for US equities and global bonds

Justify your response.

16 Viktoria Johansson is newly appointed as manager of ABC Corporation's pension fund. The current market value of the fund's assets is $10 billion, and the present value of the fund's liabilities is $8.5 billion. The fund has historically been managed using an asset-only approach, but Johansson recommends to ABC's board of directors that they adopt a liability-relative approach, specifically the hedging/return-seeking portfolios approach. Johansson assumes that the returns of the fund's liabilities are driven by changes in the returns of index-linked government bonds. Exhibit 1 presents three potential asset allocation choices for the fund.

Exhibit 1 Potential Asset Allocations Choices for ABC Corp's Pension Fund

Asset Class	Allocation 1	Allocation 2	Allocation 3
Cash	15%	5%	0%
Index-linked government bonds	70%	15%	85%
Corporate bonds	0%	30%	5%
Equities	15%	50%	10%
Portfolio Statistics			
Expected return	3.4%	6.2%	3.6%
Expected standard deviation	7.0%	12.0%	8.5%

Determine which asset allocation in Exhibit 1 would be *most appropriate* for Johansson given her recommendation. **Justify** your response.

Determine which asset allocation in Exhibit 1 would be *most appropriate* for Johansson given her recommendation. **(circle one)**		
Allocation 1	Allocation 2	Allocation 3

Justify your response.

The following information relates to Questions 17 and 18

Mike and Kerry Armstrong are a married couple who recently retired with total assets of $8 million. The Armstrongs meet with their financial advisor, Brent Abbott, to discuss three of their financial goals during their retirement.

Goal 1: An 85% chance of purchasing a vacation home for $5 million in five years.

Goal 2: A 99% chance of being able to maintain their current annual expenditures of $100,000 for the next 10 years, assuming annual inflation of 3% from Year 2 onward.

Goal 3: A 75% chance of being able to donate $10 million to charitable foundations in 25 years.

Abbott suggests using a goals-based approach to construct a portfolio. He develops a set of sub-portfolio modules, presented in Exhibit 1. Abbott suggests investing any excess capital in Module A.

Exhibit 1 "Highest Probability- and Horizon-Adjusted Return" Sub-Portfolio Modules under Different Horizon and Probability Scenarios

	A	B	C	D
Portfolio Characteristics				
Expected return	6.5%	7.9%	8.5%	8.8%
Expected volatility	6.0%	7.7%	8.8%	9.7%
	Annualized Minimum Expectation Returns			
Time Horizon	**5 Years**			
Required Success				
99%	0.3%	–0.1%	–0.7%	–1.3%
85%	3.7%	4.3%	4.4%	4.3%
75%	4.7%	5.6%	5.8%	5.9%
Time Horizon	**10 Years**			
Required Success				
99%	2.1%	2.2%	2.0%	1.7%
85%	4.5%	5.4%	5.6%	5.6%
75%	5.2%	6.3%	6.6%	6.7%
Time Horizon	**25 Years**			
Required Success				
99%	3.7%	4.3%	4.4%	4.3%
85%	5.3%	6.3%	6.7%	6.8%
75%	5.7%	6.9%	7.3%	7.5%

17 **Select**, for each of Armstrong's three goals, which sub-portfolio module from Exhibit 1 Abbott should choose in constructing a portfolio. **Justify** each selection.

Select, for each of Armstrong's three goals, which sub-portfolio module from Exhibit 1 Abbott should choose in constructing a portfolio.
(circle one module for each goal)

Goal 1	Goal 2	Goal 3
Module A	Module A	Module A
Module B	Module B	Module B
Module C	Module C	Module C
Module D	Module D	Module D

Justify each selection.

18 **Construct** the overall goals-based asset allocation for the Armstrongs given their three goals and Abbott's suggestion for investing any excess capital. **Show** your calculations.

Construct the overall goals-based asset allocation for the Armstrongs given their three goals and Abbott's suggestion for investing any excess capital.
(insert the percentage of the total assets to be invested in each module)

Module A	Module B	Module C	Module D

Show your calculations.

SOLUTIONS

1 A is correct. The allocations in Exhibit 1 are most likely from an MVO model using historical data inputs. MVO tends to result in asset allocations that are concentrated in a subset of the available asset classes. The allocations in Exhibit 1 have heavy concentrations in four of the asset classes and no investment in the other four asset classes, and the weights differ greatly from global market weights. Compared to the use of historical inputs, the Black–Litterman and reverse-optimization models most likely would be less concentrated in a few asset classes and less distant from the global weights.

2 A is correct. Theoretically, higher-risk assets would warrant a narrow corridor because high-risk assets are more likely to stray from the desired strategic asset allocation. However, narrow corridors will likely result in more frequent rebalancing and increased transaction costs, so in practice corridor width is often specified to be proportionally greater the higher the asset class's volatility. Thus, higher-risk assets should have a wider corridor to avoid frequent, costly rebalancing costs. Her other suggestions are not correct. Less-liquid asset classes should have a wider, not narrower, corridor width. Less-liquid assets should have a wider corridor to avoid frequent rebalancing costs. For taxable investors, transactions trigger capital gains in jurisdictions that tax them. For such investors, higher tax rates on capital gains should be associated with wider (not narrower) corridor widths.

3 A is correct. The original funding ratio is the market value of assets divided by the present value of liabilities. This plan's ratio is \$205 million/\$241 million = 0.8506. When the assets and liabilities both decrease by \$25 million, the funding ratio will decrease to \$180 million/\$216 million = 0.8333.

4 B is correct. The objective function expected value is $U_m^{LR} = E\left(R_{s,m}\right) - 0.005\lambda\sigma^2\left(R_{s,m}\right)$. λ is equal to 1.5, and the expected value of the objective function is shown in the rightmost column below.

Portfolio	***E*(*R*$_s$,*m*)**	**$\sigma^2(R_{s,m})$**	**$U_m^{LR} = E(R_{s,m}) - 0.005(1.5)\sigma^2(R_{s,m})$**
1	13.00	576	8.68
2	12.00	324	9.57
3	11.00	361	8.29

Portfolio 2 generates the highest value, or utility, in the objective function.

5 C is correct. The hedging/return-seeking portfolios approach is best for this client. Beade should construct two portfolios, one that includes riskless bonds that will pay off the fixed obligation in 10 years and the other a risky portfolio that earns a competitive risk-adjusted return. This approach is a simple two-step process of hedging the fixed obligation and then investing the balance of the assets in a return-seeking portfolio.

6 A is correct. Goal 1 requires a success rate of at least 95%, and Subportfolio A has the highest minimum expected return (2.05%) meeting this requirement. Goal 2 requires the highest minimum expected return that will be achieved 85% of the time. Subportfolio C meets this requirement (and has a minimum expected return of 3.26%).

7 C is correct. A risk parity asset allocation is based on the notion that each asset class should contribute equally to the total risk of the portfolio. Bonds have the lowest risk level and must contribute 25% of the portfolio's total risk, so bonds must be overweighted (greater than 25%). The equal contribution of each asset class is calculated as:

$$w_i \times \text{Cov}\left(r_i, r_p\right) = \frac{1}{n}\sigma_p^2$$

where

w_i = weight of asset i
$\text{Cov}(r_i,r_p)$ = covariance of asset i with the portfolio
n = number of assets
σ_p^2 = variance of the portfolio

In this example, there are four asset classes, and the variance of the total portfolio is assumed to be 25%; therefore, using a risk parity approach, the allocation to each asset class is expected to contribute (1/4 × 25%) = 6.25% of the total variance. Because bonds have the lowest covariance, they must have a higher relative weight to achieve the same contribution to risk as the other asset classes.

8 A is correct. Comment 1 is correct because the "120 minus your age" rule reduces the equity allocation as the client ages, while the 60/40 rule makes no such adjustment. Comments 2 and 3 are not correct. The Yale model emphasizes investing in alternative assets (such as hedge funds, private equity, and real estate) as opposed to investing in traditional asset classes (such as stock and bonds). The 1/*N* rule allocates an equal weight to each asset without regard to its investment characteristics, treating all assets as indistinguishable in terms of mean returns, volatility, and correlations.

9 C is correct. The risk aversion coefficient (λ) for Mary Perkins is 8. The utility of each asset allocation is calculated as follows:

Asset Allocation A:

$$U_A = 10.0\% - 0.005(8)(12\%)^2$$
$$= 4.24\%$$

Asset Allocation B:

$$U_B = 8.0\% - 0.005(8)(8\%)^2$$
$$= 5.44\%$$

Asset Allocation C:

$$U_C = 6.0\% - 0.005(8)(2\%)^2$$
$$= 5.84\%$$

Therefore, the preferred strategic allocation is Asset Allocation C, which generates the highest utility given Perkins's level of risk aversion.

10 C is correct. Less liquid asset classes—such as direct real estate, infrastructure, and private equity—represent unique challenges when applying many of the common asset allocation techniques. Common illiquid asset classes cannot be readily diversified to eliminate idiosyncratic risk, so representing overall asset class performance is problematic. Furthermore, there are far fewer indexes that attempt to represent aggregate performance for these less liquid asset classes than indexes of traditional highly liquid asset classes. Finally, the risk and return

characteristics associated with actual investment vehicles—such as direct real estate funds, infrastructure funds, and private equity funds—are typically significantly different from the characteristics of the asset classes themselves.

11 B is correct. The goal of risk budgeting is to maximize return per unit of risk. A risk budget identifies the total amount of risk and attributes risk to its constituent parts. An optimum risk budget allocates risk efficiently.

12 A is correct. One common criticism of MVO is that the model outputs, the asset allocations, tend to be highly sensitive to changes in the model. Another common criticism of MVO is that the resulting asset allocations tend to be highly concentrated in a subset of the available asset classes.

13 A is correct. The factors commonly used in the factor-based approach generally have low correlations with the market and with each other. This results from the fact that the factors typically represent what is referred to as a zero (dollar) investment or self-financing investment, in which the underperforming attribute is sold short to finance an offsetting long position in the better-performing attribute. Constructing factors in this manner removes most market exposure from the factors (because of the offsetting short and long positions); as a result, the factors generally have low correlations with the market and with one another. Also, the factors commonly used in the factor-based approach are typically similar to the fundamental or structural factors used in multifactor models.

14

Determine which allocation in Exhibit 1 Tomb should recommend to Youngmall. (circle one)

Allocation A	Allocation B

Justify your response.

- Tomb should recommend Allocation B.
- The expected utility of Allocation B is 1.89%, which is higher than Allocation A's expected utility of 1.74%.

MVO provides a framework to determine how much to allocate to each asset class or to create the optimal asset mix. The given objective function is:

$$U_m = E(R_m) - 0.005\lambda\sigma_m^2$$

Using the given objective function and the expected returns and expected standard deviations for Allocations A and B, the expected utilities (certainty-equivalent returns) for the two allocations are calculated as:

Allocation A: 6.7% – 0.005 (7) (11.9%)^2 = 1.74%

Allocation B: 5.9% – 0.005 (7) (10.7%)^2 = 1.89%

Therefore, Tomb should recommend Allocation B because it results in higher expected utility than Allocation A.

15 **Contrast,** using the information provided above, the results of a reverse optimization approach with that of the MVO approach for each of the following:

i. The asset allocation mix

- ■ The asset allocation weights for the reverse optimization method are inputs into the optimization and are determined by the market capitalization weights of the global market portfolio.

- The asset allocation weights for the MVO method are outputs of the optimization with the expected returns, covariances, and a risk aversion coefficient used as inputs.
- The two methods result in significantly different asset allocation mixes.
- In contrast to MVO, the reverse optimization method results in a higher percentage point allocation to global bonds, US bonds, and global equities as well as a lower percentage point allocation to cash and US equities.

The reverse optimization method takes the asset allocation weights as its inputs that are assumed to be optimal. These weights are calculated as the market capitalization weights of a global market portfolio. In contrast, the outputs of an MVO are the asset allocation weights, which are based on (1) expected returns and covariances that are forecasted using historical data and (2) a risk aversion coefficient. The two methods result in significantly different asset allocation mixes. In contrast to MVO, the reverse optimization method results in a 4.9, 5.5, and 10.1 higher percentage point allocation to US bonds, global equities, and global bonds, respectively, and a 6.1 and 14.4 lower percentage point allocation to cash and US equities, respectively.

The asset allocation under the two methods is as follows:

Asset Class	Market Cap (trillions)	Asset Allocation Weights: Reverse Optimization	MVO Approach	Difference
Cash	\$4.2	3.9%	10%	–6.1%
US bonds	\$26.8	24.9%	20%	4.9%
US equities	\$22.2	20.6%	35%	–14.4%
Global equities	\$27.5	25.5%	20%	5.5%
Global bonds	\$27.1	25.1%	15%	10.1%
Total	\$107.8	100.0%	100.0%	

ii. The values of the expected returns for US equities and global bonds

- For the reverse optimization approach, the expected returns of asset classes are the outputs of optimization with the market capitalization weights, covariances, and the risk aversion coefficient used as inputs.
- In contrast, for the MVO approach, the expected returns of asset classes are inputs to the optimization, with the expected returns generally estimated using historical data.
- The computed values for the expected returns for global bonds and US equities using the reverse optimization method are 5.3% and 9.7%, respectively.
- In contrast, the expected return estimates used in the MVO approach from Exhibit 1 for global bonds and US equities are 4.7% and 8.6%, respectively.

The output of the reverse optimization method are optimized returns which are viewed as unobserved equilibrium or imputed returns. The equilibrium returns are essentially long-run capital market returns provided by each asset class and are strongly linked to CAPM. In contrast, the expected returns in the MVO approach are generally forecasted based on historical data and are used as inputs along with covariances and the risk aversion coefficient in the optimization. The reverse-optimized returns are calculated using a CAPM approach. The return on an asset class using the CAPM approach is calculated as follows:

Return on Asset Class = Risk-Free Rate + (Beta) (Market Risk Premium)

Therefore, the implied returns for global bonds and US equities are calculated as follows:

Return on Global Bonds = 2.0% + (0.6) (5.5%) = 5.3%

Return on US Equities = 2.0% + (1.4) (5.5%) = 9.7%

The implied equilibrium returns for global bonds and US equities are 5.3% and 9.7%, respectively. These implied returns are above the forecasted returns based on historical data (from Exhibit 1) used as inputs in the MVO approach for global bonds and US equities of 4.7% and 8.6%, respectively.

16

Determine which asset allocation in Exhibit 1 would be *most appropriate* for Johansson given her recommendation.
(circle one)

Allocation 1	Allocation 2	Allocation 3

Justify your response.

- Allocation 3 is most appropriate.
- To fully hedge the fund's liabilities, 85% ($8.5 billion/$10.0 billion) of the fund's assets would be linked to index-linked government bonds.
- Residual $1.5 billion surplus would be invested into a return-seeking portfolio.

The pension fund currently has a surplus of $1.5 billion ($10.0 billion – $8.5 billion). To adopt a hedging/return-seeking portfolios approach, Johansson would first hedge the liabilities by allocating an amount equal to the present value of the fund's liabilities, $8.5 billion, to a hedging portfolio. The hedging portfolio must include assets whose returns are driven by the same factors that drive the returns of the liabilities, which in this case are the index-linked government bonds.

So, Johansson should allocate 85% ($8.5 billion/$10.0 billion) of the fund's assets to index-linked government bonds. The residual $1.5 billion surplus would then be invested into a return-seeking portfolio. Therefore, Allocation 3 would be the most appropriate asset allocation for the fund because it allocates 85% of the fund's assets to index-linked government bonds and the remainder to a return-seeking portfolio consisting of corporate bonds and equities.

17

Select, for each of Armstrong's three goals, which sub-portfolio module from Exhibit 1 Abbott should choose in constructing a portfolio.
(circle one module for each goal)

Goal 1	Goal 2	Goal 3
Module A	Module A	Module A
Module B	Module B	Module B
Module C	Module C	Module C
Module D	Module D	Module D

Justify each selection.

- Module C should be chosen for Goal 1, Module B should be chosen for Goal 2, and Module D should be chosen for Goal 3.
- The module that should be selected for each goal is the one that offers the highest return given the time horizon and required probability of success.

The module that should be selected for each goal is the one that offers the highest return given the time horizon and required probability of success. For Goal 1, which has a time horizon of five years and a required probability of success of 85%, Module C should be chosen because its 4.4% expected return is higher than the expected returns of all the other modules. Similarly, for Goal 2, which has a time horizon of 10 years and a required probability of success of 99%, Module B should be chosen because its 2.2% expected return is higher than the expected returns of all the other modules. Finally, for Goal 3, which has a time horizon of 25 years and a required probability of success of 75%, Module D should be chosen because its 7.5% expected return is higher than the expected returns of all the other modules.

18 Guideline Answer:

- The module that should be selected for each goal is the one that offers the highest return given the time horizon and required probability of success.
- Approximately 16.4%, 12.7%, 50.4%, and 20.5% should be invested in Modules A, B, C, and D, respectively.

The appropriate goals-based allocation for the Armstrongs is as follows:

	Goals			
	1	**2**	**3**	**Surplus**
Horizon (years)	5	10	25	
Probability of success	85%	99%	75%	
Selected module	**C**	**B**	**D**	**A**
Discount rate	4.4%	2.2%	7.5%	
Dollars invested (millions)	\$4.03	\$1.01	\$1.64	\$1.32
As a % of total	**50.4%**	**12.7%**	**20.5%**	**16.4%**

Supporting calculations:

For Goal 1, which has a time horizon of five years and a required probability of success of 85%, Module C should be chosen because its 4.4% expected return is higher than the expected returns of all the other modules. The present value of Goal 1 is calculated as follows:

N = 5, PV = –5,000,000, I/Y = 4.4%; CPT PV = \$4,031,508 (or \$4.03 million)

So, approximately 50.4% of the total assets of \$8 million (= \$4.03 million/\$8.00 million) should be allocated to Module C.

For Goal 2, which has a time horizon of 10 years and a required probability of success of 99%, Module B should be chosen because its 2.2% expected return is higher than the expected returns of all the other modules. The present value of Goal 2 is calculated as follows:

$$PV = \frac{\$100{,}000}{(1.022)^1} + \frac{\$100{,}000(1.03)^1}{(1.022)^2} + \frac{\$100{,}000(1.03)^2}{(1.022)^3} + \cdots + \frac{\$100{,}000(1.03)^9}{(1.022)^{10}}$$

PV = $1,013,670 (or $1.01 million)

So, approximately 12.7% of the total assets of $8 million (= $1.01 million/$8.00 million) should be allocated to Module B.

For Goal 3, which has a time horizon of 25 years and a required probability of success of 75%, Module D should be chosen because its 7.5% expected return is higher than the expected returns of all the other modules. The present value of Goal 3 is calculated as follows:

N = 25, PV = –10,000,000, I/Y = 7.5%; CPT PV = $1,639,791 (or $1.64 million)

So, approximately 20.5% of the total assets of $8 million (= $1.64 million/$8.00 million) should be allocated to Module D.

Finally, the surplus of $1,315,032 (= $8,000,000 – $4,031,508 – $1,013,670 – $1,639,791), representing 16.4% (= $1.32 million/$8.00 million), should be invested in Module A following Abbott's suggestion.

READING

14

Asset Allocation with Real-World Constraints

by Peter Mladina, Brian J. Murphy, CFA, and Mark Ruloff, FSA, EA, CERA

Peter Mladina is at Northern Trust and UCLA (USA). Brian J. Murphy, CFA, is at Willis Towers Watson (USA). Mark Ruloff, FSA, EA, CERA, is at Aon (USA).

LEARNING OUTCOMES

Mastery	The candidate should be able to:
☐	**a.** discuss asset size, liquidity needs, time horizon, and regulatory or other considerations as constraints on asset allocation;
☐	**b.** discuss tax considerations in asset allocation and rebalancing;
☐	**c.** recommend and justify revisions to an asset allocation given change(s) in investment objectives and/or constraints;
☐	**d.** discuss the use of short-term shifts in asset allocation;
☐	**e.** identify behavioral biases that arise in asset allocation and recommend methods to overcome them.

1 INTRODUCTION

This reading illustrates ways in which the asset allocation process must be adapted to accommodate specific asset owner circumstances and constraints. It addresses adaptations to the asset allocation inputs given an asset owner's asset size, liquidity, and time horizon as well as external constraints that may affect the asset allocation choice (Section 2). We also discuss the ways in which taxes influence the asset allocation process for the taxable investor (Section 3). In addition, we discuss the circumstances that should trigger a re-evaluation of the long-term strategic asset allocation (Section 4), when and how an asset owner might want to make short-term shifts in asset allocation (Section 5), and how innate investor behaviors can interfere with successful long-term planning for the investment portfolio (Section 6). Throughout the reading, we illustrate the application of these concepts using a series of hypothetical investors.

2 CONSTRAINTS IN ASSET ALLOCATION

General asset allocation principles assume that all asset owners have equal ability to access the entirety of the investment opportunity set, and that it is merely a matter of finding that combination of asset classes that best meets the wants, needs, and obligations of the asset owner. In practice, however, it is not so simple. An asset owner must consider a number of constraints when modeling and choosing among asset allocation alternatives. Some of the most important are asset size, liquidity needs, taxes, and time horizon. Moreover, regulatory and other external considerations may influence the investment opportunity set or the optimal asset allocation decision.

2.1 Asset Size

The size of an asset owner's portfolio has implications for asset allocation. It may limit the opportunity set—the asset classes accessible to the asset owner—by virtue of the scale needed to invest successfully in certain asset classes or by the availability of investment vehicles necessary to implement the asset allocation.

Economies and diseconomies of scale are perhaps the most important factors relevant to understanding asset size as a constraint. The size of an asset owner's investment pool may be too small—or too large—to capture the returns of certain asset classes or strategies efficiently. Asset owners with larger portfolios can generally consider a broader set of asset classes and strategies. On the one hand, they are more likely to have sufficient governance capacity—sophistication and staff resources—to develop the required knowledge base for the more complex asset classes and investment vehicles. They also have sufficient size to build a diversified portfolio of investment strategies, many of which have substantial minimum investment requirements. On the other hand, some asset owners may have portfolios that are *too* large; their desired minimum investment may exhaust the capacity of active external investment managers in certain asset classes and strategies. Although "too large" and "too small" are not rigidly defined, the following example illustrates the difficulty of investing a very large portfolio. Consider an asset owner with an investment portfolio of US$25 billion who is seeking to make a 5% investment in global small-cap stocks:

- The median total market capitalization of the stocks in the S&P Global SmallCap is approximately US$555 million.
- Assume a small-cap manager operates a 50-stock portfolio and is willing to own 3% of the market cap of any one of its portfolio companies. Their average position size would be US$17 million, and an effective level of assets under management (AUM) would be on the order of US$850 million. Beyond that level, the manager may be forced to expand the portfolio beyond 50 stocks or to hold position sizes greater than 3% of a company's market cap, which could then create liquidity issues for the manager.
- Now, our US$25 billion fund is looking to allocate US$1.25 billion to small-cap stocks (US$25 billion × 5%). They want to diversify this allocation across three or four active managers—a reasonable allocation of governance resources in the context of all of the fund's investment activities. The average allocation per manager is approximately US$300 to US$400 million, which would constitute between 35% and 50% of each manager's AUM. This exposes both the asset owner and the investment manager to an undesirable level of operational risk.

Although many large asset owners have found effective ways to implement a small-cap allocation, this example illustrates some of the issues associated with managing a large asset pool. These include such practical considerations as the number of investment managers that might need to be hired to fulfill an investment allocation and the ability of the asset owner to identify and monitor the required number of managers.

Research has shown that investment managers tend to incur certain disadvantages from increasing scale: Growth in AUM leads to larger trade sizes, incurring greater price impact; capital inflows may cause active investment managers to pursue ideas outside of their core investment theses; and organizational hierarchies may slow down decision making and reduce incentives.[1] Asset *owners,* however, are found to have *increasing* returns to scale, as discussed below.

A study of pension plan size and performance (using data spanning 1990–2008) found that large defined benefit plans outperformed smaller ones by 45–50 basis points per year on a risk-adjusted basis.[2] The gains are derived from a combination of cost savings related to internal management, a greater ability to negotiate fees with external managers, and the ability to support larger allocations to private equity and real estate investments. As fund size increases, the "per participant" costs of a larger governance infrastructure decline and the plan sponsor can allocate resources away from such asset classes as small-cap stocks, which are sensitive to diseconomies of scale, to such other areas as private equity funds or co-investments where they are more likely to realize scale-related benefits.

Whereas owners of large asset pools may achieve these operating efficiencies, scale may also impose obstacles related to the liquidity and trading costs of the underlying asset. Above some size, it becomes difficult to deploy capital effectively in certain active investment strategies. As illustrated in Exhibit 1, owners of very large portfolios may face size constraints in allocating to active equity strategies. The studies referenced earlier noted that these asset owners frequently choose to invest passively in developed equity markets where their size inhibits alpha potential. The asset owner's finite resources can then be allocated instead toward such strategies as private equity, hedge funds, and infrastructure, where their scale and resources provide a competitive advantage.

Exhibit 1 Asset Size and Investor Constraints

Asset Class	Investor Constraints by Size
■ Cash equivalents and money market funds	No size constraints.
■ Large-cap developed market equity ■ Small-cap developed market equity ■ Emerging market equity	Generally accessible to large and small asset owners, although the very large asset owner may be constrained in the amount of assets allocated to certain active strategies and managers.

(continued)

1 See Stein (2002); Chen, Hong, Huang, and Kubik (2004); and Pollet and Wilson (2008).

2 See Dyck and Pomorski (2011). The median plan in this study was just over US$2 billion. The 25th percentile plan was US$780 million, and the 75th percentile plan was US$6.375 billion.

Exhibit 1 (Continued)

Asset Class	Investor Constraints by Size
■ Developed market sovereign bonds ■ Investment-grade bonds ■ Non-investment-grade bonds ■ Private real estate equity	Generally accessible to large and small asset owners, although to achieve prudent diversification, smaller asset owners may need to implement via a commingled vehicle.
Alternative Investments ■ Hedge funds ■ Private debt ■ Private equity ■ Infrastructure ■ Timberland and farmland	May be accessible to large and small asset owners, although if offered as private investment vehicles, there may be legal minimum qualifications that exclude smaller asset owners. The ability to successfully invest in these asset classes may also be limited by the asset owner's level of investment understanding/expertise. Prudent diversification may require that smaller asset owners implement via a commingled vehicle, such as a fund of funds, or an ancillary access channel, such as a liquid alternatives vehicle or an alternatives ETF. For very large funds, the allocation may be constrained by the number of funds available.

Even in these strategies, very large asset owners may be constrained by scale. In smaller or less liquid markets, can a large asset owner invest enough that the exposure contributes a material benefit to the broader portfolio? For example, a sovereign wealth fund or large public pension plan may not find enough attractive hedge fund managers to fulfill their desired allocation to hedge funds. True alpha is rare, limiting the opportunity set. Asset owners who find that they have to split their mandate into many smaller pieces may end up with an index-like portfolio but with high active management fees; one manager's active bets may cancel out those of another active manager. A manager mix with no true alpha becomes index-like because the uncompensated, idiosyncratic return variation is diversified away. A much smaller allocation may be achievable, but it may be too small to meaningfully affect the risk and return characteristics of the overall portfolio. More broadly, a very large size makes it more difficult to benefit from opportunistic investments in smaller niche markets or from skilled investment managers who have a small set of unique ideas or concentrated bets. No hard and fast rules exist to determine whether a particular asset owner is too small or too large to effectively access an asset class. Greater governance resources more commonly found among owners of larger asset pools create the capacity to pursue the more complex investment opportunities, but the asset owner may still need to find creative ways to implement the desired allocation. Each asset owner has a unique set of knowledge and constraints that will influence the opportunity set.

Smaller asset owners (typically institutions with less than US$500 million in assets, and private wealth investors with less than US$25 million in assets) also find that their opportunity set may be constrained by the size of their investment portfolio. This is primarily a function of the more limited governance infrastructure typical of smaller asset owners: They may be too small to adequately diversify across the range of asset classes and investment managers or may have staffing constraints (insufficient asset size to justify a dedicated internal staff). Complex strategies may be beyond the reach of asset owners that have chosen not to develop investment expertise internally or where the oversight committee lacks individuals with sufficient investment understanding. In some asset classes and strategies, commingled investment vehicles can be used to achieve the needed diversification, provided the governing documents do not prohibit their use.

Access to other asset classes and strategies—private equity, private real estate, hedge funds, and infrastructure—may still be constrained for smaller asset owners. The commingled vehicles through which these strategies are offered typically require high minimum investments. For successful private equity and hedge fund managers, in particular, minimum investments can be in the tens of millions of (US) dollars, even for funds of funds.

Regulatory restrictions can also impose a size constraint. In the United Kingdom, for example, an asset owner in a private investment vehicle must qualify as an elective professional client, meaning they must meet two of the following three conditions:

1 The client has carried out transactions, in significant size, on the relevant market at an average frequency of 10 per quarter over the previous four quarters.

2 The size of the client's financial instrument portfolio exceeds €500,000.

3 The client works or has worked in the financial sector for at least one year in a professional position, which requires knowledge of the transactions or services envisaged.

In the United States, investors must be either accredited or qualified purchasers to invest in many private equity and hedge fund vehicles. To be a qualified purchaser, a natural person must have at least US$5 million in investments, a company must have at least US$25 million in investable assets, and an investment manager must have at least US$25 million under management. In Hong Kong SAR, the Securities and Futures Commission requires that an investor must meet the qualifications of a "Professional Investor" to invest in certain categories of assets. A Professional Investor is generally defined as a trust with total assets of not less than HK$40 million, an individual with a portfolio not less than HK$8 million, or a corporation or partnership with a portfolio not less than HK$8 million or total assets of not less than HK$40 million. The size constraints related to these asset classes suggest that smaller asset owners have real challenges achieving an effective private equity or hedge fund allocation.

Asset size as a constraint is often a more acute issue for individual investors than institutional asset owners. Wealthy families may pool assets through such vehicles as family limited partnerships, investment companies, fund of funds, or other forms of commingled vehicles to hold their assets. These pooled vehicles can then access investment vehicles, asset classes, and strategies that individual family members may not have portfolios large enough to access on their own.

Where Asset Size Constrains Investment Opportunity

As of early 2016, the 10 largest sovereign wealth funds globally each exceed US$400 billion in assets. For a fund of this size, a 5% allocation to hedge funds (the average sovereign wealth fund allocation) would imply US$20 *billion* to be deployed. The global hedge fund industry manages approximately US$2.8 trillion in total; 73% of the funds manage less than US$100 million. The remaining 27% of the funds (roughly 3,000) manage 72% of the industry's AUM; their implied average AUM is therefore US$670 million. If we assume that the asset owner would want to be no more than 20% of a firm's AUM, we can infer that the average investment might be approximately US$130 million. With US$20 billion to deploy, the fund would need to invest with nearly 150 funds to achieve a 5% allocation to hedge funds.

Sources: Sovereign Wealth Fund Institute, BarclayHedge, Eurekahedge (2016).

EXAMPLE 1

Asset Size Constraints in Asset Allocation

1 Akkarat Aromdee is the recently retired President of Alpha Beverage, a producer and distributor of energy drinks throughout Southeast Asia. Upon retiring, the company provided a lump sum retirement payment of THB880,000,000 (equivalent to €20 million), which was rolled over to a tax-deferred individual retirement savings plan. Aside from these assets, Aromdee owns company stock worth about THB70,000,000. The stock is infrequently traded. He has consulted with an investment adviser, and they are reviewing the following asset allocation proposal:

Global equities	40%
Global high-yield bonds	15%
Domestic intermediate bonds	30%
Hedge funds	10%
Private equity	5%

Describe asset size constraints that Aromdee might encounter in implementing this asset allocation. Discuss possible means to address them.

2 The CAF$40 billion Government Petroleum Fund of Caflandia is overseen by a nine-member Investment Committee. The chief investment officer has a staff with sector heads in global equities, global bonds, real estate, hedge funds, and derivatives. The majority of assets are managed by outside investment managers. The Investment Committee, of which you are a member, approves the asset allocation policy and makes manager selection decisions. Staff has recommended an increase in the private equity allocation from its current 0% to 15%, to be implemented over the next 12 to 36 months. The head of global equities will oversee the implementation of the private equity allocation.

Given the asset size of the fund, formulate a set of questions regarding the feasibility of this recommendation that you would like staff to address at the next Investment Committee meeting.

3 The Courneuve University Endowment has US$250 million in assets. The current allocation is 65% global large-capitalization stocks and 35% high-quality bonds, with a duration target of 5.0 years. The University has adopted a 5% spending policy. University enrollment is stable and expected to remain so. A capital spending initiative of US$100 million for new science buildings in the next three to seven years is being discussed, but it has not yet been approved. The University has no dedicated investment staff and makes limited use of external resources. Investment recommendations are formulated by the University's treasurer and approved by the Investment Committee, composed entirely of external board members.

The new president of the University has stated that he feels the current policy is overly restrictive, and he would like to see a more diversified program that takes advantage of the types of investment strategies used by large endowment programs. Choosing from among the following asset classes, propose a set of asset classes to be considered in the revised asset allocation. Justify your response.

- Cash equivalents and money market funds
- Large-cap developed market equity
- Small-cap developed market equity
- Emerging market equity
- Developed market sovereign bonds
- Investment-grade bonds
- Non-investment-grade bonds
- Private real estate equity
- Hedge funds
- Private debt
- Private equity

Solution to 1:

With a THB88 million (€2 million) allocation to hedge funds and a THB44 million (€1 million) allocation to private equity funds, Aromdee may encounter restrictions on his eligibility to invest in the private investment vehicles typically used for hedge fund and private equity investment. To the extent he is eligible to invest in hedge funds and/or private equity funds, a fund-of-funds or similar commingled arrangement would be essential to achieving an appropriate level of diversification. Additionally, it is essential that he and his adviser develop the necessary level of expertise to invest in these alternative assets. To achieve a prudent level of diversification, the allocation to global high-yield bonds would most likely need to be accomplished via a commingled investment vehicle.

Solution to 2:

Questions regarding the feasibility of the recommendation include the following:

- How many private equity funds do you expect to invest in to achieve the 15% allocation to private equity?
- What is the anticipated average allocation to each fund?
- Are there a sufficient number of high-quality private equity funds willing to accept an allocation of that size?
- What expertise exists at the staff or board level to conduct due diligence on private equity investment funds?
- What resources does the staff have to oversee the increased allocation to private equity?

Solution to 3:

Asset size and limited governance resources are significant constraints on the investment opportunity set available to the Endowment. The asset allocation should emphasize large and liquid investments, such as cash equivalents, developed and emerging market equity, and sovereign and investment-grade bonds. Some small portion of assets, however, could be allocated to commingled investments in real estate, private equity, or hedge funds. Given the University's limited staff resources, it is necessary to ensure that the board members have the level of expertise necessary to select and monitor these more complex asset classes. The Endowment might also consider engaging an outside expert to advise on investment activities in these asset classes.

2.2 Liquidity

Two dimensions of liquidity must be considered when developing an asset appropriate allocation solution: the liquidity needs of the asset owner and the liquidity characteristics of the asset classes in the opportunity set. Integrating the two dimensions is an essential element of successful investment planning.

The need for liquidity in an investment portfolio will vary greatly by asset owner and by the goals the assets are set aside to achieve. For example, a bank will typically have a very large portfolio supporting its day-to-day operations. That portfolio is likely to experience very high turnover and a very high need for liquidity; therefore, the investment portfolio must hold high-quality, very short-term, and highly liquid assets.

The same bank may have another designated investment pool one level removed from operating assets. Although the liquidity requirements for this portfolio may be lower, the investments most likely feature a high degree of liquidity—a substantial allocation to investment-grade bonds, perhaps with a slight extension of maturity. For its longer-term investment portfolio, the bank may choose to allocate some portion of its portfolio to less liquid investments. The opportunity set for each portfolio will be constrained by applicable banking laws and regulations.

Long-term investors, such as sovereign wealth funds and endowment funds, can generally exploit illiquidity premiums available in such asset classes as private equity, real estate, and infrastructure investments. However, pension plans may be limited in the amount of illiquidity they can absorb. For example, a frozen pension plan may anticipate the possibility of eliminating its pension obligation completely by purchasing a group annuity and relinquishing the responsibility for making pension payments to an insurance company. If there is a significant probability that the company will take this step in the near term, liquidity of plan assets will become a primary concern; and if there is a substantial allocation to illiquid assets, the plan sponsor may be unable to execute the desired annuity purchase transaction.

Liquidity needs must also consider the particular circumstances and financial strength of the asset owner and what resources they may have beyond those held in the investment portfolio. The following examples illustrate this point:

- A university must consider its prospects for future enrollments and the extent to which it relies on tuition to meet operating needs. If the university experiences a significant drop in enrollment, perhaps because of a poor economic environment, or takes on a new capital improvement project, the asset allocation policy for the endowment should reflect the increased probability of higher outflows to support university operations.
- A foundation whose mission supports medical research in a field in which a break-through appears imminent may desire a higher level of liquidity to fund critical projects than would a foundation that supports ongoing community efforts.
- An insurance company whose business is predominantly life or auto insurance, where losses are actuarially predictable, can absorb more liquidity risk than a property/casualty reinsurer whose losses are subject to unpredictable events, such as natural disasters.
- A family with several children nearing college-age will have higher liquidity needs than a couple of the same age and circumstances with no children.

When assessing the appropriateness of any given asset class for a given asset owner, it is wise to evaluate potential liquidity needs in the context of an extreme market stress event. The market losses of the 2008–2009 global financial crisis were extreme. Simultaneously, other forces exacerbated investors' distress: Many university endowments were called upon to provide an increased level of operating support; insurers dipped into reserves to offset operating losses; community foundations found their beneficiaries in even greater need of financial support; and some individual investors experienced setbacks that caused them to move, if only temporarily, from being net contributors to net spenders of financial wealth. A successful asset allocation effort will stress the proposed allocation; it will anticipate, where possible, the likely behavior of other facets of the saving/spending equation during times of stress.

It is also important to consider the intersection of asset class and investor liquidity in the context of the asset owner's governance capacity. Although the mission of the organization or trust may allow for a certain level of illiquidity, if those responsible for the oversight of the investment program do not have the mental fortitude or discipline to maintain course through the crisis, illiquid and less liquid investments are unlikely to produce the rewards typically expected of these exposures. Although rates of return may be mean-reverting, wealth is not. Losses resulting from panic selling during times of stress become permanent losses; there are fewer assets left to earn returns in a post-crash recovery.

The Case of Vanishing Liquidity

In the global financial crisis of 2008–2009, many investors learned painful truths about liquidity. When most needed—whether to rebalance or to meet spending obligations—it can evaporate. As investors liquidated their most liquid assets to meet financial obligations (or to raise cash in fear of further market declines), the remaining less liquid assets in their portfolios became an ever-larger percentage of the portfolio. Many investors were forced to sell private partnership interests on the secondary market at steeply discounted prices. Others defaulted on outstanding private fund capital commitments by refusing to honor future obligations.

Similarly, illiquidity became a substantial problem during the Asian currency crisis of 1997–1998 and again with the Russian debt default and Long-Term Capital Management (LTCM) crisis of 1998. In the following paragraphs, we describe several "liquidity crises" that are often used in stress testing asset allocation choices.

The Asian Currency Crisis of 1997

In the spring of 1997, Thailand spent billions to defend the Thai baht against speculative attacks, finally capitulating and devaluing the baht in July 1997. This triggered a series of moves throughout the region to defend currencies against speculators. Ultimately, these efforts were unsuccessful and many countries abandoned the effort and allowed their currencies to float freely. The Philippines, Indonesia, and South Korea abandoned their pegs against the US dollar. On 27 October 1997, rattled by the currency crisis, Asian and European markets declined sharply in advance of the opening of the US markets. The S&P 500 declined nearly 7%, and trading on US stock markets was suspended.

The Russian Debt/LTCM Crisis of August 1998

On 17 August 1998, the Russian government defaulted on its short-term debt. This unprecedented default of a sovereign debtor roiled the global bond markets. A global flight-to-quality ensued, which caused credit spreads to widen and liquidity to evaporate. Highly levered investors experienced significant losses. Long-Term Capital Management, with reported notional exposure of over US$125 billion (a 25-to-1 leverage ratio), exacerbated these price declines as they faced their own liquidity crisis and were forced to liquidate large relative value, distressed, convertible arbitrage, merger arbitrage, and equity positions. Ultimately, the magnitude of the liquidity squeeze for LTCM and the risk of potential disruption to global markets caused the New York branch of the Federal Reserve Bank to orchestrate a disciplined, structured bailout of the LTCM fund.

Financial markets are increasingly linked across borders and asset classes; as a result, changes in liquidity conditions in one country can directly affect liquidity conditions elsewhere. These linkages do improve access to financing and capital markets, but they also show that a liquidity problem in one part of the world can ripple across the globe—increasing volatility, creating higher execution costs for investors, and possibly leading to a reduction in credit availability and a decline in economic activity.

EXAMPLE 2

Liquidity Constraints in Asset Allocation

The Frentel Furniture Pension Fund has £200 million frozen in a defined benefit pension plan that is 85% funded. The plan has a provision that allows employees to elect a lump sum distribution of their pension benefit at retirement. The company is strong financially and is committed to fully funding the pension obligations over time. However, they also want to minimize cash contributions to the plan. Few governance resources are allocated to the pension fund, and there is no dedicated staff for pension investment activities. The current asset allocation is as shown:

Global equities	20%
Private equity	10%
Real estate	10%
Infrastructure	5%
Hedge funds	15%
Bonds	40%

The company expects to reduce their employee headcount sometime in the next three to five years, and they are tentatively planning incentives to encourage employees to retire early.

Discuss the appropriateness of the current asset allocation strategy for the pension fund, including benefits and concerns.

Solution:

In addition to the size constraints a £200 million (≈ US$250 million) plan faces when attempting to invest in real estate, private equity, infrastructure, and hedge funds, the likelihood of early retirement incentives and lump-sum distribution requests in the next three to five years indicates a need for increased sensitivity to liquidity concerns. Investments in private equity, infrastructure, and real estate may be unsuitable for the plan given their less liquid nature. Although hedge fund investments would likely be accessible via a commingled vehicle, the liquidity of the commingled vehicle should be evaluated to determine if it is consistent with the liquidity needs of the plan.

2.3 Time Horizon

An asset owner's time horizon is a critical constraint that must be considered in any asset allocation exercise. A liability to be paid at a given point in the future or a goal to be funded by a specified date each define the asset owner's horizon, thus becoming a basic input to the asset allocation solution. The changing composition of the asset owner's assets and liabilities must also be considered. As time progresses, the character of both *assets* (human capital) and *liabilities* changes.

Changing Human Capital When asset allocation considers such extended portfolio assets as human capital, the optimal allocation of financial capital can change through time (Bodie, Merton, and Samuelson 1992). Assuming no change in the investor's utility function, as human capital—with its predominately bond-like risk—declines over time, the asset allocation for financial capital would reflect an increasing allocation to bonds. This is a prime example of how time horizon can influence asset allocation.

Changing Character of Liabilities The changing character of liabilities through time will also affect the asset allocation aligned to fund those liabilities.

As an example, the term structure of liabilities changes as they approach maturity. A pension benefit program is a simple way to illustrate this point. When the employee base is young and retirements are far into the future, the liability can be hedged with long-term bonds. As the employee base ages and prospective retirements are not so far into the future, the liability is more comparable to intermediate- or even short-term bonds. When retirements are imminent, the structure of the liabilities can be characterized as cash-like, and an optimal asset allocation would also have cash-like characteristics.

Similarly, the overall profile of an individual investor's liabilities changes with the progression of time, particularly for investors with finite investment horizons. Nearer-term goals and liabilities move from partially funded to fully funded, while other, longer-term goals and liabilities move progressively closer to funding. As the relative weights of the goals to be funded shift and the time horizon associated with certain goals shortens, the aggregate asset allocation must be adapted if it is to remain aligned with the individual's goals.

Time horizon is also likely to affect the manner in which an investor prioritizes certain goals and liabilities. This will influence the desired risk profile of the assets aligned to fund them. Consider a 75-year-old retired investor with two goals:

1 Fund consumption needs through age 95

2 Fund consumption needs from age 95 through age 105

He most likely assigns a much higher priority to funding goal 1, given the lower probability that he will live beyond age 95.[3] Let's also assume that he has sufficient assets to fund goal 1 and to partially fund goal 2. The higher priority assigned to goal 1 indicates he is less willing to take risk, and this sub-portfolio will be invested more conservatively. Now consider goal 2: Given the low probability of living past 95 and the fact that he does not currently have sufficient assets to fund that goal, the sub-portfolio assigned to goal 2 is likely to have a more growth-oriented asset allocation. The priority of a given goal can change as the investor's time horizon shortens—or lengthens.

Consider the hypothetical investors Ivy and Charles Lee from the reading "Introduction to Asset Allocation." Ivy is a 54-year-old life science entrepreneur. Charles is a 55-year-old orthopedic surgeon. They have two unmarried children aged 25 (Deborah) and 18 (David). Deborah has a daughter with physical limitations. Four goals have been identified for the Lees:

1 Lifestyle/future consumption needs

2 College education for son David, 18 years old

3 Charitable gift to a local art museum in 5 years

4 Special needs trust for their granddaughter, to be funded at the death of Charles

The lifestyle/consumption goal is split into three components: required minimum consumption requirements (a worst-case scenario of reduced lifestyle), baseline consumption needs (maintaining current standard of living), and aspirational consumption needs (an improved standard of living). At age 54, the risk preferences assigned to these goals might look something like the following:

3 A 75-year-old US American male has a life expectancy of 11.1 years, per the Social Security Administration's 2014 "Actuarial Life Tables," https://www.ssa.gov/oact/STATS/table4c6_2014.html (Accessed 22 Nov 2018).

Lifestyle Goals	Risk Preference	Asset Allocation	Sub-Portfolio as % of Total*
Required minimum	Conservative	100% bonds and cash	65%
Baseline	Moderate	60% equities/40% bonds	10%
Aspirational	Aggressive	100% equities	4%
College education	Conservative	100% bonds and cash	1%
Charitable gift (aspirational)	Aggressive	100% equities	5%
Special needs trust	Moderate	60% equities/40% bonds	15%
Aggregate portfolio		≈ 25% equities/75% bonds and cash	100%

* The present value of each goal as a proportion of the total portfolio.

The asset allocation for the total portfolio aggregates the asset allocations for each of the goal-aligned sub-portfolios, weighted by the present value of each goal. For the Lees, this is an overall asset allocation of about 25% equities and 75% bonds and cash. (Each goal is discounted to its present value by expected return of its respective goal-aligned sub-portfolio.)

Move forward 20 years. The Lees are now in their mid-70s, and their life expectancy is about 12 years. Their son has completed his college education and is successfully established in his own career. The charitable gift has been made. These two goals have been realized. The assets needed to fund the baseline consumption goal are significantly reduced because fewer future consumption years need to be funded. The special needs trust for their granddaughter remains a high priority. Although the Lee's risk preferences for these goals have not changed, the overall asset allocation *will* change because the total portfolio is an aggregated mix of the remaining goal-aligned sub-portfolios, weighted by their current present values:

Lifestyle Goals	Risk Preference	Asset Allocation	Sub-Portfolio as % of Total*
Required minimum	Conservative	100% bonds and cash	54%
Baseline	Moderate	60% equities/40% bonds	9%
Aspirational	Aggressive	100% equities	3%
Special needs trust	Moderate	60% equities/40% bonds	34%
Aggregate portfolio		≈ 30% equities/70% bonds and cash	100%

* The present value of each goal as a proportion of the total portfolio. The implied assumption is that current assets are sufficient to fund all goals, provided the Lees adopt an aggressive asset allocation strategy for the aspirational and charitable gifting goals. If the value of current assets exceeds the present value of all goals, the Lees would have greater flexibility to adopt a lower risk preference for some or all goals.

Although for ease of illustration our example assumed the Lee's risk preferences remained the same, this is not likely to be the case in the real world. Required minimum and baseline consumption goals would remain very important; there is less flexibility to withstand losses caused by either reduced earnings potential or lower likelihood of the market regaining lost ground within the shorter horizon. The aspirational lifestyle goal is likely to be a much lower priority, and it may have been eliminated altogether. The special needs trust may have a higher (or lower) priority as the needs of the granddaughter and the ability of her parents to provide for her needs after their death become more evident. The preferred asset allocation for each of these goals will shift over the course of the investor's lifetime.

As an investor's time horizon shifts, both human capital and financial market considerations, along with changes in the investor's priorities, will most likely lead to different asset allocation decisions.

EXAMPLE 3

Time Horizon Constraints in Asset Allocation

Akkarat Aromdee, the recently retired President of Alpha Beverage, is 67 years old with a remaining life expectancy of 15 years. Upon his retirement two years ago, he established a charitable foundation and funded it with THB600 million (≈ US$17.3 million). The remaining financial assets, THB350 million (≈ US$10 million), were transferred to a trust that will allow him to draw a lifetime income. The assets are invested 100% in fixed-income securities, consistent with Aromdee's desire for a high level of certainty in meeting his goals. He is a widower with no children. His consumption needs are estimated at THB20 million annually. Assets remaining in the trust at his death will pass to the charities named in the trust.

While vacationing in Ko Samui, Aromdee met and later married a 45-year-old woman with two teenage children. She has limited financial assets of her own. Upon returning from his honeymoon, Aromdee meets with his investment adviser. He intends to pay the college expenses of his new stepchildren—THB2 million annually for eight years, beginning five years from now. He would also like to ensure that his portfolio can provide a modest lifetime income for his wife after his death.

Discuss how these changed circumstances are likely to influence Aromdee's asset allocation.

Solution:

At the time Aromdee established the trust, the investment horizon was 15 years and his annual consumption expenditures could easily be funded from the trust. His desire to support his new family introduces two new horizons to be considered: In five years, the trust will begin making annual payments of THB2 million to fund college expenses, and the trust will continue to make distributions to his wife after his death, though at a reduced rate. When the trust needed to support only his consumption requirements, a conservative asset allocation was appropriate. However, the payment of college expenses will reduce his margin of safety and the lengthening of the investment horizon suggests that he should consider adding equity-oriented investments to the asset mix to provide for growth in assets over time.

Time Diversification of Risk

In practice, investors often align lower risk/lower return assets with short-term goals and liabilities and higher risk/higher return assets with long-term goals and liabilities. It is generally believed that longer-horizon goals can tolerate the higher volatility associated with higher risk/higher return assets as below average and above average returns even out over time. This is the notion of time diversification.

Mean–variance optimization, typically conducted using a multi-year time horizon, assumes that asset returns follow a random walk; returns in Year X are independent of returns in Year X – 1. Under this baseline assumption, there *is* no reduction in risk with longer time horizons.[4] Although the *probability* of reduced wealth or of a shortfall in funding a goal or liability (based on the mean of the distribution of possible outcomes) may be lower at longer time horizons, the dispersion of possible outcomes widens as the investment horizon expands. Thus, the *magnitude* of potential loss or shortfall can be greater.

Consider the choice of investing US$100,000 in an S&P 500 Index fund with a 10% expected return and 15% standard deviation versus a risk-free asset with a 3% annual return.[5] The table below compares the return of the risk-free asset over various time horizons, with the range of predicted returns for the S&P 500 Index fund at a 95% confidence interval. Although the *mean* return of the distribution of S&P 500 returns exceeds that of the risk-free asset in each time period (thus the notion that the volatility of higher risk, higher return assets evens out over time), the lower boundary of expected S&P 500 returns is less than the initial investment for all periods less than 10 years! The lower boundary of the S&P 500 outcomes does not exceed the ending wealth of the risk-free investment until the investment horizon is extended to 20 years. If the confidence interval is expanded to 99%, the lower boundary of S&P 500 outcomes falls below the initial investment up until and through 20 years!

	Ending Wealth (US$)		
	S&P 500 95% Confidence Interval		
	Lower Boundary	Upper Boundary	Risk-Free Asset
1 year	81,980	147,596	103,000
5 years	83,456	310,792	115,927
10 years	102,367	657,196	134,392
15 years	133,776	130,4376	155,797
20 years	180,651	2,565,345	180,611

Although one-year returns are largely independent, there is some evidence that risky asset returns can display mean-reverting tendencies over intermediate to longer time horizons. An assumption of mean-reverting risky asset returns would support the conventional arguments for funding long-term goals and liabilities with higher risk/higher return assets, and it would also support a reduction in the allocation to these riskier assets as the time horizon shortens.

4 See Samuelson (1963) and Samuelson (1969).
5 This example is drawn from Kritzman (2015).

2.4 Regulatory and Other External Constraints

Just as an integrated asset/liability approach to asset allocation is likely to result in a different allocation decision than what might have been selected in an asset-only context, external considerations may also influence the asset allocation decision. Local laws and regulations can have a material effect on an investor's asset allocation decisions.

Pension funds, insurance companies, sovereign wealth funds, and endowments and foundations are each subject to externally imposed constraints that are likely to tilt their asset allocation decision away from what may have been selected in a pure asset/liability context.

2.4.1 *Insurance Companies*

Unlike pension fund or endowment assets—which are legally distinct from the assets of the sponsoring entity—insurance companies' investment activities are an integral part of their day-to-day operations. Although skilled underwriting may be the focus of the firm as the key to profitability, investment returns are often a material contributor to profits or losses. Regulatory requirements and accounting treatment vary from country to country, but insurers are most often highly focused on matching assets to the projected, probabilistic cash flows of the risks they are underwriting. Fixed-income assets, therefore, are typically the largest component of an insurance company's asset base, and investing with skill in this asset class is a key to competitive pricing and success. In some regions, the relevant accounting treatment may be a book value approach, rendering variability in the market pricing of assets to be a secondary consideration as long as an asset does not have to have its book value written down as "other than temporarily impaired" ("OTTI"). Risk considerations for an insurance company include the need for capital to pay policyholder benefits and other factors that directly influence the company's financial strength ratings. Some of the key considerations are risk-based capital measures, yield, liquidity, the potential for forced liquidation of assets to fund negative claims development, and credit ratings.

Additionally, allocations to certain asset classes are often constrained by a regulator. For example, the maximum limit on equity exposure is often 10%, but it ranges as high as 30% in Switzerland and 50% in Mexico. Israel and Korea impose a limit of 15% on real estate investments.[6] Restrictions on non-publicly traded securities might also limit the allocation to such assets as private equity, for example, and there may also be limits on the allocation to high-yield bonds. Insurance regulators generally set a minimum capital level for each insurer based on that insurer's mix of assets, liabilities, and risk. Many countries are moving to Solvency II regulatory standards designed to harmonize risk-based capital requirements for insurance companies across countries.[7] Asset classes are often treated differently for purposes of determining whether an insurer meets risk-based capital requirements.

2.4.2 *Pension Funds*

Pension fund asset allocation decisions may be constrained by regulation and influenced by tax rules.[8] Some countries regulate maximum or minimum percentages in certain asset classes. For example, Japanese pension funds must hold a certain minimum percentage of assets in Japanese bonds in order to maintain their tax-exempt status. Canada allows a maximum of 10% of market value invested in any one entity

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6 https://www.oecd.org/finance/private-pensions/Regulation-of-Insurance-Company-and-Pension-Fund-Investment.pdf (September 2015)--accessed 23 November 2018).

7 Solvency II is an EU legislative program implemented in all 28 member states, including the United Kingdom, in January 2016. It introduces a new, harmonized EU-wide insurance regulatory regime.

8 Information in this section is based on the OECD "Annual Survey of Investment Regulation of Pension Funds" (2017).

or related entities; Switzerland generally limits real estate investments to 30%; Estonia allows a maximum of 75% of assets invested in public equity with no limit on foreign investments; and Brazil allows a maximum of 70% in public equity with a maximum of 10% in foreign public equity.[9] Ukraine limits bond investments to no more than 40%.

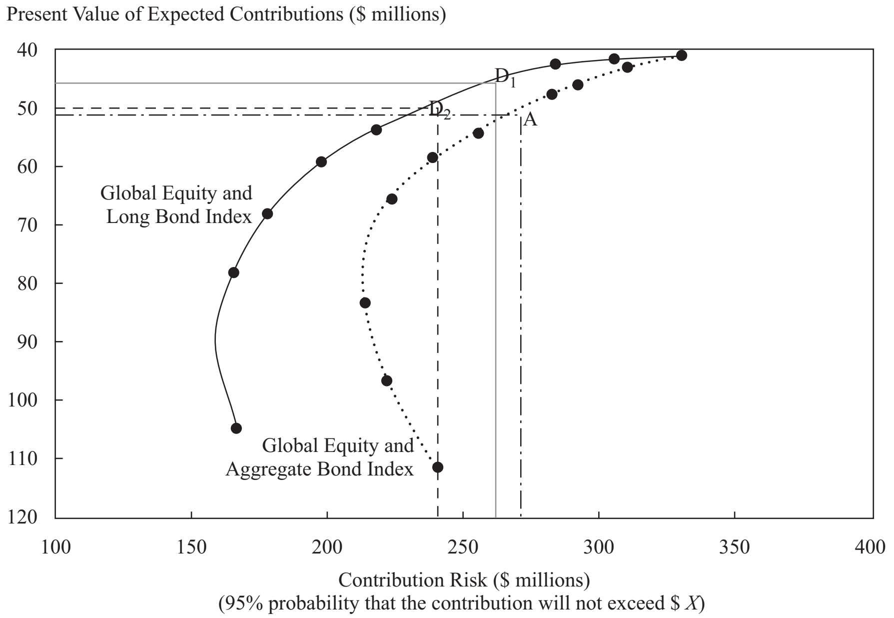
Pension funds are also subject to a wide array of funding, accounting, reporting, and tax constraints that may influence the asset allocation decision. (For example, US public pension funding and public and corporate accounting rules favor equity investments—higher equity allocations support a higher discount rate—and thus lower pension cost. Loss recognition is deferred until later through the smoothing mechanism.) The plan sponsor's appetite for risk is defined in part by these constraints, and the choice among asset allocation alternatives is often influenced by funding and financial statement considerations, such as the anticipated contributions, the volatility of anticipated contributions, or the forecasted pension expense or income under a given asset allocation scenario. The specific constraints vary by jurisdiction, and companies with plans in multiple jurisdictions must satisfy the rules and regulations of each jurisdiction while making sound financial decisions for the organization as a whole.

Exhibit 2 illustrates how funding considerations may affect the asset allocation decision. In this chart, risk is defined as the probability of contributions exceeding some threshold amount. In this case, the risk threshold is specified as the 95th percentile of the present value of contributions—that point on the distribution of possible contributions (using Monte Carlo simulation) where the plan sponsor can be 95% certain that contributions will not exceed that amount.

Assume that an allocation of 70% equities/30% aggregate bonds represents the most efficient portfolio for the plan sponsor's desired level of risk in an asset optimization framework. In Exhibit 2, we can see that the 70% equity/30% aggregate bond mix (Portfolio A) is associated with a present value (PV) of expected contributions of approximately US$51 million (y-axis) and a 95% confidence level that contributions will not exceed approximately US$275 million (x-axis)—Portfolio A in Exhibit 2. If the plan sponsor were to shift to longer-duration bonds (from aggregate to long bonds) to better match the duration of liabilities—Portfolio D_1 on Exhibit 2—the PV of expected contributions declines by approximately US$5 million and the 95% confidence threshold improves to approximately US$265 million. In fact, Portfolio D_1 results in nearly the lowest PV of contributions for this plan sponsor. (Note that the vertical axis is ordered from highest contributions at the bottom and lowest contributions at the top, consistent with the notion of lower contributions as a better outcome.)

9 Foreign investment is restricted to MERCOSUR countries for equities (other asset classes are more flexible).

Exhibit 2 Efficient Frontiers Where Risk Is Defined as the Risk of Large Contributions



Now consider Portfolio D_2, 60% equities/40% long bonds. Reducing the equity exposure from 70% to 60% lowers the contribution risk significantly, with only marginally higher expected PV of contributions than Portfolio A. (A lower equity allocation implies a lower expected rate of return, which increases the PV of contributions. However, the lower equity allocation also reduces the probability that less-than-expected returns will lead to unexpectedly large contributions.) The sponsor that wishes to reduce contribution risk substantially is likely to give serious consideration to moving from Portfolio A to Portfolio D_2.

By iterating through various efficient frontiers using different definitions of risk, the sponsor is able to better understand the risk and reward trade-offs of alternative asset allocation choices. The regulatory or tax constraints on minimum and maximum contributions, or on minimum required funded levels, or other values that are important to the plan sponsor, can be factored into the simulations so the sponsor can better understand how these constraints might affect the risk and reward trade-offs.

2.4.3 *Endowments and Foundations*

Endowments and foundations are often established with the expectation that they will exist in perpetuity and thus can invest with a long investment horizon. In addition, the sponsoring entity often has more flexibility over payments from the fund than does a pension plan sponsor or insurance company. As a result, endowments and foundations generally can adopt a higher-risk asset allocation than other institutions. However, two categories of externally imposed constraints may influence the asset allocation decisions of an endowment or foundation: tax incentives and credit-worthiness considerations.

- *Tax incentives.* Although some endowments and foundations—US public foundations and some Austrian and Asian foundations, for example—are not required to make minimum distributions, many countries provide tax benefits tied to certain minimum spending requirements. For example, a private foundation may be subject to a requirement that it make charitable expenditures equal to at least 5% of the market value of its assets each year or risk losing its tax-favored status. These spending requirements may be relaxed if certain types of socially responsible investments are made, which can, in turn, create a bias toward socially responsible investments for some endowments and foundations, irrespective of their merits in an asset allocation context.

- *Credit considerations*. Although endowments and foundations typically have a very long investment horizon, sometimes external factors may restrict the level of risk-taking in the portfolio. For example, endowment or foundation assets are often used to support the balance sheet and borrowing capabilities of the university or the foundation organization. Lenders often require that the borrower maintain certain minimum balance sheet ratios. Therefore, the asset allocation adopted by the organization will consider the risks of breaking these bond covenants or otherwise negatively affecting the borrowing capabilities of the organization.

As an example, although a hospital foundation fund would normally have a long investment horizon and the ability to invest in less liquid asset classes, it might limit the allocation to illiquid assets in order to support certain liquidity and balance sheet metrics specified by its lender(s).

2.4.4 *Sovereign Wealth Funds*

Although every sovereign wealth fund (SWF) is unique with respect to its mission and objectives, some broad generalizations can be made with respect to the external constraints that may affect a fund's asset allocation choices. In general, SWFs are government-owned pools of capital invested on behalf of the peoples of their states or countries, investing with a long-term orientation. They are not generally seeking to defease a set of liabilities or known obligations as is common with pension funds and, to a lesser extent, endowment funds.

The governing entities adopt regulations that constrain the opportunity set for asset allocation. For example, the Korean SWF KIC cannot invest in Korean won-denominated domestic assets;[10] and the Norwegian SWF NBIM is not permitted to invest in any alternative asset class other than real estate, which is limited to no more than 7% of assets.[11] Furthermore, as publicly owned entities, SWFs are typically subject to broad public scrutiny and tend to adopt a lower-risk asset allocation than might otherwise be considered appropriate given their long-term investment horizon in order to avoid reputation risk.

In addition to the broad constraints of asset size, liquidity, time horizon, and regulations, there may be cultural or religious factors which also constrain the asset allocation choices. Environmental, social, and governance (ESG) considerations are becoming increasingly important to institutional and individual investors alike. Sharia law, for example, prohibits investment in any business that has links to pork, alcohol, tobacco, pornography, prostitution, gambling, or weaponry, and it constrains investments in most businesses that operate on interest payments (like major Western banks and mortgage providers) and in businesses that transfer risk (such as major Western insurers).[12]

ESG goals are not typically modeled during the asset allocation decision process. Instead, these goals may be achieved through the implementation of the asset allocation, or the asset owner may choose to set aside a targeted portion of the assets for these missions. The asset allocation process would treat this "set-aside" in much the

10 https://mpra.ub.uni-muenchen.de/44028/1/MPRA_paper_44028.pdf (accessed 23 November 2018) Note: in principle, KIC must invest only in assets denominated in foreign currencies. If KIC manages KRW-denominated assets temporarily for an unavoidable reason, it must be either in the form of bank deposits or passively held public debt.

11 https://www.nbim.no/en/investments/investment-strategy/ (accessed 23 November 2018).

12 Islamic Investment Network (www.islamicinvestmentnetwork.com/sharialaw.php).

same way that a concentrated stock position might be handled: The risk, return, and correlation characteristics of this holding are specified; the "set aside" asset becomes an asset class in the investor's opportunity set; and the asset allocation constraints will designate a certain minimum investment in this asset class.

EXAMPLE 4

External Constraints and Asset Allocation

1. An insurance company has traditionally invested its pension plan using the asset allocation strategy adopted for its insurance assets: The pension assets are 95% invested in high-quality intermediate duration bonds and 5% in global equities. The duration of pension liabilities is approximately 25 years. Until now, the company has always made contributions sufficient to maintain a fully funded status. Although the company has a strong capability to fund the plan adequately and a relatively high tolerance for variability in asset returns, as part of a refinement in corporate strategy, management is now seeking to reduce long-term expected future cash contributions. Management is willing to accept more risk in the asset return, but they would like to limit contribution risk and the risk to the plan's funded status. The Investment Committee is considering three asset allocation proposals for the pension plan:

   A Maintain the current asset allocation with the same bond portfolio duration.

   B Increase the equity allocation and lengthen the bond portfolio duration to increase the hedge of the duration risk in the liabilities.

   C Maintain the current asset allocation of 95% bonds and 5% global equities, but increase the duration of bond investments.

   Discuss the merits of each proposal.

2. A multinational corporation headquartered in Mexico has acquired a former competitor in the United States. It will maintain both the US pension plan with US$250 million in assets and the Mexican pension plan with MXN$18,600 million in assets (≈ US$1 billion). Both plans are 95% funded and have similar liability profiles. The Mexican pension trust has an asset allocation policy of 30% equities (10% invested in the Mexican equity market and 20% in equity markets outside Mexico), 10% hedge funds, 10% private equity, and 50% bonds. The treasurer has proposed that the company adopt a consistent asset allocation policy across all of the company's pension plans worldwide.

   Critique the treasurer's proposal.

Solution to 1:

Given the intermediate duration bond allocation, Proposal A fails to consider the mismatch between pension assets and liabilities and risks a reduction in the funded status and *increased* contributions if bond yields decline. (If yields decline across the curve, the shorter duration bond portfolio will fail to hedge the increase in liabilities.) To meet the objective of lower future contributions, the asset allocation must include a higher allocation to equities. Proposal B has this higher allocation, and the extension of duration in the bond portfolio in Proposal B reduces balance sheet and surplus risk relative to the pension liabilities. The net effect could be a reduction in short-term contribution risk; moreover, if the greater expected return on equities is realized, it should result in reduced contributions to the plan over the long term. Proposal C improves the hedging of the liabilities, and it may result in a modest improvement in the expected return on assets if the yield curve is upward-sloping. However, the expected return on Proposal C is likely lower than the expected return of Proposal B and is therefore unlikely to achieve the same magnitude of reduction in future cash contributions. Proposal C would be appropriate if the goal was focused on reducing surplus risk rather than reducing long-term contributions.

Solution to 2:

The treasurer's proposal fails to consider the relative asset size of the two pension plans as well as the likelihood that plans in different jurisdictions may be subject to different funding, regulatory, and financial reporting requirements. The US pension plan may be unable to effectively access certain alternative asset classes, such as private equity, infrastructure, and hedge funds. Although economies of scale may be realized if management of the pension assets is consolidated under one team, the legal and regulatory differences of the markets in which they operate mean that the asset allocation policy must be customized to each plan.

3 ASSET ALLOCATION FOR THE TAXABLE INVESTOR

Portfolio theory developed in a frictionless world. But in the real world, taxes on income and capital gains can erode the returns achieved by taxable investors. The asset owner who ignores taxes during the asset allocation process is overlooking an economic variable that can materially alter the outcome. Although tax adjustments can be made after the asset allocation has been determined, this is a suboptimal approach because the pre-tax and after-tax risk and return characteristics of each asset class can be materially different.

Some assets are less tax efficient than others because of the character of their returns—the contribution of interest, dividends, and realized or unrealized capital gains to the total return. Interest income is usually taxed in the tax year it is received, and it often faces the highest tax rates. Therefore, assets that generate returns largely comprised of interest income tend to be less tax efficient in many countries.[13] Jurisdictional rules can also affect how the returns of certain assets are taxed. In the United States, for example, the interest income from state and local government bonds is generally exempt from federal income taxation. As a result, these bonds often constitute a large portion of a US high-net-worth investor's bond allocation. Preferred stocks, often used in lieu of bonds as an income-producing asset, are also eligible for more favorable tax treatment in many jurisdictions, where the income from preferred shares may be taxed at more favorable dividend tax rates.

The tax environment is complex. Different countries have different tax rules and rates, and these rules and rates can change frequently. However, looking across the major economies, there are some high-level commonalities in how investment returns are taxed. Interest income is taxed typically (but not always) at progressively higher income tax rates. Dividend income and capital gains are taxed typically (but not always) at lower tax rates than those applied to interest income and earned income (wages and salaries, for example). Capital losses can be used to offset capital gains (and sometimes income). Generally, interest income incurs the highest tax rate, with dividend income taxed at a lower rate in some countries, and long-term capital gains

13 See Deloitte's tax guides and country highlights: https://dits.deloitte.com/#TaxGuides.

receive the most favorable tax treatment in many jurisdictions. Once we move beyond these general commonalities, however, the details of tax treatment among countries quickly diverge.

Entities and accounts can be subject to different tax rules. For example, retirement savings accounts may be tax deferred or tax exempt, with implications for the optimal asset allocation solution. These rules provide opportunities for strategic asset *location*—placing less tax-efficient assets in tax-advantaged accounts.

We will provide a general framework for considering taxes in asset allocation. We will not survey global tax regimes or incorporate all potential tax complexities into the asset allocation solution. When considering taxes in asset allocation, the objective is to model material investment-related taxes, thereby providing a closer approximation to economic reality than is represented when ignoring taxes altogether.

For simplicity, we will assume a basic tax regime that represents no single country but includes the key elements of investment-related taxes that are roughly representative of what a typical taxable asset owner in the major developed economies must contend with.

3.1 After-Tax Portfolio Optimization

After-tax portfolio optimization requires adjusting each asset class's expected return and risk for expected tax. The expected after-tax return is defined in Equation 1:

$$r_{at} = r_{pt}(1 - t) \tag{1}$$

where

r_{at} = the expected after-tax return
r_{pt} = the expected pre-tax (gross) return
t = the expected tax rate

This can be straightforward for bonds in cases where the expected return is driven by interest income. Take, for example, an investment-grade par bond with a 3% coupon expected to be held to maturity. If interest income is subject to a 40% expected tax rate, the bond has an expected after-tax return of 1.80% [0.03(1 – 0.40) = 0.018].

The expected return for equity typically includes both dividend income and price appreciation (capital gains). Equation 2 expands Equation 1 accordingly:

$$r_{at} = p_d r_{pt}(1 - t_d) + p_a r_{pt}(1 - t_{cg}) \tag{2}$$

where

p_d = the proportion of r_{pt} attributed to dividend income
p_a = the proportion of r_{pt} attributed to price appreciation
t_d = the dividend tax rate
t_{cg} = the capital gains tax rate

The treatment of the capital gains portion of equity returns can be more complex. Assuming no dividend income, a stock with an 8% expected pre-tax return that is subject to a 25% capital gains tax rate has an expected after-tax return of 6% [0.08(1 – 0.25) = 0.06]. This is an approximation satisfactory for modeling purposes.[14]

Taxable assets may have existing unrealized capital gains or losses (i.e., the cost basis is below or above market value), which come with embedded tax liabilities (or tax assets). Although there is not a clear consensus on how best to deal with existing

14 A more precise estimation of the expected after-tax return also takes into account the effect of the holding period on the capital gains tax. For those interested in a more detailed discussion of these issues, see Mladina (2011).

unrealized capital gains (losses), many approaches adjust the asset's current market value for the value of the embedded tax liability (asset) to create an after-tax value. Reichenstein (2006) approximates the after-tax value by subtracting the value of the embedded capital gains tax from the market value, as if the asset were sold today. Horan and Al Zaman (2008) assume the asset is sold in the future and discount the tax liability to its present value using the asset's after-tax return as the discount rate. Turvey, Basu, and Verhoeven (2013) argue that the after-tax risk-free rate is the more appropriate discount rate because the embedded tax liability is analogous to an interest-free loan from the government, where the tax liability can be arbitraged away by dynamically investing in the risk-free asset. We will discuss how to incorporate after-tax values into the portfolio optimization process in Section 3.3, where we address strategies to reduce the impact of taxes.

The ultimate purpose of an asset can be a consideration when modeling tax adjustments. In the preceding material on asset allocation, we discussed goals-based investing. If the purpose of a given pool of assets is to fund consumption in 10 years, then that 10-year holding period may influence the estimated implied annual capital gains tax rate. If the purpose of the specified pool of assets is to fund a future gift of appreciated stock to a tax-exempt charity, then capital gains tax may be ignored altogether. Through this alignment of goals with assets, goals-based investing facilitates more-precise tax adjustments.

Although correlation assumptions need not be adjusted when modeling asset allocation choices for the taxable asset owner (taxes are proportional to return, after-tax co-movements are the same as pre-tax co-movements), taxes do affect the standard deviation assumption for each asset class. The expected after-tax standard deviation is defined in Equation 3:

$$\sigma_{at} = \sigma_{pt}(1 - t) \tag{3}$$

where

σ_{at} = the expected after-tax standard deviation

σ_{pt} = the expected pre-tax standard deviation

Taxes alter the distribution of returns by both reducing the expected mean return and muting the dispersion of returns. Taxes truncate both the high and low ends of the distribution of returns, resulting in lower highs and higher lows. The effect of taxes is intuitive when considering a positive return, but the same economics apply to a negative return: Losses are muted by the same $(1 - t)$ tax adjustment. The investor is not taxed on losses but instead receives the economic benefit of a capital loss, whether realized or not. In many countries, a realized capital loss can offset a current or future realized capital gain. An unrealized capital loss captures the economic benefit of a cost basis that is above the current market value, making a portion of expected future appreciation tax free.

How does the optimal asset allocation along a pre-tax efficient frontier compare with the optimal asset allocation along an after-tax efficient frontier? Let's assume all investment assets are taxable and that cost bases equal current market values. Assume also that interest income is taxed at 40%, and dividend income and capital gains are taxed at 25%.

The asset classes we will consider include investment-grade (IG) bonds, high-yield (HY) bonds, and equity. Exhibit 3 shows the expected pre-tax returns and standard deviations for each asset class as well as the correlation matrix. Note that for east of illustration, we have assumed that the IG bonds and HY bond returns are comprised of 100% interest income. In practice, some portion of th expected return would be eligible for capital gains tax treatment.

Exhibit 3 Expected Pre-Tax Return and Risk

	Return	Std. Dev.
IG bonds	3.0%	4.0%
HY bonds	5.0%	10.0%
Equity	8.0%	20.0%

Correlations	IG Bonds	HY Bonds	Equity
IG bonds	1.0	0.2	0.0
HY bonds	0.2	1.0	0.7
Equity	0.0	0.7	1.0

Employing mean–variance portfolio optimization with these pre-tax inputs, we obtain the optimal asset allocations in Exhibit 4, which shows the allocations for portfolios P1 (lowest risk), P25, P50 (median risk), P75, and P100 (highest risk)—each on an efficient frontier comprised of 100 portfolios.

Exhibit 4 Optimal Pre-Tax Asset Mixes

	$P1_{pt}$	$P25_{pt}$	$P50_{pt}$	$P75_{pt}$	$P100_{pt}$
IG bonds	93%	52%	25%	0%	0%
HY bonds	5%	18%	26%	33%	0%
Equity	2%	30%	49%	67%	100%

Using Equations 1, 2, and 3, we calculate the expected after-tax returns and standard deviations displayed in Exhibit 5. No adjustments are made to correlations.

Exhibit 5 Expected After-Tax Return and Risk

	Return	Std. Dev.
IG bonds	1.8%	2.4%
HY bonds	3.0%	6.0%
Equity	6.0%	15.0%

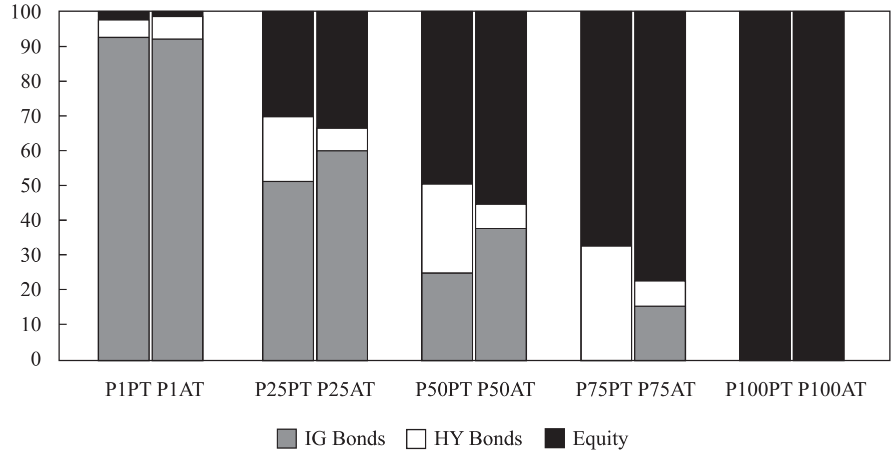
Portfolio optimization using these after-tax inputs produces the optimal asset allocations shown in Exhibit 6.

Exhibit 6 Optimal After-Tax Asset Mixes

	$P1_{at}$	$P25_{at}$	$P50_{at}$	$P75_{at}$	$P100_{at}$
IG bonds	92%	60%	38%	16%	0%
HY bonds	7%	7%	7%	7%	0%
Equity	1%	33%	55%	77%	100%

In Exhibit 7, we compare the pre-tax and after-tax efficient frontiers from these previous exhibits. Note that the portfolios at either extreme (P1 and P100) are essentially unchanged after taxes are factored into the assumptions. In portfolios P25, P50, and P75, however, you can see a significant reduction in the allocation to high-yield bonds. This is because of the heavier tax burden imposed on high-yield bonds. Although investment-grade bonds receive the same tax treatment, they are less risky than high-yield bonds and demonstrate a lower correlation with equity, so they continue to play the important role of portfolio risk reduction.

Exhibit 7 Pre-Tax and After-Tax Asset Allocation Comparisons



The optimal after-tax asset allocation depends on the interaction of after-tax returns, after-tax risk, and correlations. If an asset class or strategy is tax inefficient, it can still play a diversifying role in an optimal after-tax asset allocation if the asset or strategy offers sufficiently low correlations. After-tax portfolio optimization helps answer that question.

3.2 Taxes and Portfolio Rebalancing

Among tax-exempt institutional asset owners, periodic portfolio rebalancing—reallocating assets to return the portfolio to its target strategic asset allocation—is an integral part of sound portfolio management. This is no less true for taxable asset owners, but with the important distinction that more frequent rebalancing exposes the taxable asset owner to realized taxes that could have otherwise been deferred or even avoided. Whereas the tax burden incurred by liquidating assets to fund-required consumption cannot be avoided, rebalancing is discretionary; thus, the taxable asset owner should consider the trade-off between the benefits of tax minimization and the merits of maintaining the targeted asset allocation by rebalancing. The decision to rebalance and incur taxes is driven by each asset owner's unique circumstances.

Because after-tax volatility is less than pre-tax volatility (Equation 3) and asset class correlations remain the same, it takes larger asset class movements to materially alter the risk profile of the taxable portfolio. This suggests that rebalancing ranges for a taxable portfolio can be wider than those of a tax-exempt portfolio with a similar risk profile.

For example, consider a portfolio with a 50% allocation to equity, where equity returns are subject to a 25% tax rate. A tax-exempt investor may establish a target allocation to equities of 50%, with an acceptable range of 40% to 60% (50% plus or minus 10%). A taxable investor with the same target equity allocation can achieve a similar risk constraint with a range of 37% to 63% (50% plus or minus 13%). The equivalent rebalancing range for the taxable investor is derived by adjusting the permitted 10% deviation (up or down) by the tax rate, as shown in Equation 4:

$$R_{at}=R_{pt}/(1-t) \tag{4}$$

where

R_{at} = the after-tax rebalancing range

R_{pt} = the pre-tax rebalancing range

In our example, the 10% rebalancing range for a tax-exempt investor becomes a 13.3% rebalancing range for a taxable investor (when ranges are viewed and monitored from the same gross return perspective):

$$0.10/(1 - 0.25) = 13.3\%$$

Broader rebalancing ranges for the taxable investor reduce the frequency of trading and, consequently, the amount of taxable gains.

3.3 *Strategies to Reduce Tax Impact*

Additional strategies can be used to reduce taxes, including tax-loss harvesting and choices in the placement of certain types of assets in taxable or tax-exempt accounts (strategic asset location). Tax-loss harvesting is intentionally trading to realize a capital loss, which is then used to offset a current or future realized capital gain in another part of the portfolio, thereby reducing the taxes owned by the investor. It is discussed elsewhere in the curriculum, but we address strategic asset location strategies here.

Strategic asset location refers to placing (or locating) less tax-efficient assets in accounts with more favorable tax treatment, such as retirement savings accounts.

Aggregating assets across accounts with differing tax treatment requires modifying the asset value inputs to the portfolio optimization. Assets held in tax-*exempt* accounts require no tax adjustment to their market values. Assets in tax-*deferred* accounts grow tax free but are taxed upon distribution. Because these assets cannot be distributed (and consumed) without incurring the tax, the tax burden is inseparable from the economic value of the assets. Thus, the after-tax value of assets in a tax-deferred account is defined by Equation 5:

$$v_{at} = v_{pt}(1 - t_i) \tag{5}$$

where

v_{at} = the after-tax value of assets

v_{pt} = the pre-tax market value of assets

t_i = the expected income tax rate upon distribution

In our earlier example, we had three asset classes: investment-grade bonds, high-yield bonds, and equities. If we assume that each of these three asset classes can be held in either of two account types—taxable or tax-deferred—then our optimization uses six different after-tax asset classes (three asset classes times two account types). The three asset classes in taxable accounts use the after-tax return and risk inputs derived earlier. The three asset classes in tax-deferred accounts (which grow tax free) use expected pre-tax return and risk inputs. The optimization adds constraints based on the after-tax value of the assets currently available in each account type and derives the optimal after-tax asset allocation and asset location simultaneously.

As a general rule, the portion of a taxable asset owner's assets that are eligible for lower tax rates and deferred capital gains tax treatment should first be allocated to the investor's taxable accounts. For example, equities should generally be held in taxable accounts, while taxable bonds and high-turnover trading strategies should generally be located in tax-exempt and tax-deferred accounts to the extent possible.

One important exception to this general rule regarding asset location applies to assets held for near-term liquidity needs. Because tax-exempt and tax-deferred accounts may not be immediately accessible without tax penalty, a portion of the bond allocation may be held in taxable accounts if its role is to fund near-term consumption requirements.

EXAMPLE 5

Asset Allocation and the Taxable Investor

1 Sarah Moreau, 45 years old, is a mid-level manager at a consumer products company. Her investment portfolio consists entirely of tax-deferred retirement savings accounts. Through careful savings and investments, she is on track to accumulate sufficient assets to retire at age 60. Her portfolio is currently allocated as indicated below:

Investment-grade bonds	20%
High-yield bonds	20%
Common stock–dividend income strategy	30%
Common stock–total return (capital gain) strategy	30%
Total portfolio	100%

The common stock–dividend income strategy focuses on income-oriented, high-dividend-paying stocks; the common stock–total return strategy focuses on stocks that represent good, long-term opportunities but pay little to no dividend. For the purposes of this example, we will assume that the expected long-term return is equivalent between the two strategies. Moreau has a high comfort level with this portfolio and the overall level of risk it entails.

Moreau has recently inherited additional monies, doubling her investable assets. She intends to use this new, taxable portfolio to support causes important to her personally over her lifetime. There is no change in her risk tolerance. She is interviewing prospective investment managers and has asked each to recommend an asset allocation strategy for the new portfolio using the same set of asset classes. She has received the following recommendations:

	Recommendation		
	A	B	C
Investment-grade bonds	20%	40%	30%
High-yield bonds	20%	0%	0%
Common stock–dividend income strategy	30%	30%	0%
Common stock–total return (capital gain) strategy	30%	30%	70%
Total portfolio	100%	100%	100%

Which asset allocation is *most* appropriate for the new portfolio? Justify your response.

2 How should Moreau distribute these investments among her taxable and tax-exempt accounts?

3 You are a member of the Investment Committee for a multinational corporation, responsible for the supervision of two portfolios. Both portfolios were established to fund retirement benefits: One is a tax-exempt defined benefit pension fund, and the other is taxable, holding assets intended to fund non-exempt retirement benefits. The pension fund has a target allocation of 70% equities and 30% fixed income, with a +/– 5% rebalancing range. There is no formal asset allocation policy for the taxable portfolio; it has simply followed the same allocation adopted by the pension portfolio. Because of recent strong equity market returns, both portfolios are now allocated 77% to equities and 23% to bonds. Management expects that the equity markets will continue to produce strong returns in the near term. Staff has offered the following options for rebalancing the portfolios:

A Do not rebalance.

B Rebalance both portfolios to the 70% equity/30% fixed-income target allocation.

C Rebalance the tax-exempt portfolio to the 70% equity/30% fixed-income target allocation, but expand the rebalancing range for the taxable portfolio.

Which recommendation is *most* appropriate? Justify your response.

Solution to 1:

Recommendation C would be the most appropriate asset allocation for the new portfolio. The high-yield bond and common stock–dividend income strategies are tax disadvantaged in a taxable portfolio. (Although investment-grade bonds are also tax disadvantaged, they maintain the role of controlling portfolio risk to maintain Moreau's risk preference.) By shifting this equity-like risk to the total return common stock strategy, Moreau should achieve a greater after-tax return. Given the lower standard deviation characteristics of after-tax equity returns when held in the taxable portfolio, a higher allocation to common stocks may be justified without exceeding Moreau's desired risk level. Recommendations A and B do not consider the negative tax implications of holding the high-yield and/or common stock–dividend income strategies in a taxable portfolio. Recommendation B also fails to consider Moreau's overall risk tolerance: The volatility of the common stock–capital gain strategy is lower when held in a taxable portfolio, thus a higher allocation to this strategy can enhance returns while remaining within Moreau's overall risk tolerance.[15]

Solution to 2:

If Moreau is willing to think of her investable portfolio as a single portfolio, rather than as independent "retirement" and "important causes" portfolios, she should hold the allocation to high-yield bonds and dividend-paying stocks in her tax-exempt retirement portfolio. In addition, subject to the overall volatility of the individual tax-exempt and taxable portfolios, it would be sensible to bear any increased stock risk in the taxable portfolio. A new optimization for *all* of Moreau's assets—using pre-tax and after-tax risk and return assumptions and subject to the constraint that half of the assets are held in a taxable portfolio and half are held in the tax-exempt portfolio—would more precisely allocate investments across portfolio (account) types.

Asset Location for Optimal Tax Efficiency

	Tax Advantaged Retirement Account	Taxable Account
Investment-grade bonds	X	
High-yield bonds	X	
Common stock–dividend income strategy	X	
Common stock–total return (capital gain) strategy		X

Solution to 3:

Recommendation C is the most appropriate course of action. Rebalancing of the tax-exempt portfolio is unencumbered by tax considerations, and rebalancing maintains the desired level of risk. The rebalancing range for the taxable portfolio can be wider than that of the tax-exempt portfolio based on the desire to minimize avoidable taxes and the lower volatility of after-tax equity returns. Recommendation A (no rebalancing) does not address the increased level of risk in the tax-exempt portfolio that results from the increase in the stock allocation. Recommendation B would create an unnecessary tax liability for the company, given that the portfolio is still operating in a reasonable range of risk when adjusted for taxes.

15 Investment-grade bonds also have lower after-tax volatility. The equivalent risk portfolios in pre-tax and after-tax environments are a function of a complex interaction of after-tax returns, standard deviations, and correlations.

Increasing Allocations to Fixed Income in Corporate Pension Plans

Increasing allocations to fixed income by defined benefit pension funds worldwide have been driven largely by a desire to better hedge plan liabilities. In some countries, accounting standards discourage de-risking. De-risking, however, is not the only argument in favor of a higher fixed-income allocation.

De-risking

There has been much discussion globally of pension plans "de-risking"—moving toward larger fixed-income allocations to better hedge liabilities, thereby reducing contribution uncertainty. Some countries' accounting rules, however—most notably those in the United States—discourage companies from moving in that direction. Under US GAAP accounting rules, for example, a higher allocation to equities allows the plan sponsor to employ a higher return assumption, thereby reducing pension cost, a non-cash expense that directly affects reported income.

For underfunded pension plans, de-risking leads to higher pension contributions. If a company has a weak core business with a higher-than-average probability of going bankrupt and makes only the minimum required contribution, it might be argued that the asset allocation decision was contrary to the interests of plan participants. If the company were to go bankrupt, the participants would get only the benefits covered by any government guaranty program. Had the company taken equity risk in the plan, there would have been a possibility of closing the funding gap, resulting in higher benefit payments.

Efficient Allocation of Risk

A higher allocation to fixed income—and a lower allocation to equity—might also be driven by corporate governance considerations. Pension investment activities are not a core competency of many companies, especially non-financial companies. Assuming that the company has a limited appetite for risk, shareholders might prefer that management allocate its risk budget to the core business of the company where they are expected to have skill, rather than to the pension fund. The rewards per unit of risk should presumably be greater in the company's core business, and the improved profitability should offset the increase in pension contributions required as a result of the lower equity allocation.

A Holistic Approach to Asset Location

Finally, some have argued that an asset allocation of 100% fixed-income securities can be justified on the premise that the company is acting as an agent for the benefit of all stakeholders, including shareholders and plan participants. This argument centers on tax-efficient asset location. A taxable investor—the shareholder and plan participant—should prefer to take his long-term equity risk in that portion of his overall portfolio where he will receive the benefit of lower capital gains rates rather than in tax-deferred accounts, the proceeds of which will be taxed at income tax rates. Consider a small business owner with US$3 million in total assets. The assets are split between a pension fund of which he is the sole participant (US$1 million) and a taxable portfolio (US$2 million). Assume that the asset allocation that represents his preferred level of risk is 67% equities and 33% fixed income. Where should this individual hold his equity exposure? As discussed, the more favorable tax treatment of equity returns argues for holding the equity exposure in his taxable account, while the investments subject to the higher tax rate should be held in the tax-deferred account—the pension plan. Theoretically, this tax efficiency argument can be extended to pension funds operated by publicly traded companies.[16]

16 For those interested in a more detailed discussion of this concept, see "The Case against Stock in Public Pension Funds" (Bader and Gold 2007) or the UBS Q-Series article, "Pension Fund Asset Allocation" (Cooper and Bianco 2003).

4 REVISING THE STRATEGIC ASSET ALLOCATION

An asset owner's strategic asset allocation is not a static decision. Circumstances often arise that justify revisiting the original decision, either to confirm its appropriateness or to consider a change to the current allocation strategy. It is sound financial practice to periodically re-examine the asset allocation strategy even in the absence of one of the external factors discussed next. Many institutional asset owners typically revisit the asset allocation policy at least once every five years through a formal asset allocation study, and all asset owners should affirm annually that the asset allocation remains appropriate given their needs and circumstances.

The circumstances that might trigger a special review of the asset allocation policy can generally be classified as relating to a change in *goals*, a change in *constraints*, or a change in *beliefs*. Among the reasons to review the strategic asset allocation are the following:

Goals

- Changes in business conditions affecting the organization supporting the fund and, therefore, expected changes in the cash flows
- A change in the investor's personal circumstances that may alter her risk appetite or risk capacity

Over an individual's lifespan, or throughout the course of an institutional fund's lifespan, it is unlikely that the investment goals and objectives will remain unchanged. An individual may get married, have children, or become disabled, for example, each of which may have implications for the asset allocation strategy.

Significant changes in the core business of an organization supporting or benefiting from the trust might prompt a re-examination of the asset allocation strategy. For example, an automobile manufacturer that has historically generated a significant portion of its revenues from its consumer finance activities may find that technology is disrupting this source of revenue as more online tools become available to car buyers. With greater uncertainty in its revenue stream, company management may move to reduce risk-taking in the pension fund in order to achieve a goal of reducing the variability in year-to-year contributions.

A university may embark on a long-term capital improvement plan that is reliant on the endowment fund for financial support. Or the university may be experiencing declining enrollments and must lean more heavily on the endowment fund to support its ongoing operational expenditures. The source of funds to a sovereign wealth fund may shrink considerably or even evaporate. When any of these, or similar, events occur or are anticipated, the existing asset allocation policy should be re-evaluated.

Constraints A material change in any one of the constraints mentioned earlier—time horizon, liquidity needs, asset size, or regulatory or other external constraints—is also reason to re-examine the existing asset allocation policy. Some of these changes might include the following:

- Changes in the expected payments from the fund
- A significant cash inflow or unanticipated expenditure
- Changes in regulations governing donations or contributions to the fund
- Changes in time horizon resulting from the adoption of a lump sum distribution option at retirement
- Changes in asset size as a result of the merging of pension plans

Changes in the expected payments from the fund can materially affect the asset allocation strategy. For example, a university reduces its spending policy from 5% to 4% of assets annually; an individual retires early, perhaps for health reasons or an involuntary late-career layoff; or a US corporate pension sponsor reduces or freezes pension benefits because it can no longer afford increasing Pension Benefit Guaranty Corporation[17] premiums. Faced with lower payouts, the university endowment may have greater latitude to invest in less liquid segments of the market. Decisions as to how and where to invest given this greater flexibility should be made within the framework of an asset allocation study to ensure the resulting allocation achieves the optimal trade-off of risk and return.

Similarly, a significant cash inflow has the potential to materially affect the asset allocation strategy. If a university endowment fund with £500 million in assets receives a gift of £100 million, the new monies *could* be invested in parallel with the existing assets, but that fails to consider the increased earning potential of the fund and any spending requirements associated with the donation. Pausing to formally reassess the fund's goals, objectives, constraints, and opportunities through an asset allocation study allows the asset owner to consider more broadly how best to maximize this additional wealth.

A change in regulations may also give rise to a change in asset allocation policy. Examples of regulatory changes that could trigger a re-examination of the asset allocation include the following:

- Regulatory changes in the United States in 2006 mandated a change in the liability discount rate, which resulted in larger pension contributions. With higher required contributions, there was less need to reach for higher investment returns. Many US corporate pension plans began de-risking (adopting an asset allocation strategy focused on hedging the liabilities) to reduce contribution volatility.
- UK tax incentives (30% of social impact investment costs can be deducted from income tax) and relaxed regulations for institutional investors were instituted to encourage socially responsible (impact) investing.

Again, an asset allocation study to objectively evaluate the effect of these changes on the investment opportunity set can help ensure that any new investment strategies adopted are consistent with the fund's overarching goals and objectives.

Beliefs Investment beliefs are a set of guiding principles that govern the asset owner's investment activities. Beliefs are not static, however, and changes in the economic environment and capital market expectations or a change in trustees or committee members are two factors that may lead to an altering of the principles that guide investment activities.[18]

An integral aspect of any asset allocation exercise is the forecasting of expected returns, volatilities, and correlations of the asset classes in the opportunity set. It follows, then, that a material change in the outlook for one or more of the asset classes may heavily influence the asset allocation outcome.

Consider the 2015–2016 environment relative to the environment that prevailed in 1984–2014. The 1984–2014 investing environment was characterized by declining inflation and interest rates (from the extraordinarily high levels of the 1970s and early 1980s); strong global GDP growth, aided by favorable demographics; gains in productivity; and rapid growth in China. Corporate profit growth was extremely robust, reflecting revenue growth from new markets, declining corporate taxes over

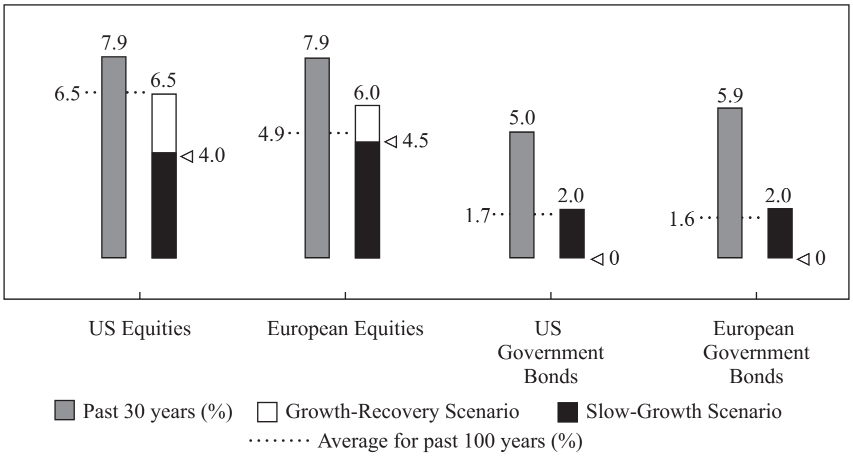
17 The Pension Benefit Guaranty Corporation insures certain US pension plan benefits.

18 For an example of an investment belief statement, see www.uss.co.uk/how-uss-invests/investment-approach/investment-beliefs-and-principles.

the period, and improved efficiencies. Despite increased market turbulence, returns on US and Western European equities and bonds during the past 30 years were considerably higher than the long-run trend.

The environment of 2015–2016 was much less favorable for investors. The dramatic decline in inflation and interest rates ended, and labor force expansion and productivity gains stalled, with negative implications for GDP growth. The largest developed-country companies that generated much of the profits of the past 30 years were faced with competitive pressures as emerging-market companies expanded and technology advances changed the competitive landscape. In April 2016, McKinsey Global Institute published a projection of stocks and bonds under two growth scenarios—a slow growth scenario and a moderate growth scenario (Exhibit 8). In neither instance do the expected returns of the next 30 years come close to the returns of the past 30 years.[19] Clearly, an asset allocation developed in 2010 built on return expectations based on the prior 26 years would look materially different than an asset allocation developed using more current, forward-looking return assumptions.

Exhibit 8 A Major Shift in Underlying Return Assumptions



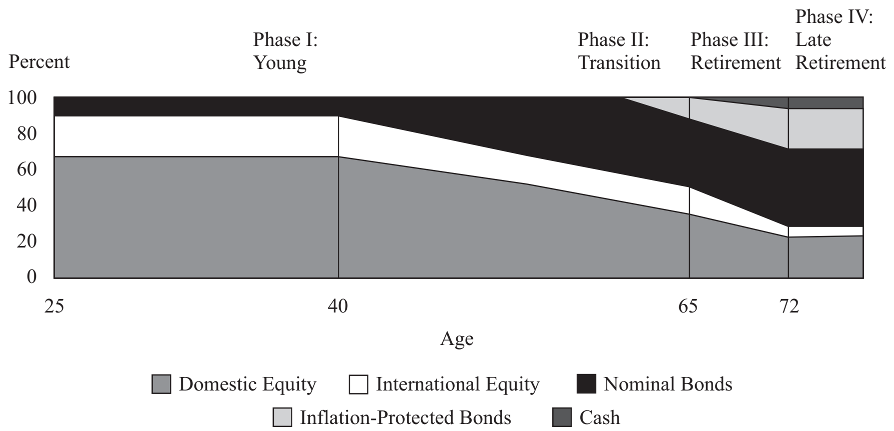
Notes:
Numbers for growth-recovery and slow-growth scenarios reflect the range between the low end of the slow-growth scenario and the high end of the growth-recovery scenario.
European equities: Weighted average real returns based on each year's Geary-Khamis purchasing power parity GDP for 14 countries in Western Europe.
US and European government bonds: Bond duration for United States is primarily 10 years; for Europe, duration varies by country but is typically 20 years.
Source: McKinsey Global Institute (www.mckinsey.com/industries/private-equity-and-principal-investors/our-insights/why-investors-may-need-to-lower-their-sights).

Finally, as new advisers or members join the Investment Committee, they bring their own beliefs and biases regarding certain investment activities. Conducting an asset allocation study to educate these new members of the oversight group and introduce them to the investment philosophy and process that has been adopted by the organization will smooth their integration into the governance system and ensure that they have a holistic view of the asset owner's goals and objectives.

19 McKinsey Global Institute, "Diminishing Returns: Why Investors May Need to Lower Their Expectations" (May 2016).

In some instances, a change to an asset allocation strategy may reasonably be implemented without a formal asset allocation study. Certain milestones are reasonable points at which to implement a change in the policy, in most instances, reducing the level of risk. (For pension funds, these "milestones" are typically related to changes in the plan's funded status.) Anticipating these milestones by putting an asset allocation policy in place that anticipates these changes allows the investor to respond more quickly to changing circumstances and in a non-reactive and objective manner. This rebalancing policy is frequently referred to as a "glide path." Target-date mutual funds common in retirement investing for individuals are one example of this approach to asset allocation. Exhibit 9 illustrates one fund company's approach to migrating the asset allocation away from equities and towards bonds as retirement approaches.

Exhibit 9 An Asset Allocation Glide Path



Source: Vanguard, "Target-Date Funds: A Solid Foundation for Retirement Investors" (May 2009): www.vanguard.com/jumppage/targetretirement/TRFCOMM.pdf.

In an institutional framework, the Investment Committee may specify certain funding levels it seeks to achieve. At the start of the period, an underfunded pension plan might adopt a higher equity allocation in an attempt to reduce the underfunding. If this is successful, the plan becomes better funded and there is less of a desire or need to take the higher level of equity risk. A pension fund may quickly implement "pre-programmed" asset allocation changes as the funded status of a pension plan improves. Typically, these planned reallocations are spelled out in an Investment Policy Statement.

EXAMPLE 6

Revising the Strategic Asset Allocation

1 Auldberg University Endowment Fund (AUE) has assets totaling CAF$200 million. The current asset allocation is as follows:

- CAF$100 million in domestic equities
- CAF$60 million in domestic government debt
- CAF$40 million in Class B office real estate

AUE has historically distributed to the University 5% of the 36-month moving average of net assets, contributing approximately CAF$10 million of Auldberg University's CAF$60 million annual operating budget. Real estate income (from the University's CAF$350 million direct investment in domestic commercial real estate assets, including office buildings and industrial parks, much of it near the campus) and provincial subsidies have been the main source of income to the University. Admission is free to all citizens who qualify academically.

Growth in the Caflandia economy has been fueled by low interest rates, encouraging excess real estate development. There is a strong probability that the economy will soon go into recession, negatively impacting both the property values and the income potential of the University's real estate holdings.

Gizi Horvath, a University alumnus, has recently announced an irrevocable CAF$200 million gift to AUE, to be paid in equal installments over the next five years. AUE employs a well-qualified staff with substantial diverse experience in equities, fixed income, and real estate. Staff has recommended that the gift from Ms. Horvath be invested using the same asset allocation policy that the endowment has been following successfully for the past five years. They suggest that the asset allocation policy should be revisited once the final installment has been received.

Critique staff's recommendation, and identify the case facts that support your critique.

2 The Government Petroleum Fund of Caflandia (GPFC) is operating under the following asset allocation policy, which was developed with a 20-year planning horizon. Target weights and actual weights are given:

	Target Asset Allocation	Current Asset Allocation
Global equities	30%	38%
Global high-yield bonds	10%	15%
Domestic intermediate bonds	30%	25%
Hedge funds	15%	15%
Private equity	15%	7%

When this asset allocation policy was adopted 5 years ago, the petroleum revenues that support the sovereign wealth fund were projected to continue to grow for at least the next 25 years and intergenerational distributions were expected to begin in 20 years. However, since the adoption of this policy, alternate fuel sources have eroded both the price and quantity of oil exports, the economy is undergoing significant restructuring, inflows to the fund have been suspended, and distributions are expected to begin within 5 years.

What are the implications of this change in the liquidity constraints for the current asset allocation policy?

3 O-Chem Corp has a defined benefit pension plan with US$1.0 billion in assets. The plan is closed, the liabilities are frozen, and the plan is currently 65% funded. The company intends to increase cash contributions to improve the funded status of the plan and then purchase annuities to fully address all of the plan's pension obligations. As part of an asset allocation analysis conducted every five years, the company has recently decided to allocate 80% of assets to liability-matching bonds and the remaining 20%

to a mix of global equities and real estate. An existing private equity portfolio is in the midst of being liquidated. This allocation reflects a desired reduction in the level of investment risk.

O-Chem has just announced an ambitious US$15 billion capital investment program to build new plants for refining and production. The CFO informed the Pension Committee that the company will be contributing to the plan only the minimum funding required by regulations for the foreseeable future. It is estimated that achieving fully funded status for the pension plan under minimum funding requirements and using the current asset allocation approach will take at least 10 years.

What are the implications of this change in funding policy for the pension plan's asset allocation strategy?

Solution to 1:

The size of the anticipated contributions will double AUE's assets over the next five years, potentially increasing the opportunity set of asset classes suitable for their investment program. Given that a typical asset allocation study encompasses a long investment horizon—10 years, 20 years, or more—staff should begin to evaluate the opportunities available to them today in *anticipation* of the future cash flows. Given the material change in the economic balance sheet along with changes in the asset size, liquidity, and time horizon constraints, AUE should plan on a regular, more frequent, formal review of the asset allocation policy until the situation stabilizes. The asset allocation study should explore the feasibility of adding new asset classes as well as the ability to improve diversification within existing categories, perhaps by including non-domestic equities and bonds. Furthermore, the forecast economic environment may materially alter the outflows from the fund in support of the University's day-to-day operations. Cash flows from the University's real estate holdings are likely to decline, as are the values of those real estate assets. Given the outlook for real estate, a strong case can be made to limit or reduce the endowment's investment in real estate; moreover, consideration should be given to the effect of declining income from the current real estate investment.

Solution to 2:

GPFC had adopted a long-range asset allocation policy under the expectation of continuing net cash inflows and no immediate liquidity constraints. With the change in circumstances, the need for liquidity in the fund has increased significantly. The current asset allocation policy allocates 40% of the fund's assets to less liquid asset classes—high-yield bonds, hedge funds, and private equity. Although the allocation to private equity has not been fully implemented, the fund is overweight high-yield bonds and at the target weight for hedge funds. These asset classes—or the size of the allocation to these asset classes—may no longer be appropriate for the fund given the change in circumstances.

Solution to 3:

The Investment Committee should conduct a new asset allocation study to address the changes in cash flow forecasts. The lower contributions imply that the pension plan will need to rely more heavily on investment returns to reach its funding objectives. A higher allocation to return-seeking assets, such as public and private equities, is warranted. The company should suspend the current private equity liquidation plan until the new asset allocation study has been completed. A liability-matching bond portfolio is still appropriate, although less than the current 80% of assets should be allocated to this portfolio.

5 SHORT-TERM SHIFTS IN ASSET ALLOCATION

Strategic asset allocation (SAA), or policy asset allocation, represents long-term investment policy targets for asset class weights, whereas tactical asset allocation (TAA) allows short-term deviations from SAA targets.[20] TAA moves might be justified based on cyclical variations within a secular trend (e.g., stage of business or monetary cycle) or temporary price dislocations in capital markets. TAA has the objective of increasing return, or risk-adjusted return, by taking advantage of short-term economic and financial market conditions that appear more favorable to certain asset classes. In seeking to capture a short-term return opportunity, TAA decisions move the investor's risk away from the targeted risk profile. TAA is predicated on a belief that investment returns, in the short run, are predictable. (This contrasts with the random walk assumption more strongly embedded in most SAA processes.) Using either short-term views or signals, the investor actively re-weights broad asset classes, sectors, or risk factor premiums. TAA is not concerned with individual security selection. In other words, generating alpha through TAA decisions is dependent on successful market or factor timing rather than security selection. TAA is an asset-only approach. Although tactical asset allocation shifts must still conform to the risk constraints outlined in the investment policy statement, they do not expressly consider liabilities (or goals in goals-based investing).

The SAA policy portfolio is the benchmark against which TAA decisions are measured. Tactical views are developed and bets are sized relative to the asset class targets of the SAA policy portfolio. The sizes of these bets are typically subject to certain risk constraints. The most common risk constraint is a pre-established allowable range around each asset class's policy target. Other risk constraints may include either a predicted tracking error budget versus the SAA or a range of targeted risk (e.g., an allowable range of predicted volatility).

The success of TAA decisions can be evaluated in a number of ways. Three of the most common are

- a comparison of the Sharpe ratio realized under the TAA relative to the Sharpe ratio that would have been realized under the SAA;
- evaluating the information ratio or the *t*-statistic of the average excess return of the TAA portfolio relative to the SAA portfolio; and
- plotting the realized return and risk of the TAA portfolio versus the realized return and risk of portfolios along the SAA's efficient frontier. This approach is particularly useful in assessing the risk-adjusted TAA return. The TAA portfolio may have produced a higher return or a higher Sharpe ratio than the SAA portfolio, but it could be less optimal than other portfolios along the investor's efficient frontier of portfolio choices.

The composition of the portfolio's excess return over the SAA portfolio return can also be examined more closely using attribution analysis, evaluating the specific overweights and underweights that led to the performance differential.

Tactical investment decisions may incur additional costs—higher trading costs and taxes (in the case of taxable investors). Tactical investment decisions can also increase the concentration of risk relative to the policy portfolio. For example, if the tactical decision is to overweight equities, not only is the portfolio risk increased but

20 SAA and TAA are distinct from GTAA (global tactical asset allocation), an opportunistic investment strategy that seeks to take advantage of pricing or valuation anomalies across multiple asset classes, typically equities, fixed income, and currencies.

also the diversification of risk contributions is reduced. This is particularly an issue when the SAA policy portfolio relies on uncorrelated asset classes. These costs should be weighed against the predictability of short-term returns.

There are two broad approaches to TAA. The first is discretionary, which relies on a qualitative interpretation of political, economic, and financial market conditions. The second is systematic, which relies on quantitative signals to capture documented return anomalies that may be inconsistent with market efficiency.

5.1 Discretionary TAA

Discretionary TAA is predicated on the existence of manager skill in predicting and timing short-term market moves away from the expected outcome for each asset class that is embedded in the SAA policy portfolio. In practice, discretionary TAA is typically used in an attempt to mitigate or hedge risk in distressed markets while enhancing return in positive return markets (i.e., an asymmetric return distribution).

Short-term forecasts consider a large number of data points that provide relevant information about current and expected political, economic, and financial market conditions that may affect short-term asset class returns. Data points might include valuations, term and credit spreads, central bank policy, GDP growth, earnings expectations, inflation expectations, and leading economic indicators. Price-to-earnings ratios, price-to-book ratios, and the dividend yield are commonly used valuation measures that can be compared to historical averages and across similar assets to inform short-to-intermediate-term tactical shifts. Term spreads provide information about the business cycle, inflation, and potential future interest rates. Credit spreads gauge default risk, borrowing conditions, and liquidity. Other data points are more directly related to current and expected GDP and earnings growth.

Short-term forecasts may also consider economic sentiment indicators. TAA often assumes a close relationship between the economy and capital market returns. Because consumer spending is a major driver of GDP in developed countries, consumer sentiment is a key consideration. Consumer confidence surveys provide insight as to the level of optimism regarding the economy and personal finances.

TAA also considers market sentiment—indicators of the optimism or pessimism of financial market participants. Data points considered in gauging market sentiment include margin borrowing, short interest, and a volatility index.

- Margin borrowing measures give an indication of the current level of bullishness, and the capacity for more or less margin borrowing has implications for future bullishness. Higher prices tend to inspire confidence and spur more buying; similarly, more buying on margin tends to spur higher prices. The aggregate level of margin can be an indicator that bullish sentiment is overdone, although the level of borrowing must be considered in the context of the rate of change in borrowing.
- Short interest measures give an indication of current bearish sentiment and also have implications for future bearishness. Although rising short interest indicates increasing negative sentiment, a high short interest ratio may be an indication of the extreme pessimism that often occurs at market lows.
- The volatility index, commonly known as the fear index, is a measure of market expectations of near-term volatility. VDAX-NEW in Germany, V2X in the United Kingdom, and VIX in the United States each measure the level of expected volatility of their respective indexes as implied by the bid/ask quotations of index options; it rises when put option buying increases and falls when call buying activity increases.

Different approaches to discretionary TAA may include different data points and relationships and also may prioritize and weight those data points differently depending on both the approach and the prevailing market environment. Despite the plethora of data inputs, the interpretation of this information is qualitative at its core.

5.2 Systematic TAA

Using signals, systematic TAA attempts to capture asset class level return anomalies that have been shown to have some predictability and persistence. Value and momentum, for example, are factors that have been determined to offer some level of predictability, both among securities within asset classes (for security selection) and at the asset class level (for asset class timing).

The value factor is the return of value stocks over the return of growth stocks. The momentum factor is the return of stocks with higher prior returns over the return of stocks with lower prior returns. Value and momentum (and size) factors have been determined to have some explanatory power regarding the relative returns of equity securities within the equity asset class. Value and momentum phenomena are also present at the asset class level and can be used in making tactical asset allocation decisions across asset classes.

Valuation ratios have been shown to have some explanatory power in predicting variation in future equity returns. Predictive measures for equities include dividend yield, cash flow yield, and Shiller's earnings yield (the inverse of Shiller's P/E[21]). Sometimes these yield measures are defined as the excess of the yield over the local risk-free rate or inflation.[22]

Other asset classes have their own value signals, such as yield and carry in currencies, commodities, and/or fixed income. Carry in currencies uses short-term interest rate differentials to determine which currencies (or currency-denominated assets) to overweight (or own) and which to underweight (or sell short). Carry in commodities compares positive (backwardation) and negative (contango) roll yields to determine which commodities to own or short. And for bonds, yields-to-maturity and term premiums (yields in excess of the local risk-free rate) signal the relative attractiveness of different fixed-income markets.

Asset classes can trend positively or negatively for some time before changing course. Trend following is an investment or trading strategy based on the expectation that asset class (or asset) returns will continue in the same upward or downward trend that they have most recently exhibited.[23] A basic trend signal is the most recent 12-month return: The expectation is that the direction of the most recent 12-month returns can be expected to persist for the next 12 months. Shorter time frames and different weighting schemes can also be used. For example, another trend signal is the moving-average crossover, where the moving average price of a shorter time frame is compared with the moving average price of a longer time frame. This signals an upward (downward) trend when the moving average of the shorter time frame is above (below) the moving average of the longer time frame. Trend signals are widely used in systematic TAA. Asset classes may be ranked or categorized into positive or negative buckets based on their most recent prior 12-month performance and over- or

21 A price-to-earnings ratio based on the average inflation-adjusted earnings of the previous 10 years.

22 Return predictability for equity markets is driven by historical mean-reversion, which tends to occur over the intermediate-term. These valuation measures are often used as signals for TAA, but they can also be used to shape return expectations for SAA.

23 Trend following is also called time-series momentum. Cross-sectional momentum describes the relative momentum returns of securities within the same asset class.

underweighted accordingly. More-complex signals for both momentum/trend signals (such as those that use different lookback periods or momentum signals correlated with earnings momentum) and value/carry are also used.

EXAMPLE 7

Short-Term Shifts in Asset Allocation

1 The investment policy for Alpha Beverage Corporation's pension fund allows staff to overweight or underweight asset classes, within pre-established bands, using a TAA model that has been approved by the Investment Committee. The asset allocation policy is reflected in Exhibit 10, and the output of the TAA model is given in Exhibit 11. Using the data presented in Exhibits 10 and 11, recommend a TAA strategy for the pension fund and justify your response.

Exhibit 10 Strategic Asset Allocation Policy

SAA Policy	Current Weight	Target Allocation	Upper Policy Limit	Lower Policy Limit
Investment-grade bonds	45%	40%	45%	35%
High-yield bonds	10%	10%	15%	5%
Developed markets equity	35%	40%	45%	35%
Emerging markets equity	10%	10%	15%	5%

Exhibit 11 Trend Signal (the positive or negative trailing 12-month excess return)

	12-Month Return	Risk-Free Return	Excess Return	Signal
Investment-grade bonds	4%	1%	3%	Long
High-yield bonds	–2%	1%	–3%	Short
Developed markets equity	5%	1%	4%	Long
Emerging markets equity	–10%	1%	–11%	Short

2 One year later, the Investment Committee for Alpha Beverage Corporation is conducting its year-end review of pension plan performance. Staff has prepared the following exhibits regarding the tactical asset allocation decisions taken during the past year. Assume that all investments are implemented using passively managed index funds. Evaluate the effectiveness of the TAA decisions.

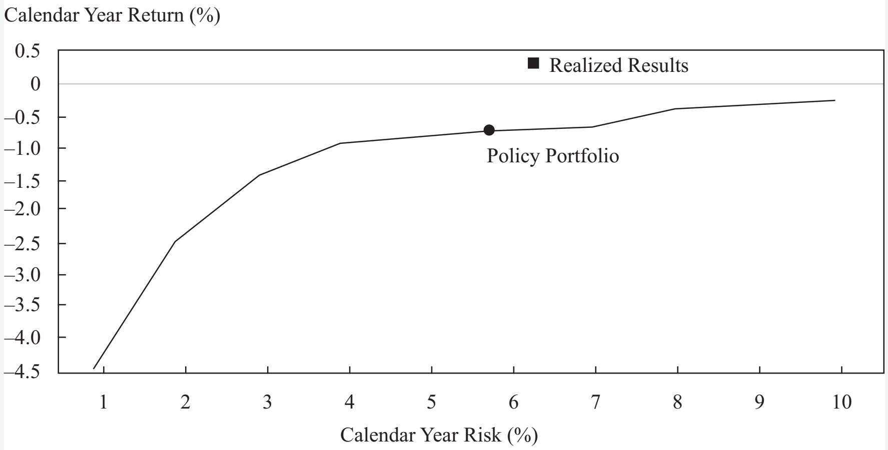
Exhibit 12A

Asset Class	Asset Allocation	Calendar Year Return
Investment-grade bonds	45%	3.45%
High-yield bonds	5%	–6.07%
Developed markets equity	45%	–0.32%
Emerging markets equity	5%	–14.60%

Exhibit 12B

	Policy Portfolio	Realized Results
12-month return	–0.82%	0.38%
Risk-free rate	0.50%	0.50%
Standard deviation	5.80%	6.20%
Sharpe ratio	–0.23	–0.02

Exhibit 12C



Solution to 1:

The TAA decision must be taken in the context of the SAA policy constraints. Thus, although the signals for high-yield bonds and emerging market equities are negative, the minimum permissible weight in each is 5%. Similarly, although the signals for investment-grade bonds and developed markets equities are positive, the maximum permissible weight in each is 45%. Asset classes can be over- or underweighted to the full extent of the policy limits. Based on the trend signals and the policy constraints, the recommended tactical asset allocation is as follows:

- Investment-grade bonds 45% *(overweight by 5%)*
- High-yield bonds 5% *(underweight by 5%)*
- Developed markets equity 45% *(overweight by 5%)*
- Emerging markets equity 5% *(underweight by 5%)*

Solution to 2:

The decision to overweight investment grade bonds and underweight emerging markets equity and high-yield bonds was a profitable one. The chosen asset allocation added approximately 120 basis points to portfolio return over the year. Although portfolio risk was elevated relative to the policy portfolio (standard deviation of 6.2% versus 5.8% for the policy portfolio), the portfolio positioning improved the fund's Sharpe ratio relative to allocations they might have selected along the efficient frontier.

A Silver Lining to the 2008–2009 Financial Crisis

Prior to 2008, corporate pension plans had begun to shift the fixed-income component of their policy portfolios from an intermediate maturity bond index to a long bond index. Despite the relatively low interest rates at the time, this move was made to better align the plans' assets with the long duration liability payment stream. The fixed-income portfolios were typically benchmarked against a long government and credit index that included both government and corporate bonds. Swaps or STRIPS* were sometimes used to extend duration.

During the financial crisis that began in 2008, these heavier and longer-duration fixed-income positions performed well relative to equities (the long government and credit index was up 8%, whereas the S&P 500 Index was down 37% in 2008), providing plan sponsors with a level of investment protection that had not been anticipated. Additionally, with its exposure to higher-returning government bonds that benefited from investors' flight to safety, this fixed-income portfolio often outperformed the liabilities. (Recall from the earlier discussion on pension regulation that pension liabilities are typically measured using corporate bond yields. Thus, liabilities rose in the face of declining corporate bond yields while the liability-hedging asset rose even further given its overall higher credit quality.) This was an unintended asset/liability mismatch that had very positive results. Subsequent to this rally in bonds, some plan sponsors made a tactical asset allocation decision—to move out of swaps and government bonds and into physical corporate bonds (non-derivative fixed-income exposure)—locking in the gains and better hedging the liability.

* Treasury STRIPS are fixed-income securities with no interest payments that are sold at a discount to face value and mature at par. STRIPS is an acronym for Separate Trading of Registered Interest and Principal of Securities.

6 DEALING WITH BEHAVIORAL BIASES IN ASSET ALLOCATION

Although global capital markets are competitive pricing engines, human behavior can be less rational than most economic models assume. Behavioral finance—the hybrid study of financial economics and psychology—has documented a number of behavioral biases that commonly arise in investing. The CFA Program reading "The Behavioral Biases of Individuals" discusses 16 common behavioral biases. The biases most relevant in asset allocation include loss aversion, the illusion of control, mental accounting, representativeness bias, framing, and availability bias. An effective investment program will address these decision-making risks through a formal asset allocation process with its own objective framework, governance, and controls. An important first step toward mitigating the negative effects of behavioral biases is simply acknowledging that they exist; just being aware of them can reduce their influence on decision making. It is also possible to incorporate certain behavioral biases into the investment decision-making process to produce better outcomes. This is most commonly practiced in goals-based investing. We will discuss strategies that help deal with these common biases.

6.1 Loss Aversion

Loss-aversion bias is an emotional bias in which people tend to strongly prefer avoiding losses as opposed to achieving gains. A number of studies on loss aversion suggest that, psychologically, losses are significantly more powerful than gains. The utility derived from a gain is much lower than the utility given up with an equivalent loss. This behavior is related to the marginal utility of wealth, where each additional dollar of wealth is valued incrementally less with increasing levels of wealth.

A diversified multi-asset class portfolio is generally thought to offer an approximately symmetrical distribution of returns around a positive expected mean return. Financial market theory suggests that a rational investor would think about risk as the dispersion or uncertainty (variance) around the mean (expected) outcome. However, loss aversion suggests the investor assigns a greater weight to the negative outcomes than would be implied by the actual shape of the distribution. Looking at this another way, risk is not measured relative to the expected mean return but rather on an absolute basis, relative to a 0% return. The loss-aversion bias may interfere with an investor's ability to maintain his chosen asset allocation through periods of negative returns.

In goals-based investing, loss-aversion bias can be mitigated by framing risk in terms of shortfall probability or by funding high-priority goals with low-risk assets.

Shortfall probability is the probability that a portfolio will not achieve the return required to meet a stated goal. Where there are well-defined, discrete goals, sub-portfolios can be established for each goal and the asset allocation for that sub-portfolio would use shortfall probability as the definition of risk.

Similarly, by segregating assets into sub-portfolios aligned to goals designated by the client as high-priority and investing those assets in risk-free or low risk assets of similar duration, the adviser mitigates the loss-aversion bias associated with this particular goal—freeing up other assets to take on a more appropriate level of risk. Riskier assets can then be used to fund lower-priority and aspirational goals.

In institutional investing, loss aversion can be seen in the herding behavior among plan sponsors. Adopting an asset allocation not too different from the allocation of one's peers minimizes reputation risk.

6.2 Illusion of Control

The illusion of control is a cognitive bias—the tendency to overestimate one's ability to control events. It can be exacerbated by overconfidence, an emotional bias. If investors believe they have more or better information than what is reflected in the market, they have (excessive) confidence in their ability to generate better outcomes. They may perceive *information* in what are random price movements, which may lead to more frequent trading, greater concentration of portfolio positions, or a greater willingness to employ tactical shifts in their asset allocation. The following investor behaviors might be attributed to this illusion of control:

- Alpha-seeking behaviors, such as attempted market timing in the form of extreme tactical asset allocation shifts or all in/all out market calls—the investor who correctly anticipated a market reversal now believes he has superior insight on valuation levels.
- Alpha-seeking behaviors based on a belief of superior resources—the institutional investor who believes her internal resources give her an edge over other investors in active security selection and/or the selection of active investment managers.
- Excessive trading, use of leverage, or short selling—the long/short equity investor who moves from a normal exposure range of 65% long/20% short to 100% long/50% short.
- Reducing, eliminating, or even shorting asset classes that are a significant part of the global market portfolio based on non-consensus return and risk forecasts—the chair of a foundation's investment committee who calls for shortening the duration of the bond portfolio from six years to six months based on insights drawn from his position in the banking industry.
- Retaining a large, concentrated legacy asset that contributes diversifiable risk—the employee who fails to diversify her holding of company stock.

Hindsight bias—the tendency to perceive past investment outcomes as having been predictable—exacerbates the illusion of control.

In the asset allocation process, an investor who believes he or she has better information than others may use estimates of return and risk that produce asset allocation choices that are materially different from the market portfolio. This can result in undiversified portfolios with outsized exposures to just one or two minor asset classes, called extreme corner portfolios. Using such biased risk and return estimates results in a biased asset allocation decision—precisely what an objective asset allocation process seeks to avoid.

The illusion of control can be mitigated by using the global market portfolio as the starting point in developing the asset allocation. Building on the basic principles of CAPM, Markowitz's mean–variance theory, and efficient market theory, the global market portfolio offers a theoretically sound benchmark for asset allocation. Deviations from this baseline portfolio must be thoughtfully considered and rigorously vetted, ensuring the asset allocation process remains objective. A formal asset allocation process that employs long-term return and risk forecasts, optimization constraints anchored around asset class weights in the global market portfolio, and strict policy ranges will significantly mitigate the illusion of control bias in asset allocation.

6.3 Mental Accounting

Mental accounting is an information-processing bias in which people treat one sum of money differently from another sum based solely on the mental account the money is assigned to. Investors may separate assets or liabilities into buckets based on subjective criteria. For example, an investor may consider his retirement investment portfolio independent of the portfolio that funds his child's education, even if the combined asset allocation of the two portfolios is sub-optimal. Or an employee with significant exposure to her employer's stock through vested stock options may fail to consider this exposure alongside other assets when establishing a strategic asset allocation.

Goals-based investing incorporates mental accounting directly into the asset allocation solution. Each goal is aligned with a discrete sub-portfolio, and the investor can specify the acceptable level of risk for each goal. Provided each of the sub-portfolios lies along the same efficient frontier, the sum of the sub-portfolios will also be efficient.[24]

Concentrated stock positions also give rise to another common mental accounting issue that affects asset allocation. For example, the primary source of an entrepreneur's wealth may be a concentrated equity position in the publicly traded company he founded. The entrepreneur may prefer to retain a relatively large exposure to this one security within his broader investment portfolio despite the inherent risk. Although there may be rational reasons for this preference—including ownership control, an information advantage, and tax considerations—the desire to retain this riskier exposure is more often the result of a psychological loyalty to the asset that generated his wealth. This mental accounting bias is further reinforced by the endowment effect—the tendency to ascribe more value to an asset already owned rather than another asset one might purchase to replace it.

The concentrated stock/mental accounting bias can be accommodated in goals-based asset allocation by assigning the concentrated stock position to an aspirational goal—one that the client would *like* to achieve but to which he or she is willing to assign a lower probability of success. Whereas lifetime consumption tends to be a high-priority goal requiring a well-diversified portfolio to fund it with confidence, an aspirational goal such as a charitable gift may be an important but much less highly valued goal. It can reasonably be funded with the concentrated stock position. (This could have the additional benefit of avoiding capital gains tax altogether!)

6.4 Representativeness Bias

Representativeness, or recency, bias is the tendency to overweight the importance of the most recent observations and information relative to a longer-dated or more comprehensive set of long-term observations and information. Tactical shifts in asset allocation, those undertaken in response to recent returns or news—perhaps shifting the asset allocation toward the highest or lowest allowable ends of the policy ranges—are particularly susceptible to recency bias. Return chasing is a common manifestation of recency bias, and it results in overweighting asset classes with good recent performance.

It is believed that asset prices largely follow a random walk; past prices cannot be used to predict future returns. If this is true, then shifting the asset allocation in response to recent returns, or allowing recent returns to unduly influence the asset class assumptions used in the asset allocation process, will likely lead to sub-optimal results. *If,* however, asset class returns exhibit trending behavior, the recent past *may* contain information relevant to tactical shifts in asset allocation. And if asset class returns are mean-reverting, comparing current valuations to historical norms may signal the potential for a reversal or for above-average future returns.

Recency bias is not uniformly negative. Random walk, trending, and mean-reversion may be simultaneously relevant to the investment decision-making process, although their effect on asset prices will unfold over different time horizons. The strongest defenses against recency bias are an objective asset allocation process and a strong governance framework. It is important that the investor objectively evaluate the motivation underlying the response to recent market events. A formal asset allocation policy with pre-specified allowable ranges will constrain recency bias. A strong

24 This condition holds when the asset allocation process is unconstrained. With a long-only constraint, some efficiency is lost but the effect is much less significant than the loss of efficiency from inaccurately specifying risk aversion (which goals-based approaches to asset allocation attempt to mitigate). See Das, Markowitz, Scheid, and Statman (2010) and Das et al. (2011).

governance framework with the appropriate level of expertise and well-documented investment beliefs increases the likelihood that shifts in asset allocation are made objectively and in accordance with those beliefs.

6.5 Framing Bias

Framing bias is an information-processing bias in which a person may answer a question differently based solely on the way in which it is asked. One example of framing bias is common in committee-oriented decision-making processes. In instances where one individual frequently speaks first and speaks with great authority, the views of other committee members may be suppressed or biased toward this first position put on the table.

A more nuanced form of framing bias can be found in asset allocation. The investor's choice of an asset allocation may be influenced merely by the manner in which the risk-to-return trade-off is presented.

Risk can mean different things to different investors: volatility, tail risk, the permanent loss of capital, or a failure to meet financial goals. These definitions are all closely related, but the relative importance of each of these aspects can influence the investor's asset allocation choice. Further, the investor's perception of each of these risks can be influenced by the manner in which they are presented—gain and loss potential framed in money terms versus percentages, for example.

Investors are often asked to evaluate portfolio choices using expected return, with standard deviation as the sole measure of risk. Standard deviation measures the dispersion or volatility around the mean (expected) return. Other measures of risk may also be used. Value at risk (VaR) is a loss threshold: "If I choose this asset mix, I can be pretty sure that my losses will not exceed X, most of the time." More formally, VaR is the minimum loss that would be expected a certain percentage of the time over a certain period of time given the assumed market conditions. Conditional value at risk (CVaR) is the probability-weighted average of losses when the VaR threshold is breached. VaR and CVaR both measure downside or tail risk.

Exhibit 13 shows the expected return and risk for five portfolios that span an efficient frontier from P1 (lowest risk) to P100 (highest risk). A normal distribution of returns is assumed; therefore, the portfolio's VaR and CVaR are a direct function of the portfolio's expected return and standard deviation. In this case, standard deviation, VaR, and CVaR measure precisely the same risk but frame that risk differently. Standard deviation presents that risk as volatility, while VaR and CVaR present it as risk of loss. When dealing with a normal distribution, as this example presumes, the 5% VaR threshold is simply the point on the distribution 1.65 standard deviations below the expected mean return.

Exhibit 13 There's More Than One Way to Frame Risk

	P1	P25	P50	P75	P100
Return	3.2%	4.9%	6.0%	7.0%	8.0%
Std. Dev.	3.9%	7.8%	11.9%	15.9%	20.0%
VaR (5%)	–3.2%	–8.0%	–13.6%	–19.3%	–25.0%
CVaR (5%)	–4.8%	–11.2%	–18.5%	–25.8%	–33.2%

When viewing return and volatility alone, many investors may gravitate to P50 with its 6.0% expected return and 11.9% standard deviation. P50 represents the median risk portfolio that appeals to many investors in practice because it balances high-risk and low-risk choices with related diversification benefits. However, loss-aversion bias suggests that some investors who gravitate to the median choice might actually find the −18.5% CVaR of P50 indicative of a level of risk they find very uncomfortable. The CVaR frame intuitively communicates a different perspective of exactly the same risk that is already fully explained by standard deviation—namely, the downside or tail-risk aspects of the standard deviation and mean. With this example, you can see that how risk is framed and presented can affect the asset allocation decision.

The framing effect can be mitigated by presenting the possible asset allocation choices with multiple perspectives on the risk/reward trade-off. The most commonly used risk measure—standard deviation—can be supplemented with additional measures, such as **shortfall probability** (the probability of failing to meet a specific liability or goal)[25] and tail-risk measures (e.g., VaR and CVaR). Historical stress tests and Monte Carlo simulations can also be used to capture and communicate risk in a tangible way. These multiple perspectives of the risk and reward trade-offs among a set of asset allocation choices compel the investor to consider more carefully what outcomes are acceptable or unacceptable.

6.6 Availability Bias

Availability bias is an information-processing bias in which people take a mental shortcut when estimating the probability of an outcome based on how easily the outcome comes to mind. Easily recalled outcomes are often perceived as being more likely than those that are harder to recall or understand. For example, more recent events or events in which the investor has personally been affected are likely to be assigned a higher probability of occurring again, regardless of the objective odds of the event actually occurring.

As an example, many private equity investors experienced a liquidity squeeze during the financial crisis that began in 2008. Their equity portfolios had suffered large losses, and their private equity investments were illiquid. Worse yet, they were contractually committed to additional capital contributions to those private equity funds. At the same time, their financial obligations continued at the same or an even higher pace. Investors who personally experienced this confluence of negative events are likely to express a strong preference for liquid investments, assigning a higher probability to such an event occurring again than would an investor who had cash available to acquire the private equity interests that were sold at distressed prices.

Familiarity bias stems from availability bias: People tend to favor the familiar over the new or different because of the ease of recalling the familiar. In asset allocation, familiarity bias most commonly results in a **home bias**—a preference for securities listed on the exchanges of one's home country. However, concentrating portfolio exposure in home country securities, particularly if the home country capital markets are small, results in a less diversified, less efficient portfolio. Familiarity bias can be mitigated by using the global market portfolio as the starting point in developing the asset allocation, where deviations from this baseline portfolio must be thoughtfully considered and rigorously vetted.

Familiarity bias may also cause investors to fall into the trap of comparing their investment decisions (and performance) to others', without regard for the appropriateness of those decisions for their own specific facts and circumstances. By avoiding

25 Shortfall risk and shortfall probability are often used to refer to the same concept. This author prefers shortfall probability because the measure refers to the probability of shortfall, not the magnitude of the potential shortfall. For example, you may have a low probability of shortfall but the size of the shortfall could be significant. In this case, it could be misleading to say the shortfall risk is low.

comparison of investment returns or asset allocation decisions with others, an organization is more capable of identifying the asset allocation that is best tailored to their needs.

Investment decision making is subject to a wide range of potential behavioral biases. This is true in both private wealth *and* institutional investing. Employing a formal asset allocation process using the global market portfolio as the starting point for asset allocation modeling is a key component of ensuring the asset allocation decision is as objective as possible.

A strong governance structure, such as that discussed in the overview reading on asset allocation, is a necessary first step to mitigating the effect that these behavioral biases may have on the long-term success of the investment program. Bringing a diverse set of views to the deliberation process brings more tools to the table to solve any problem and leads to better and more informed decision making. A clearly stated mission—a common goal—and a commitment from committee members and other stakeholders to that mission are critically important in constraining the influence of these biases on investment decisions.

Effective Investment Governance

Six critical elements of effective investment governance are

1. clearly articulated long- and short-term investment objectives of the investment program;
2. allocation of decision rights and responsibilities among the functional units in the governance hierarchy, taking account of their knowledge, capacity, time, and position in the governance hierarchy;
3. established processes for developing and approving the investment policy statement that will govern the day-to-day operation of the investment program;
4. specified processes for developing and approving the program's strategic asset allocation;
5. a reporting framework to monitor the program's progress toward the agreed-upon goals and objectives; and
6. periodic governance audits.

EXAMPLE 8

Mitigating Behavioral Biases in Asset Allocation

Ivy Lee, the retired founder of a publicly traded company, has two primary goals for her investment assets. The first goal is to fund lifetime consumption expenditures of US$1 million per year for herself and her husband; this is a goal the Lees want to achieve with a high degree of certainty. The second goal is to provide an end-of-life gift to Auldberg University. Ivy has a diversified portfolio of stocks and bonds totaling US$5 million and a sizable position in the stock of the company she founded. The following table summarizes the facts.

Investor Profile	
Annual consumption needs	US$1,000,000
Remaining years of life expectancy	40
Diversified stock holdings	US$3,000,000
Diversified bond holdings	US$2,000,000
Concentrated stock holdings	US$15,000,000
Total portfolio	US$20,000,000

Assume that a 60% equity/40% fixed-income portfolio represents the level of risk Ivy is willing to assume with respect to her consumption goal. This 60/40 portfolio offers an expected return of 6.0%. (For simplicity, this illustration ignores inflation and taxes.)

The present value of the expected consumption expenditures is US$15,949,075. This is the amount needed on hand today, which, if invested in a portfolio of 60% equities and 40% fixed income, would fully fund 40 annual cash distributions of US$1,000,000 each.[26]

The concentrated stock has a highly uncertain expected return and comes with significant idiosyncratic (stock-specific) risk. A preliminary mean–variance optimization using three "asset classes"—stocks, bonds, and the concentrated stock—results in a zero allocation to the concentrated stock position. But Ivy prefers to retain as much concentrated stock as possible because it represents her legacy and she has a strong psychological loyalty to it.

1 Describe the behavioral biases most relevant to developing an asset allocation recommendation for Ivy.
2 Recommend and justify an asset allocation for Ivy given the facts presented above.

Solution to 1:

Two behavioral biases that the adviser must be aware of in developing an asset allocation recommendation for Ivy are illusion of control and mental accounting. Because Ivy was the founder of the company whose stock comprises 75% of her investment portfolio, she may believe she has more or better information about the return prospects for this portion of the portfolio. The belief that she has superior information may lead to a risk assessment that is not reflective of the true risk in the holding. Using a goals-based approach to asset allocation may help Ivy more fully understand the risks inherent in the concentrated stock position. The riskier, concentrated stock position can be assigned to a lower-priority goal, such as the gift to Auldberg University.

Solution to 2:

	Beginning Asset Allocation	Recommended Asset Allocation
Diversified stocks	US$3,000,000	US$9,600,000
Diversified bonds	US$2,000,000	US$6,400,000
Funding of lifestyle goal		*US$16,000,000*

26 Assumes cash distributions occur at the beginning of the year and the expected return is the geometric average.

	Beginning Asset Allocation	Recommended Asset Allocation
Concentrated stock	US$15,000,000	US$4,000,000
Total portfolio	US$20,000,000	US$20,000,000

It is recommended that Ivy fully fund her high-priority lifestyle consumption needs (US$15,949,075) with US$16 million in a diversified portfolio of stocks and bonds. To achieve this, US$11 million of the concentrated stock position should be sold and the proceeds added to the diversified portfolio that supports lifestyle consumption needs. The remaining US$4 million of concentrated stock can be retained to fund the aspirational goal of an end-of-life gift to Auldberg University. In this example, the adviser has employed the mental accounting bias to achieve a suitable outcome: By illustrating the dollar value needed to fund the high-priority lifetime consumption needs goal, the adviser was able to clarify for Ivy the risks in retaining the concentrated stock position. The adviser might also simulate portfolio returns and the associated probability of achieving Ivy's goals using a range of scenarios for the performance of the concentrated stock position. Framing the effect this one holding may have on the likelihood of achieving her goals may help Ivy agree to reduce the position size. Consideration of certain behavioral biases like mental accounting can improve investor outcomes when they are incorporated in an objective decision-making framework.

SUMMARY

- The primary constraints on an asset allocation decision are asset size, liquidity, time horizon, and other external considerations, such as taxes and regulation.
- The size of an asset owner's portfolio may limit the asset classes accessible to the asset owner. An asset owner's portfolio may be too small—or too large—to capture the returns of certain asset classes or strategies efficiently.
- Complex asset classes and investment vehicles require sufficient governance capacity.
- Large-scale asset owners may achieve operating efficiencies, but they may find it difficult to deploy capital effectively in certain active investment strategies given liquidity conditions and trading costs.
- Smaller portfolios may also be constrained by size. They may be too small to adequately diversify across the range of asset classes and investment managers, or they may have staffing constraints that prevent them from monitoring a complex investment program.
- Investors with smaller portfolios may be constrained in their ability to access private equity, private real estate, hedge funds, and infrastructure investments because of the high required minimum investments and regulatory restrictions associated with those asset classes. Wealthy families may pool assets to meet the required minimums.
- The liquidity needs of the asset owner and the liquidity characteristics of the asset classes each influence the available opportunity set.
- Liquidity needs must also take into consideration the financial strength of the investor and resources beyond those held in the investment portfolio.

- When assessing the appropriateness of any given asset class for a given investor, it is important to evaluate potential liquidity needs in the context of an extreme market stress event.
- An investor's time horizon must be considered in any asset allocation exercise. Changes in human capital and the changing character of liabilities are two important time-related constraints of asset allocation.
- External considerations—such as regulations, tax rules, funding, and financing needs—are also likely to influence the asset allocation decision.
- Taxes alter the distribution of returns by both reducing the expected mean return and muting the dispersion of returns. Asset values and asset risk and return inputs to asset allocation should be modified to reflect the tax status of the investor. Correlation assumptions do not need to be adjusted, but taxes do affect the return and the standard deviation assumptions for each asset class.
- Periodic portfolio rebalancing to return the portfolio to its target strategic asset allocation is an integral part of sound portfolio management. Taxable investors must consider the tax implications of rebalancing.
- Rebalancing thresholds may be wider for taxable portfolios because it takes larger asset class movements to materially alter the risk profile of the taxable portfolio.
- Strategic asset location is the placement of less tax-efficient assets in accounts with more-favorable tax treatment.
- An asset owner's strategic asset allocation should be re-examined periodically, even in the absence of a change in the asset owner's circumstances.
- A special review of the asset allocation policy may be triggered by a change in goals, constraints, or beliefs.
- In some situations, a change to an asset allocation strategy may be implemented without a formal asset allocation study. Anticipating key milestones that would alter the asset owner's risk appetite, and implementing pre-established changes to the asset allocation in response, is often referred to as a "glide path."
- Tactical asset allocation (TAA) allows short-term deviations from the strategic asset allocation (SAA) targets and are expected to increase risk-adjusted return. Using either short-term views or signals, the investor actively re-weights broad asset classes, sectors, or risk-factor premiums. The sizes of these deviations from the SAA are often constrained by the Investment Policy Statement.
- The success of TAA decisions is measured against the performance of the SAA policy portfolio by comparing Sharpe ratios, evaluating the information ratio or the *t*-statistic of the average excess return of the TAA portfolio relative to the SAA portfolio, or plotting outcomes versus the efficient frontier.
- TAA incurs trading and tax costs. Tactical trades can also increase the concentration of risk.
- Discretionary TAA relies on a qualitative interpretation of political, economic, and financial market conditions and is predicated on a belief of persistent manager skill in predicting and timing short-term market moves.
- Systematic TAA relies on quantitative signals to capture documented return anomalies that may be inconsistent with market efficiency.
- The behavioral biases most relevant in asset allocation include loss aversion, the illusion of control, mental accounting, recency bias, framing, and availability bias.

- An effective investment program will address behavioral biases through a formal asset allocation process with its own objective framework, governance, and controls.
- In goals-based investing, loss-aversion bias can be mitigated by framing risk in terms of shortfall probability or by funding high-priority goals with low-risk assets.
- The cognitive bias, illusion of control, and hindsight bias can all be mitigated by using a formal asset allocation process that uses long-term return and risk forecasts, optimization constraints anchored around asset class weights in the global market portfolio, and strict policy ranges.
- Goals-based investing incorporates the mental accounting bias directly into the asset allocation solution by aligning each goal with a discrete sub-portfolio.
- A formal asset allocation policy with pre-specified allowable ranges may constrain recency bias.
- The framing bias effect can be mitigated by presenting the possible asset allocation choices with multiple perspectives on the risk/reward trade-off.
- Familiarity bias, a form of availability bias, most commonly results in an overweight in home country securities and may also cause investors to inappropriately compare their investment decisions (and performance) to other organizations. Familiarity bias can be mitigated by using the global market portfolio as the starting point in developing the asset allocation and by carefully evaluating any potential deviations from this baseline portfolio.
- A strong governance framework with the appropriate level of expertise and well-documented investment beliefs increases the likelihood that shifts in asset allocation are made objectively and in accordance with those beliefs. This will help to mitigate the effect that behavioral biases may have on the long-term success of the investment program.

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PRACTICE PROBLEMS

The following information relates to questions 1–6

Rebecca Mayer is an asset management consultant for institutions and high-net-worth individuals. Mayer meets with Sebastian Capara, the newly appointed Investment Committee chairman for the Kinkardeen University Endowment (KUE), a very large tax-exempt fund.

Capara and Mayer review KUE's current and strategic asset allocations, which are presented in Exhibit 1. Capara informs Mayer that over the last few years, Kinkardeen University has financed its operations primarily from tuition, with minimal need of financial support from KUE. Enrollment at the University has been rising in recent years, and the Board of Trustees expects enrollment growth to continue for the next five years. Consequently, the board expects very modest endowment support to be needed during that time. These expectations led the Investment Committee to approve a decrease in the endowment's annual spending rate starting in the next fiscal year.

Exhibit 1 Kinkardeen University Endowment—Strategic Asset Allocation Policy

Asset Class	Current Weight	Target Allocation	Lower Policy Limit	Upper Policy Limit
Developed markets equity	30%	30%	25%	35%
Emerging markets equity	28%	30%	25%	35%
Investment-grade bonds	15%	20%	15%	25%
Private real estate equity	15%	10%	5%	15%
Infrastructure	12%	10%	5%	15%

As an additional source of alpha, Mayer proposes tactically adjusting KUE's asset-class weights to profit from short-term return opportunities. To confirm his understanding of tactical asset allocation (TAA), Capara tells Mayer the following:

Statement 1 The Sharpe ratio is suitable for measuring the success of TAA relative to SAA.

Statement 2 Discretionary TAA attempts to capture asset-class-level return anomalies that have been shown to have some predictability and persistence.

Statement 3 TAA allows a manager to deviate from the IPS asset-class upper and lower limits if the shift is expected to produce higher expected risk-adjusted returns.

Capara asks Mayer to recommend a TAA strategy based on excess return forecasts for the asset classes in KUE's portfolio, as shown in Exhibit 2.

Exhibit 2 Short-Term Excess Return Forecast

Asset Class	Expected Excess Return
Developed markets equity	2%
Emerging markets equity	5%
Investment-grade bonds	–3%
Private real estate equity	3%
Infrastructure	–1%

Following her consultation with Capara, Mayer meets with Roger Koval, a member of a wealthy family. Although Koval's baseline needs are secured by a family trust, Koval has a personal portfolio to fund his lifestyle goals.

In Koval's country, interest income is taxed at progressively higher income tax rates. Dividend income and long-term capital gains are taxed at lower tax rates relative to interest and earned income. In taxable accounts, realized capital losses can be used to offset current or future realized capital gains. Koval is in a high tax bracket, and his taxable account currently holds, in equal weights, high-yield bonds, investment-grade bonds, and domestic equities focused on long-term capital gains.

Koval asks Mayer about adding new asset classes to the taxable portfolio. Mayer suggests emerging markets equity given its positive short-term excess return forecast. However, Koval tells Mayer he is not interested in adding emerging markets equity to the account because he is convinced it is too risky. Koval justifies this belief by referring to significant losses the family trust suffered during the recent economic crisis.

Mayer also suggests using two mean–variance portfolio optimization scenarios for the taxable account to evaluate potential asset allocations. Mayer recommends running two optimizations: one on a pre-tax basis and another on an after-tax basis.

1 The change in the annual spending rate, in conjunction with the board's expectations regarding future enrollment and the need for endowment support, could justify that KUE's target weight for:

A infrastructure be increased.

B investment-grade bonds be increased.

C private real estate equity be decreased.

2 Which of Capara's statements regarding tactical asset allocation is correct?

A Statement 1

B Statement 2

C Statement 3

3 Based on Exhibits 1 and 2, to attempt to profit from the short-term excess return forecast, Capara should increase KUE's portfolio allocation to:

A developed markets equity and decrease its allocation to infrastructure.

B emerging markets equity and decrease its allocation to investment-grade bonds.

C developed markets equity and increase its allocation to private real estate equity.

4 Given Koval's current portfolio and the tax laws of the country in which he lives, Koval's portfolio would be more tax efficient if he reallocated his taxable account to hold more:

A high-yield bonds.

B investment-grade bonds.

C domestic equities focused on long-term capital gain opportunities.

5 Koval's attitude toward emerging markets equity reflects which of the following behavioral biases?

A Hindsight bias

B Availability bias

C Illusion of control

6 In both of Mayer's optimization scenarios, which of the following model inputs could be used without adjustment?

A Expected returns

B Correlation of returns

C Standard deviations of returns

The following information relates to questions 7–13

Elsbeth Quinn and Dean McCall are partners at Camel Asset Management (CAM). Quinn advises high-net-worth individuals, and McCall specializes in retirement plans for institutions.

Quinn meets with Neal and Karina Martin, both age 44. The Martins plan to retire at age 62. Twenty percent of the Martins' $600,000 in financial assets is held in cash and earmarked for funding their daughter Lara's university studies, which begin in one year. Lara's education and their own retirement are the Martins' highest-priority goals. Last week, the Martins learned that Lara was awarded a four-year full scholarship for university. Quinn reviews how the scholarship might affect the Martins' asset allocation strategy.

The Martins have assets in both taxable and tax-deferred accounts. For baseline retirement needs, Quinn recommends that the Martins maintain their current overall 60% equity/40% bonds (± 8% rebalancing range) strategic asset allocation. Quinn calculates that given current financial assets and expected future earnings, the Martins could reduce future retirement savings by 15% and still comfortably retire at 62. The Martins wish to allocate that 15% to a sub-portfolio with the goal of making a charitable gift to their alma mater from their estate. Although the gift is a low-priority goal, the Martins want the sub-portfolio to earn the highest return possible. Quinn promises to recommend an asset allocation strategy for the Martins' aspirational goal.

Next, Quinn discusses taxation of investments with the Martins. Their interest income is taxed at 35%, and capital gains and dividends are taxed at 20%. The Martins want to minimize taxes. Based on personal research, Neal makes the following two statements:

Statement 1	The after-tax return volatility of assets held in taxable accounts will be less than the pre-tax return volatility.
Statement 2	Assets that receive more favorable tax treatment should be held in tax-deferred accounts.

The equity portion of the Martins' portfolios produced an annualized return of 20% for the past three years. As a result, the Martins' equity allocation in both their taxable and tax-deferred portfolios has increased to 71%, with bonds falling to 29%.

The Martins want to keep the strategic asset allocation risk levels the same in both types of retirement portfolios. Quinn discusses rebalancing; however, Neal is somewhat reluctant to take money out of stocks, expressing confidence that strong investment returns will continue.

Quinn's CAM associate, McCall, meets with Bruno Snead, the director of the Katt Company Pension Fund (KCPF). The strategic asset allocation for the fund is 65% stocks/35% bonds. Because of favorable returns during the past eight recession-free years, the KCPF is now overfunded. However, there are early signs of the economy weakening. Since Katt Company is in a cyclical industry, the Pension Committee is concerned about future market and economic risk and fears that the high-priority goal of maintaining a fully funded status may be adversely affected. McCall suggests to Snead that the KCPF might benefit from an updated IPS. Following a thorough review, McCall recommends a new IPS and strategic asset allocation.

The proposed IPS revisions include a plan for short-term deviations from strategic asset allocation targets. The goal is to benefit from equity market trends by automatically increasing (decreasing) the allocation to equities by 5% whenever the S&P 500 Index 50-day moving average crosses above (below) the 200-day moving average.

7 Given the change in funding of Lara's education, the Martins' strategic asset allocation would *most likely* decrease exposure to:

A cash.

B bonds.

C equities.

8 The *most* appropriate asset allocation for the Martins' new charitable gift subportfolio is:

A 40% equities/60% bonds.

B 70% equities/30% bonds.

C 100% equities/0% bonds.

9 Which of Neal's statements regarding the taxation of investments is correct?

A Statement 1 only

B Statement 2 only

C Both Statement 1 and Statement 2

10 Given the Martins' risk and tax preferences, the taxable portfolio should be rebalanced:

A less often than the tax-deferred portfolio.

B as often as the tax-deferred portfolio.

C more often than the tax-deferred portfolio.

11 During the rebalancing discussion, which behavioral bias does Neal exhibit?

A Framing bias

B Loss aversion

C Representativeness bias

12 Given McCall's IPS recommendation, the *most* appropriate new strategic asset allocation for the KCPF is:

A 40% stocks/60% bonds.

B 65% stocks/35% bonds.

C 75% stocks/25% bonds.

13 The proposal for short-term adjustments to the KCPF asset allocation strategy is known as:

A de-risking.
B systematic tactical asset allocation.
C discretionary tactical asset allocation.

SOLUTIONS

1 A is correct. A lower annual spending rate, in addition to the board's expectations of rising enrollment and minimal need for endowment support over the next five years, indicates a decreased need for liquidity. Therefore, KUE could justify an increase in the strategic allocation to less liquid asset classes (such as private real estate equity and infrastructure) and a decrease in the strategic allocation to liquid assets (such as investment-grade bonds).

2 A is correct. The Sharpe ratio is suitable for measuring the success of TAA relative to SAA. Specifically, the success of TAA decisions can be evaluated by comparing the Sharpe ratio realized under the TAA with the Sharpe ratio that would have been realized under the SAA.

3 A is correct. The forecast for expected excess returns is positive for developed markets equity and negative for infrastructure. Therefore, to attempt to profit from the short-term excess return forecast, KUE can overweight developed markets equity and underweight infrastructure. These adjustments to the asset-class weights are within KUE's lower and upper policy limits.

4 C is correct. As a general rule, the portion of a taxable asset owner's assets that are eligible for lower tax rates and deferred capital gains tax treatment should first be allocated to the investor's taxable accounts. Assets that generate returns mainly from interest income tend to be less tax efficient and in Koval's country are taxed at progressively higher rates. Also, the standard deviation (volatility) of after-tax returns is lower when equities are held in a taxable account. Therefore, Koval's taxable account would become more tax efficient if it held more domestic equities focused on long-term capital gain opportunities.

5 B is correct. Availability bias is an information-processing bias in which people take a mental shortcut when estimating the probability of an outcome based on how easily the outcome comes to mind. On the basis of the losses incurred by his family trust during the recent economic crisis, Koval expresses a strong preference for avoiding the emerging markets equity asset class. Such behavior is consistent with availability bias, where investors who personally experience an adverse event are likely to assign a higher probability to such an event occurring again.

6 B is correct. After-tax portfolio optimization requires adjusting each asset class's expected return and risk for expected taxes. The correlation of returns is not affected by taxes and does not require an adjustment when performing after-tax portfolio optimization.

7 A is correct. The changing character of liabilities through time affects the asset allocation to fund those liabilities. The Martins' investment horizon for some of their assets has changed. The amount of liquidity needed for Lara's near-term education has been greatly reduced owing to the receipt of the scholarship. The Martins will likely still have to pay for some university-related expenses; however, a large part of the $120,000 in cash that is earmarked for Lara's expenses can now be allocated to the Martins' long-term goal of early retirement. Retirement is 18 years away, much longer than the one- to five-year horizon for university expenses. Therefore, the Martins' allocation to cash would likely decrease.

8 C is correct. The Martins' sub-portfolio is aspirational and a low priority. Investors are usually willing to take more risk on lower-priority, aspirational portfolios. The charitable gift will be made from their estate, which indicates a long time horizon. In addition, the Martins want the highest return possible. Therefore, the highest allocation to equities is most appropriate.

9 A is correct. Taxes alter the distribution of returns by both reducing the expected mean return and muting the dispersion of returns. The portion of an owner's taxable assets that are eligible for lower tax rates and deferred capital gains tax treatment should first be allocated to the investor's taxable accounts.

10 A is correct. The Martins wish to maintain the same risk level for both retirement accounts based on their strategic asset allocation. However, more frequent rebalancing exposes the taxable asset owner to realized taxes that could have otherwise been deferred or even avoided. Rebalancing is discretionary, and the Martins' also wish to minimize taxes. Because after-tax return volatility is lower than pre-tax return volatility, it takes larger asset-class movements to materially alter the risk profile of a taxable portfolio. This suggests that rebalancing ranges for a taxable portfolio can be wider than those of a tax-exempt/tax-deferred portfolio with a similar risk profile; thus, rebalancing occurs less frequently.

11 C is correct. Representativeness, or recency, bias is the tendency to overweight the importance of the most recent observations and information relative to a longer-dated or more comprehensive set of long-term observations and information. Return chasing is a common result of this bias, and it results in overweighting asset classes with strong recent performance.

12 A is correct. McCall recommends a new IPS. Changes in the economic environment and capital market expectations or changes in the beliefs of committee members are factors that may lead to an altering of the principles that guide investment activities. Because the plan is now overfunded, there is less need to take a higher level of equity risk. The Pension Committee is concerned about the impact of future market and economic risks on the funding status of the plan. Katt Company operates in a cyclical industry and could have difficulty making pension contributions during a recession. Therefore, a substantial reduction in the allocation to stocks and an increase in bonds reduce risk. The 40% stocks/60% bonds alternative increases the allocation to bonds from 35% to 60%. Increasing the fixed-income allocation should moderate plan risk, provide a better hedge for liabilities, and reduce contribution uncertainty.

13 B is correct. Using rules-based, quantitative signals, systematic tactical asset allocation (TAA) attempts to capture asset-class-level return anomalies that have been shown to have some predictability and persistence. Trend signals are widely used in systematic TAA. A moving-average crossover is a trend signal that indicates an upward (downward) trend when the moving average of the shorter time frame, 50 days, is above (below) the moving average of the longer time frame, 200 days.

PORTFOLIO MANAGEMENT

STUDY SESSION 6

Derivatives and Currency Management

The purpose of this study session is to illustrate ways in which derivatives might be used in typical investment situations. Few asset managers or individual investors will ever use all of the strategies described here. However, an informed investment professional should still be aware of these important strategies and understand the associated risk–return trade-offs.

The first reading examines widely used options strategies, including covered calls, protective puts and select spread and combination option strategies. Derivatives strategy selection is discussed and demonstrated in a series of applications.

The second reading shows how swaps, forwards, and futures can be used to change the risk exposure of an existing position. There are many ways in which investment managers and investors can use swaps, forwards, futures, and volatility derivatives. The typical applications of these derivatives involve modifying investment positions for hedging purposes or for taking directional bets, creating or replicating desired payoffs, implementing asset allocation and portfolio rebalancing decisions, and even inferring current market expectations.

When the strategic asset allocation includes exposure to global markets, non-domestic currencies create additional sources of portfolio volatility and potential returns. The final reading in this study session explores how currency exposures can be managed to reflect a client's investment objectives and constraints.

READING ASSIGNMENTS

Reading 15	Option Strategies by Adam Schwartz, PhD, CFA, and Barbara Valbuzzi, CFA
Reading 16	Swaps, Forwards, and Futures Strategies by Barbara Valbuzzi, CFA
Reading 17	Currency Management: An Introduction by William A. Barker, PhD, CFA

READING

15

Options Strategies

by Adam Schwartz, PhD, CFA, and Barbara Valbuzzi, CFA

Adam Schwartz, PhD, CFA, is at Bucknell University (USA). Barbara Valbuzzi, CFA (Italy).

LEARNING OUTCOMES

Mastery	*The candidate should be able to:*
☐	**a.** demonstrate how an asset's returns may be replicated by using options;
☐	**b.** discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a covered call position;
☐	**c.** discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a protective put position;
☐	**d.** compare the delta of covered call and protective put positions with the position of being long an asset and short a forward on the underlying asset;
☐	**e.** compare the effect of buying a call on a short underlying position with the effect of selling a put on a short underlying position;
☐	**f.** discuss the investment objective(s), structure, payoffs, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of the following option strategies: bull spread, bear spread, straddle, and collar;
☐	**g.** describe uses of calendar spreads;
☐	**h.** discuss volatility skew and smile;
☐	**i.** identify and evaluate appropriate option strategies consistent with given investment objectives;
☐	**j.** demonstrate the use of options to achieve targeted equity risk exposures.

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1 INTRODUCTION

Derivatives are financial instruments through which counterparties agree to exchange economic cash flows based on the movement of underlying securities, indexes, currencies, or other instruments or factors. A derivative's value is thus *derived* from the economic performance of the underlying. Derivatives may be created directly by counterparties or may be facilitated through established, regulated market exchanges. Direct creation between counterparties has the benefit of tailoring to the counterparties' specific needs but also the disadvantage of potentially low liquidity. Exchange-traded derivatives often do not match counterparties' specific needs but do facilitate early termination of the position, and, importantly, mitigate counterparty risk. Derivatives facilitate the exchange of economic risks and benefits where trades in the underlying securities might be less advantageous because of poor liquidity, transaction costs, regulatory impediments, tax or accounting considerations, or other factors.

Options are an important type of contingent-claim derivative that provide their owner with the right but not an obligation to a payoff determined by the future price of the underlying asset. Unlike other types of derivatives (i.e., swaps, forwards, and futures), options have nonlinear payoffs that enable their owners to benefit from movements in the underlying in one direction without being hurt by movements in the opposite direction. The cost of this opportunity, however, is the upfront cash payment required to enter the options position.

Options can be combined with the underlying and with other options in a variety of different ways to modify investment positions, to implement investment strategies, or even to infer market expectations. Therefore, investment managers routinely use option strategies for hedging risk exposures, for seeking to profit from anticipated market moves, and for implementing desired risk exposures in a cost-effective manner.

The main purpose of this reading is to illustrate how options strategies are used in typical investment situations and to show the risk–return trade-offs associated with their use. Importantly, an informed investment professional should have such a basic understanding of options strategies to competently serve his investment clients.

Section 2 of this reading shows how certain combinations of securities (i.e., options, underlying) are equivalent to others. Section 3 discusses two of the most widely used options strategies, covered calls and protective puts. In Section 4, we look at popular spread and combination option strategies used by investors. The focus of Section 5 is implied volatility embedded in option prices and related volatility skew and surface. Section 6 discusses option strategy selection. Section 7 demonstrates a series of applications showing ways in which an investment manager might solve an investment problem with options. The reading concludes with a summary.

2 POSITION EQUIVALENCIES

It is useful to think of derivatives as building blocks that can be combined to create a specific payoff with the desired risk exposure. A synthetic position can be created for any option or stock strategy. Most of the time, market participants use synthetic positions to transform the payoff profile of their positions when their market views change. We cover a few of these relationships in the following pages. First, a brief recap of put–call parity and put–call–forward parity will help readers to understand such synthetic positions.

As you may remember, put–call parity shows the equivalence (or parity) of a portfolio of a call and a risk-free bond with a portfolio of a put and the underlying, which leads to the relationship between put and call prices. Put–call parity can be expressed in the following formula, where S_0 is the price of the underlying; p_0 and c_0 are the prices (i.e., premiums) of the put and call options, respectively; and $X/(1 + r)^T$ is the present value of the risk-free bond: $S_0 + p_0 = c_0 + X/(1 + r)^T$.

A closely related concept is put–call–forward parity, which identifies the equivalence between buying a fiduciary call, given by the purchase of a call and the risk-free bond, and a synthetic protective put. The latter involves the purchase of a put option and a forward contract on the underlying that expires at the same time as the put option. In the put–call–forward parity formula, S_0 is replaced with a forward contract to buy the underlying, where the forward price is given by $F_0(T) = S_0(1 + r)^T$. Therefore, put–call–forward parity is: $F_0(T)/(1 + r)^T + p_0 = c_0 + X/(1 + r)^T$.

2.1 Synthetic Forward Position

The combination of a long call and a short put with identical strike price and expiration, traded at the same time on the same underlying, is equivalent to a **synthetic long forward position**. In fact, the long call creates the upside and the short put creates the downside on the underlying.

Consider an investor who buys an at-the-money (ATM) call and simultaneously sells a put with the same strike and the same expiration date. Whatever the stock price at expiration, one of the two options will be in the money. If the contract has a physical settlement, the investor will buy the underlying stock by paying the strike price. In fact, on the expiration date, the investor will exercise the call she owns if the stock price is above the strike price. Otherwise, if the underlying price is below the strike price, the put owner will exercise his right to deliver the stock and the investor (who sold the put) must buy it for the strike price. Exhibit 1 shows the values of the two options and the combined position at expiration, compared with the value of the stock purchase at that same time. The stock in this case does not pay dividends.

Exhibit 1 Synthetic Long Forward Position at Expiration

Stock price at expiration:	40	50	60
Alternative 1:			
Long 50-strike call payoff	0	0	10
Short 50-strike put payoff	–10	0	0
Total value	–10	0	10
Alternative 2:			
Long stock at 50	–10	0	10
Total value	–10	0	10

We now compare the same option strategy with the payoff of a forward or futures contract in Exhibit 2. The motivation to create a synthetic long forward position could be to exploit an arbitrage opportunity presented by the actual forward price or the need for an alternative to the outright purchase of a long forward position. Frequently, a forward contract is used instead of futures to acquire a stock position because it allows for contract customization.

Exhibit 2 Synthetic Long Forward Position vs. Long Forward/Futures

Stock price at expiration:	40	50	60
Alternative 1:			
Long 50-strike call payoff	0	0	10
Short 50-strike put payoff	–10	0	0
Total value	–10	0	10
Alternative 3: Long forward/futures at 50			
Value	–10	0	10

EXAMPLE 1

Synthetic Long Forward Position vs. Long Forward/Futures

A market maker has sold a three-month forward contract on Vodafone that allows the client (counterparty) to buy 10,000 shares at 200.35 pence (100p = £1) at expiration. The current stock price (S_0) is 200p, and the stock does not pay dividends until after the contract matures. The annualized interest rate is 0.70%. The cost (i.e., premium) of puts and calls on Vodafone is identical.

1 Discuss (a) how the market maker can hedge her short forward position upon the sale of the forward contract and (b) the market maker's position upon expiration of the forward contract.

2 Discuss how the market maker can hedge her short forward contract position using a synthetic long forward position, and explain what happens at expiry if the Vodafone share price is above or below 200.35p.

Solution 1:

a To offset the short forward contract position, the market maker can borrow £20,000 (= 10,000 × S_0/100) and buy 10,000 Vodafone shares at 200p. There is no upfront cost because the stock purchase is 100% financed.

b At the expiry of the forward contract, the market maker delivers the 10,000 Vodafone shares she owns to the client that is long the forward, and then the market maker repays her loan. The net outflow for the market maker is zero because the following two transactions offset each other:

Amount received for the delivery of shares: 10,000 × 200.35p = £20,035

Repayment of loan: 10,000 × 200p [1 + 0.700% × (90/360)] = £20,035

Solution 2:

To hedge her short forward position, the market maker creates a synthetic long forward position. She purchases a call and sells a put, both with a strike price of 200.35p and expiring in three months.

At the expiry of the forward contract, if the stock price is above 200.35p, the market maker exercises her call, pays £20,035 (=10,000 × 200.35p), and receives 10,000 Vodafone shares. She then delivers these shares to the client and receives £20,035.

At the expiry of the forward contract, if the stock price is below 200.35p, the owner of the long put will exercise his option, and the market maker receives the 10,000 Vodafone shares for £20,035. She then delivers these shares to the client and receives £20,035.

Consider now a trader who wants to short a stock over a specified period. He needs to borrow the stock from the market and then sell the borrowed shares. Instead, the trader can create a **synthetic short forward position** by selling a call and buying a put at the same strike price and maturity. When using options to replicate a short stock position, it is important to be aware of early assignment risk that could arise with American-style options. As Exhibit 3 shows, the payoff is the exact opposite of the synthetic long forward position.

The same outcome can be achieved be selling forwards or futures contracts (as seen in Exhibit 3). These instruments are also commonly used to eliminate future price risk. Consider an investor who owns a stock and wants to lock in a future sales price. The investor might enter into a forward or futures contract (as seller) requiring her to deliver the shares at a future date in exchange for a cash amount determined today. Because the initial and final stock prices are known, this investment should pay the risk-free rate. For a dividend-paying stock, the dividends expected to be paid on the stock during the term of the contract will decrease the price of the forward or futures.

Exhibit 3 Synthetic Short Forward Position

Stock price at expiration:	40	50	60
Alternative 1:			
Short 50-strike call payoff	0	0	–10
Long 50-strike put payoff	10	0	0
Total value	10	0	–10
Alternative 2:			
Short stock at 50	10	0	–10
Value	10	0	–10
Alternative 3:			
Short forward/futures at 50	10	0	–10
Value	10	0	–10

Synthetic forwards on stocks and equity indexes are often used by market makers that have sold a forward contract to customers—to hedge the risk, the market-maker would implement a synthetic long forward position—or by investment banks wishing to hedge forward exposure arising from structured products.

2.2 Synthetic Put and Call

As already described, market participants can use synthetic positions to transform the payoff and risk profile of their positions. The symmetrical payoffs of long and short stock, forward, and futures positions can be altered by implementing synthetic options positions. For example, the symmetric payoff of a short stock position can become asymmetrical if the investor transforms it into a synthetic long put position by buying a call.

Exhibit 4 shows the payoffs of a synthetic long put position that consists of short stock at 50 and a long call with an exercise price of 50. It can be seen that the payoffs from this synthetic put position at various stock prices at option expiration are identical to those of a long put with a 50-strike price. Of course, all positions are assumed to expire at the same time. Note that the same transformation of payoff and risk profile for a position of short forwards or futures can also be accomplished using long call options.

Exhibit 4 Synthetic Long Put

Stock price at expiration:	**40**	**50**	**60**
Alternative 1:			
Short stock at 50	10	0	–10
Long 50-strike call payoff	0	0	+10
Total value	10	0	0
Alternative 2			
Long 50-strike put payoff	10	0	0
Value	10	0	0

EXAMPLE 2

Synthetic Long Put

Three months ago, Wing Tan, a hedge fund manager, entered into a short forward contract that requires him to deliver 50,000 Generali shares, which the fund does not currently own, at €18/share in one month from now. The stock price is currently €16/share. The hedge fund's research analyst, Gisele Rossi, has a non-consensus expectation that the company will report an earnings "beat" next month. The stock does not pay dividends.

1 Under the assumption that Tan maintains the payoff profile of his current short forward position, discuss the conditions for profit or loss at contract expiration.

2 After discussing with Rossi her earnings outlook, Tan remains bearish on Generali. He decides to hedge his risk, however, in case the stock does report a positive earnings surprise. Discuss how Tan can modify his existing position to produce an asymmetrical, risk-reducing payoff.

Solution 1:

If Tan decides to keep the current payoff profile of his position, at the expiry date, given a stock price of S_T, the profit or loss on the short forward will be 50,000 × (€18 – S_T). The position will be profitable only if S_T is below €18; otherwise the manager will incur in a loss.

Solution 2:

Tan decides to modify the payoff profile on his short forward position so that, at expiration, it will benefit from any stock price decrease below €16 while avoiding losses if the stock rises above that price. He purchases a call option with a strike price €16 and one month to maturity at a cost (premium) of €0.50. At expiration, the payoffs are as follows:

- On the short forward contract: 50,000 × (€18 – S_T)
- On the long call: 50,000 × {Max[0,(S_T – €16)] – €0.50}
- On the combined position: 50,000 × {(€18 – S_T) + [Max[0,(S_T – €16)] – €0.50]}

If S_T ≤ €16, the call will expire worthless and the profit will amount to 50,000 × (€18 – S_T + 0 – €0.50).

If S_T > €16, the call is exercised and the Generali shares delivered for a maximum profit of 50,000 × (€18 – €16 – €0.50) = €75,000.

In similar fashion, an investor with a long stock position can change his payoff and risk profile into that of a long call by purchasing a put ("protective put" strategy). The long put eliminates the downside risk, whereas the long stock leaves the profit potential unlimited. As shown in Exhibit 5, the strategy has a payoff profile resembling that of a long call. Again, all positions are assumed to expire at the same time. We will have much more to say about the protective put strategy later in this reading. Finally, the payoff profile of a long call can also be achieved by adding a long put to a long forward or futures position, all with the same expiration dates and the same strike and forward (or futures) prices.

Exhibit 5 Synthetic Long Call

Stock price at expiration:	40	50	60
Alternative 1:			
Long stock at 50	–10	0	10
Long 50-strike put payoff	10	0	0
Total value	0	0	10
Alternative 2			
Long 50-strike call payoff	0	0	10
Value	0	0	10

3 COVERED CALLS AND PROTECTIVE PUTS

Writing a **covered call** is a very common option strategy used by both individual and institutional investors. In this strategy, a party that already owns shares sells a call option, giving another party the right to buy their shares at the exercise price.[1] The

1 When someone creates (writes) a call without owning the underlying asset, it is known as a "naked" call.

investor owns the shares and has taken on the potential obligation to deliver the shares to the call option buyer and accept the exercise price as the price at which she sells the shares. For her willingness to do this, the investor receives the premium on the option.

When someone simultaneously holds a long position in an asset and a long position in a put option on that asset, the put is often called a **protective put**. The name comes from the fact that the put protects against losses in the value of the underlying asset.

The examples that follow use the convention of identifying an option by the underlying asset, expiration, exercise price, and option type. For example, in Exhibit 6, the PBR October 16 call option sells for 1.42. The underlying asset is Petróleo Brasileiro (PBR) common stock, the expiration is October, the exercise price is 16, the option is a call, and the call premium is 1.42. It is important to note that even though we will refer to this as the October 16 option, it does not expire on 16 October. Rather, 16 reflects the price at which the call owner has the right to buy, otherwise known as the exercise price or strike.

Petróleo Brasileiro (PBR)	October	16	Call
Underlying asset	*Expiration*	*Exercise price*	*Option type*

On some exchanges, certain options may have weekly expirations in addition to a monthly expiration, which means investors need to be careful in specifying the option of interest. For a given underlying asset and exercise price, there may be several weekly and one monthly option expiring in October. The examples that follow all assume a single monthly expiration.

3.1 Investment Objectives of Covered Calls

Consider the option data in Exhibit 6. Suppose there is one month until the September expiration. By convention, option listings show data for a single call or put, but in practice, the most common trading unit for an exchange-traded option is one contract covering 100 shares. Besides call and put premiums for various strike (i.e., exercise) prices and monthly expirations, the option data also shows implied volatilities as well as the “Greeks” (variables so named because most of the common ones are denoted by Greek letters). Implied volatility is the value of the unobservable volatility variable that equates the result of an option pricing model—such as the Black–Scholes–Merton (BSM) model—to the market price of an option, using all other required (and observable) input variables, including the option’s strike price, the price of the underlying, the time to option expiration, and the risk-free interest. Before proceeding further, we provide a brief review of the Greeks because they will be an integral part of the discussion of the various option strategies to be presented.

- **Delta (Δ)** is the change in an option’s price in response to a change in price of the underlying, all else equal. Delta provides a good approximation of how an option’s price will change for a small change in the underlying’s price. Delta for long calls is always positive; delta for long puts is always negative. *Delta (Δ) ≈ Change in value of option/Change in value of underlying.*
- **Gamma (Γ)** is the change in an option’s delta for a change in price of the underlying, all else equal. Gamma is a measure of the curvature in the option price in relationship to the underlying price. Gamma for long calls and long puts is always positive. *Gamma (Γ) ≈ Change in delta/Change in value of underlying.*

- **Vega (ν)** is the change in an option's price for a change in volatility of the underlying, all else equal. Vega measures the sensitivity of the underlying to volatility. Vega for long calls and long puts is always positive. *Vega (ν) ≈ Change in value of option/Change in volatility of underlying.*
- **Theta (Θ)** is the daily change in an option's price, all else equal. Theta measures the sensitivity of the option's price to the passage of time, known as time decay. Theta for long calls and long puts is generally negative.

Assume the current PBR share price is 15.84 and the risk-free rate is 4%. Now let us consider three different market participants who might logically use covered calls.

Exhibit 6 PBR Option Prices, Implied Volatilities, and Greeks

Call Prices			Exercise Price	Put Prices		
SEP	OCT	NOV		SEP	OCT	NOV
1.64	1.95	2.44	15	0.65	0.99	1.46
0.97	1.42	1.90	16	1.14	1.48	1.96
0.51	1.02	1.44	17	1.76	2.09	2.59

Call Implied Volatility				Put Implied Volatility		
SEP	OCT	NOV		SEP	OCT	NOV
64.42%	57.33%	62.50%	15	58.44%	56.48%	62.81%
55.92%	56.11%	60.37%	16	59.40%	56.35%	62.27%
51.07%	55.87%	58.36%	17	59.59%	56.77%	63.40%

Delta: change in option price per change of +1 in stock price, all else equal

Call Deltas				Put Deltas		
SEP	OCT	NOV		SEP	OCT	NOV
0.657	0.647	0.642	15	−0.335	−0.352	−0.359
0.516	0.540	0.560	16	−0.481	−0.460	−0.438
0.351	0.434	0.475	17	−0.620	−0.564	−0.513

Gamma: change in delta per change of +1 in stock price, all else equal

Call Gammas				Put Gammas		
SEP	OCT	NOV		SEP	OCT	NOV
0.125	0.100	0.075	15	0.136	0.102	0.075
0.156	0.109	0.082	16	0.147	0.109	0.080
0.159	0.109	0.086	17	0.140	0.107	0.079

Theta: daily change in option price, all else equal

Call Thetas (daily)				Put Thetas (daily)		
SEP	OCT	NOV		SEP	OCT	NOV
−0.019	−0.012	−0.011	15	−0.015	−0.010	−0.009
−0.018	−0.013	−0.011	16	−0.017	−0.011	−0.010
−0.015	−0.012	−0.011	17	−0.016	−0.011	−0.010

(continued)

Exhibit 6 (Continued)

Vega: change in option price per 1% increase in volatility, all else equal

Call Vegas (per %)				Put Vegas (per %)		
SEP	OCT	NOV		SEP	OCT	NOV
0.017	0.024	0.030	15	0.017	0.024	0.030
0.018	0.026	0.031	16	0.018	0.026	0.031
0.017	0.025	0.032	17	0.017	0.025	0.032

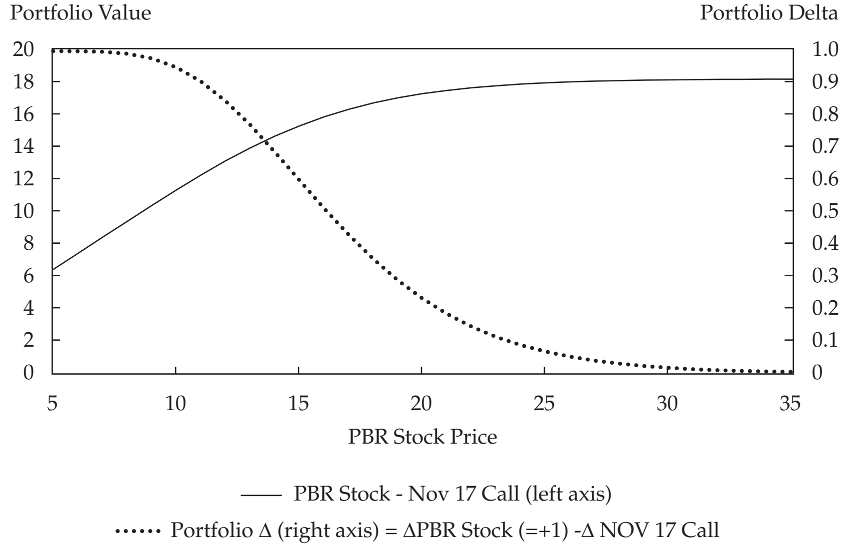
3.1.1 *Market Participant #1: Yield Enhancement*

The most common motivation for writing covered calls is cash generation in anticipation of limited upside moves in the underlying. The call option writer keeps the premium regardless of what happens in the future. Some covered call writers view the premium they receive as an additional source of income in the same way they view cash dividends. For a covered call, a long position in 100 shares of the underlying is required for each short call contract. No additional cash margin is needed if the long position in the underlying is maintained. If the stock price exceeds the strike price at expiry, the underlying shares will be "called away" from the covered call writer and then delivered to satisfy the option holder's right to buy shares at the strike price. It is important to recognize, however, that when someone writes a call option, he is essentially giving up the returns above the strike price to the call holder.

Consider an individual investor who owns PBR and believes the stock price is likely to remain relatively flat over the next few months. With the stock currently trading at just under 16, the investor might think it unlikely that the stock will rise above 17. Exhibit 6 shows that the premium for a call option expiring in September with an exercise price of 17, referred to as the SEP 17 call, is 0.51. She could write that call and receive this premium. Alternatively, she could write a different call, say the NOV 17 call, and receive 1.44. There is a clear trade-off between the size of the option premium and the likelihood of option exercise. The option writer would get more cash from writing the longer-term option (because of a larger time premium), but there is a greater chance that the option would move in the money, resulting in the option being exercised by the buyer and, therefore, the stock being called away from the writer. The view of the covered call writer can be understood in terms of the call option's implied volatility. Essentially, writing the call expresses the view that the volatility of the underlying asset will be lower than the pricing of the option suggests. As shown in Exhibit 6, the implied volatility of the NOV 17 options is 58.36%. By writing the NOV 17 call for 1.44, the covered call investor believes that the volatility of the underlying asset will be less than the option's implied volatility of 58.36%. The call buyer believes the stock will move far enough above the strike price of 17 to provide a payoff greater than the 1.44 cost of the call.

Although it may be acceptable to think of the option premium as income, it is important to remember that the call writer has given up an important benefit of stock ownership: capital gains above the strike price. This dynamic can be seen in Exhibit 7. Consider an investor with a long position in PBR stock (with delta of +1) and a short position in a PBR NOV 17 call. The investor enjoys the benefit of the call premium of 1.44. This cushions the value of the position (Stock – Call, or S – C) as the PBR share price drops. If the PBR stock price drops to 5, the call option will drop to essentially 0. The portfolio will be worth about 6.44, as shown in Exhibit 7. As the stock price increases, however, the short call position begins to limit portfolio gains. If the price of PBR shares rises to 30, the call option delta approaches 1, so the delta of the portfolio (S – C) approaches 0. The portfolio gains from the long PBR stock position will be reduced by losses on the short call position. As the in-the-money option expires, the maximum value of the portfolio will approach 18.44, the exercise price of 17 plus the 1.44 premium, as in Exhibit 7.

Exhibit 7 Covered Call Portfolio Value: Long PBR Stock—NOV 17 Call



3.1.2 *Market Participant #2: Reducing a Position at a Favorable Price*

Next, consider Sofia Porto, a retail portfolio manager with a portfolio that has become overweighted in energy companies. She wants to reduce this imbalance. Porto holds 5,000 shares of PBR, an energy company, and she expects the price of this stock to remain relatively stable over the next month. She may decide to sell 1,000 shares for 15.84 each. As an alternative, Porto might decide to write 10 exchange-traded PBR SEP 15 call contracts. This means she is creating 10 option contracts, each of which covers 100 shares. In exchange for this contingent claim, she receives the option premium of 1.64/call × 100 calls/contract × 10 contracts = 1,640. Because the current PBR stock price (15.84) is above the exercise price of 15, the options she writes are in the money. Given her expectation that the stock price will be stable over the next month, it is likely that the option will be exercised. Because Porto wants to reduce the overweighting in energy stocks, this outcome is desirable. If the option is exercised, she has effectively sold the stock at 16.64. She receives 1.64 when she writes the option, and she receives 15 when the option is exercised. Porto could have simply sold the shares at their original price of 15.84, but in this specific situation, the option strategy resulted in a price improvement of 0.80 ([15 + 1.64] – 15.84) per share, or 5.05% (0.80/15.84), in a month's time.[2] By maintaining the stock position and selling a 15 call, she still risks the possibility of a stock price decline during the coming month resulting in a realized price lower than the current market price of 15.84. For example, if the PBR share price declined to 10 over the next month, Porto would realize only 10 + 1.64 =11.64 on her covered call position.

2 Porto's effective selling price of 16.64 is 0.80 higher than the original price of 15.84: 0.80/15.84 = 5.05%.

An American option premium can be viewed as having two parts: exercise value (also called intrinsic value) and time value.[3]

Call Premium = Time Value + Intrinsic Value = Time Value + Max(0,$S - X$)

In this case, the right to buy at 15 when the stock price is 15.84 has an exercise (or intrinsic) value of 0.84. The option premium is 1.64, which is 0.80 more than the exercise value. This difference of 0.80 is called time value.

1.64 = Time Value + (15.84 – 15)

Someone who writes covered calls to improve on the market is capturing the time value, which augments the stock selling price. Remember, though, that giving up part of the return distribution would result in an opportunity loss if the underlying goes up.

3.1.3 *Market Participant #3: Target Price Realization*

A third popular use of options is really a hybrid of the first two objectives. This strategy involves writing calls with an exercise price near the target price for the stock. Suppose a bank trust department holds PBR in many of its accounts and that its research team believes the stock would be properly priced at 16 per share, which is only slightly higher than its current price. In those accounts for which the investment policy statement permits option activity, the manager might choose to write near-term calls with an exercise price near the target price, 16 in this case. Suppose an account holds 500 shares of PBR. Writing 5 SEP 16 call contracts at 0.97 brings in 485 in cash. If the stock is above 16 in a month, the stock will be called away at the strike price (target price), with the option premium adding an additional 6% positive return to the account.[4] If PBR fails to rise to 16, the manager might write a new OCT expiration call with the same objective in mind.

Although this strategy is popular, the investor should not view it as a source of free money. The stock is currently very close to the target price, and the manager could simply sell it and be satisfied. Although the covered call writing program potentially adds to the return, there is also the chance that the stock could experience bad news or the overall market might pull back, resulting in an opportunity loss relative to the outright sale of the stock. The investor also would have an opportunity loss if the stock rose sharply above the exercise price and it was called away at a lower-than-market price.

The exposure from the short position in the PBR SEP 16 call can be understood in terms of the Greeks in Exhibit 6. Delta measures how the option price changes as the underlying asset price changes, and gamma measures the rate of change in delta.[5] A PBR SEP 16 call has a delta = 0.516 and a gamma of 0.156. A short call will reduce the delta of the portfolio (S – C) from +1 to +0.484 (= +1[Share] – 0.516[Short Call]). The lower portfolio delta will reduce the upside opportunity. A share price increase of 1 will result in a portfolio gain of approximately 0.484.[6] The delta of the portfolio is not constant. By selling the PBR 16 call, the portfolio is now "short gamma". Remember, gamma is the rate of change of delta. Although the underlying PBR share has a gamma of 0, the short call will make the gamma of the portfolio –0.156. As the price of PBR

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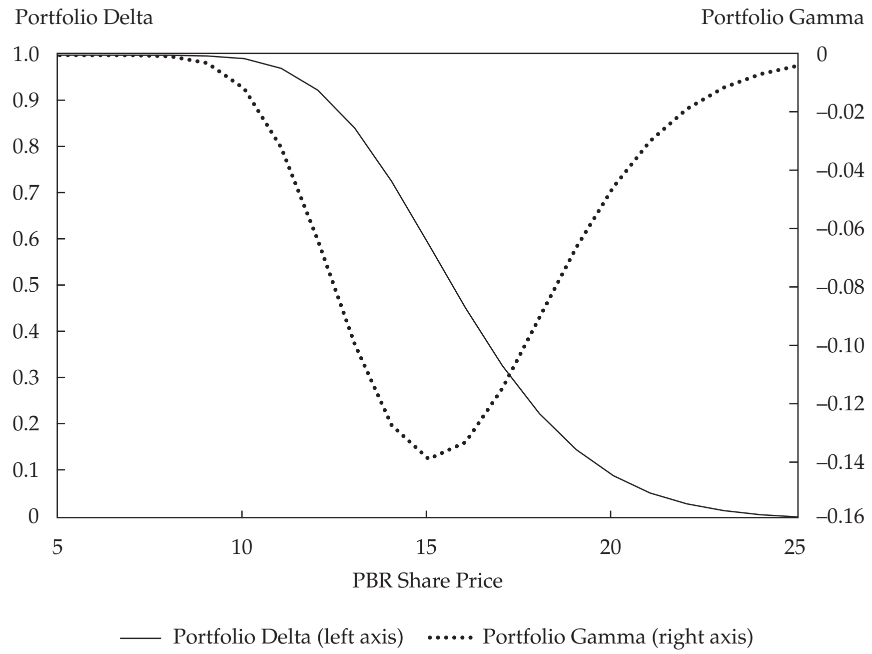
3 In addition to exercise value, some use the term "economic value" for intrinsic value because it is the value of the option if the investor were to exercise it at this very moment and trade out of the stock position.
4 Relative to a stock price of 16, the option premium of 0.97 is 0.97/16 = 6.06%.
5 Delta is the calculus first derivative of the option price with respect to the underlying asset price. Gamma is the second derivative of the option price with respect to the underlying asset price.
6 The delta approximates the portfolio price change for very small changes in the underlying price. The delta itself is changing at a rate of gamma. For a change as large as 1%, the actual portfolio value will increase at a rate of less than 0.484 because it is short gamma.

shares increases above 16, the delta of the PBR call position will change, at a rate of gamma. Gamma is greatest for an ATM option and becomes progressively smaller as the option moves either into or out of the money (as seen in Exhibit 8).

Gamma of an ATM option can increase dramatically as the time to expiration approaches or volatility increases. Traders with large gamma exposure (especially large negative gamma) should be aware of the speed with which the position values can change. The change in portfolio delta and gamma for a PBR SEP 16 covered call as a function of share price can be seen in Exhibit 8. As the price of PBR shares increase, the portfolio delta changes at a rate of gamma. As the share price moves above the exercise price of 16, the portfolio (S – C) delta drops at a rate gamma towards its eventual limit of 0, effectively eliminating any remaining upside in the position.

Exhibit 8 Delta vs. Gamma for PBR 16 Covered Call Portfolio



3.1.4 *Profit and Loss at Expiration*

In the process of learning option strategies, it is always helpful to look at a graphical display of the profit and loss possibilities at the option expiration. Suppose an investor owns PBR, currently trading at 15.84. The investor believes gains may be limited above a price of 17 and decides to write a call against the long share position. The 17 strike calls will have no intrinsic value because the share price is currently 15.84. The investor must now consider the available option maturities (SEP, OCT, and NOV) as shown in Exhibit 6. In deciding which option to write, the investor may consider the option premiums and implied volatilities. Based on the investor's view that volatility will remain low over the next three months, the investor chooses to write the NOV call. At 58.36%, the NOV 17 call has highest implied volatility of the available 17 strike options, so it would be the most overvalued assuming low volatility. The option premium of 1.44 is completely explained by the time value of the NOV option, because the NOV 17 option has no exercise value (Option premium = Time value + Intrinsic value; 1.44 = Time value + Max[0,15.84 – 17]). If the stock is above 17 at expiration, the option holder will exercise the call option and the investor will deliver the shares in exchange for the exercise price of 17. The maximum gain with a covered call is the appreciation to the exercise price plus the option premium.[7]

Some symbols will be helpful in learning these relationships:

S_0 = Stock price when option position opened
S_T = Stock price at option expiration
X = Option exercise price
c_0 = Call premium received or paid

The maximum gain is $(X - S_0) + c_0$. With a starting price of 15.84, a sale price of 17 results in 1.16 of price appreciation. The option writer would keep the option premium of 1.44 for a total gain of 1.16 + 1.44 = 2.60. This is the maximum gain from this strategy because all price appreciation above 17 belongs to the call holder. The call writer keeps the option premium regardless of what the stock does, so if it were to drop, the overall loss is reduced by the option premium received. Exhibit 9 shows the situation. The breakeven price for a covered call is the stock price minus the premium, or $S_0 - c_0$. In other words, the breakeven point occurs when the stock falls by the premium received—in this example, 15.84 – 1.44 = 14.40. The maximum loss would occur if the stock became worthless; it equals the original stock price minus the option premium received, or $S_0 - c_0$.[8] In this single unlikely scenario, the investor would lose 15.84 on the stock position but still keep the premium of 1.44, for a total loss of 14.40.

At option expiration, the *value* of the covered call position is the stock price minus the exercise value of the call. Any appreciation beyond the exercise price belongs to the option buyer, so the covered call writer does not earn any gains beyond that point. Symbolically,

$$\text{Covered Call Expiration Value} = S_T - \text{Max}[(S_T - X),0]. \quad (1)$$

The *profit* at option expiration is the covered call value plus the option premium received minus the original price of the stock:

$$\text{Covered Call Profit at Expiration} = S_T - \text{Max}[(S_T - X),0] + c_0 - S_0. \quad (2)$$

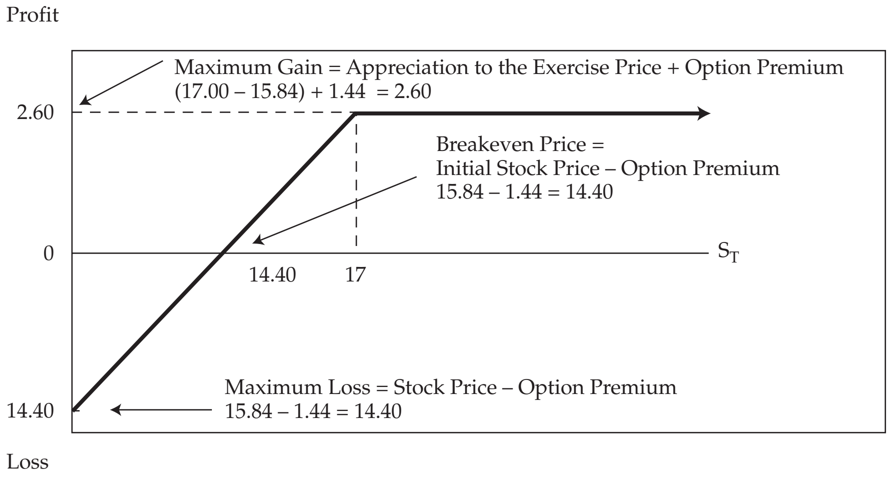
In summary:

Maximum gain = $(X - S_0) + c_0$
Maximum loss = $S_0 - c_0$
Breakeven price = $S_0 - c_0$
Expiration value = $S_T - \text{Max}[(S_T - X),0]$
Profit at expiration = $S_T - \text{Max}[(S_T - X),0] + c_0 - S_0$

7 If someone writes an in-the-money covered call, there is “depreciation” to the exercise price, so the difference would be subtracted. For instance, if the stock price is 50 and a 45 call sells for 7, the maximum gain is –(50 – 45) + 7 = 2.

8 Note that with a covered call, the breakeven price and the maximum loss are the same value.

Exhibit 9 Covered Call P&L Diagram: Stock at 15.84, Write 17 Call at 1.44



It is important to remember that these profit and loss diagrams depict the situation only at the end of the option's life.[9] Most equity covered call writing occurs with exchange-traded options, so the call writer always has the ability to buy back the option before expiration. If, for instance, the PBR stock price were to decline by 1 shortly after writing the covered call, the call value would most likely also decline. If this investor correctly believed the decline was temporary, he might buy the call back at the new lower option premium, making a profit on that trade, and then write the option again after the share price recovered.

EXAMPLE 3

Characteristics of Covered Calls

S_0 = Stock price when option position opened = 25.00
X = Option exercise price = 30.00
S_T = Stock price at option expiration = 31.33
c_0 = Call premium received = 1.55

1. Which of the following correctly calculates the maximum gain from writing a covered call?
   - **A** $(S_T - X) + c_0 = 31.33 - 30.00 + 1.55 = 2.88$
   - **B** $(S_T - S_0) - c_0 = 31.33 - 25.00 - 1.55 = 4.78$
   - **C** $(X - S_0) + c_0 = 30.00 - 25.00 + 1.55 = 6.55$
2. Which of the following correctly calculates the breakeven stock price from writing a covered call?
   - **A** $S_0 - c_0 = 25.00 - 1.55 = 23.45$
   - **B** $S_T - c_0 = 31.33 - 1.55 = 29.78$
   - **C** $X + c_0 = 30.00 + 1.55 = 31.55$

9 It is also important to note that the general shape of the profit and loss diagram for a covered call is the same as that of writing a put. Covered call writing is the most common use of options by individual investors, whereas writing puts is the least common.

3 Which of the following correctly calculates the maximum loss from writing a covered call?

A $S_0 - c_0 = 25.00 - 1.55 = 23.45$

B $S_T - c_0 = 31.33 - 1.55 = 29.78$

C $S_T - X + c_0 = 31.33 - 30.00 + 1.55 = 2.88$

Solution to 1:

C is correct. The covered call writer participates in gains up to the exercise price, after which further appreciation is lost to the call buyer. That is, $X - S_0 = 30.00 - 25.00 = 5.00$. The call writer also keeps c_0, the option premium, which is 1.55. So, the total maximum gain is 5.00 + 1.55 = 6.55.

Solution to 2:

A is correct. The call premium of 1.55 offsets a decline in the stock price by the amount of the premium received: 25.00 – 1.55 = 23.45.

Solution to 3:

A is correct. The stock price can fall to zero, causing a loss of the entire investment, but the option writer still keeps the option premium received: 25.00 – 1.55 = 23.45

3.2 Investment Objective of Protective Puts

The protective put is often viewed as a classic example of buying insurance. The investor holds a risky asset and wants protection against a loss in value. He then buys insurance in the form of the put, paying a premium to the seller of the insurance, the put writer. The exercise price of the put is similar to the coverage amount for an insurance policy. The insurance policy deductible is similar to the difference between the current asset price and the strike price of the put. A protective put with a low exercise price is like an insurance policy with a high deductible. Although less expensive, a low strike put involves greater price exposure before the payoff function goes into the money. For an insurance policy, a higher deductible is less expensive and reflects the increased risk borne by the insured party. For a protective put, a lower exercise price is less costly and has a greater risk of loss in the position.

Like traditional term insurance, this form of insurance provides coverage for a period of time. At the end of the period, the insurance expires and either pays off or not. The buyer of the insurance may or may not choose to renew the insurance by buying another put. A protective put can appear to be a great transaction with no drawbacks, because it provides downside protection with upside potential, but let us take a closer look.

3.2.1 *Loss Protection/Upside Preservation*

Suppose a portfolio manager has a client with a 50,000 share position in PBR. Her research suggests there may be a negative shock to the stock price in the next four to six weeks, and he wants to guard against a price decline. Consider the put prices shown in Exhibit 6; the purchase of a protective put presents the manager with some choices. Puts represent a right to sell at the strike price, so higher-strike puts will be more expensive. For this reason, the put buyer may select the 15-strike PBR put. Longer-term American puts are more expensive than their equivalent (same strike price) shorter-maturity puts. The put buyer must be sure the put will not expire before the expected price shock has occurred. The portfolio manager could buy a one-month (SEP) 15-strike put for 0.65. This put insures against the portion of the underlying return distribution that is below 15, but it will not protect against a price shock occurring after the SEP expiration.

Alternatively, the portfolio manager could buy a two-month option, paying 0.99 for an OCT 15 put, or she could buy a three-month option, paying 1.46 for a NOV 15 put. Note that there is not a linear relationship between the put value and its time until expiration. A two-month option does not sell for twice the price of a one-month option, nor does a three-month option sell for three times the price of a one-month option. The portfolio manager can also reduce the cost of insurance by increasing the size of the deductible (i.e., the current stock price minus the put exercise price), perhaps by using a put option with a 14 exercise price. A put option with an exercise price of 14 would have a lower premium but would not protect against losses in the stock until it falls to 14.00 per share. The option price is cheaper, but on a 50,000 share position, the deductible would be 50,000 more than if the exercise price of 15 were selected.[10]

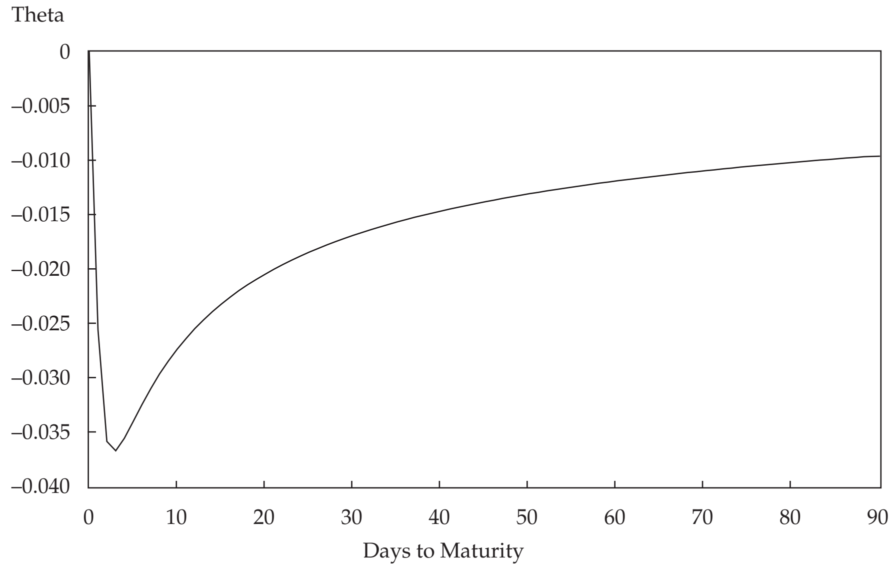
Because of the uncertainty about the timing of the "shock event" she anticipates, the manager might consider the characteristics of the available option maturities. Given our assumptions, three of the BSM model inputs for the available 15 strike options are the same (PBR stock price 15.84, the strike price 15 and the risk-free rate of interest 4%). The difference in the cost of the SEP, OCT, and NOV options will be explained by the differences in time and the term structure of volatility. The BSM model assumes option volatility does not change over time or with strike price. In practice, volatility can vary across time and strike prices. For the 15 puts, the implied volatility is slightly greater for the NOV option, perhaps reflecting other traders' concerns about a shock event before expiration. Because the PBR stock price is 15.84 and the put options are all 15 strike, all three maturities have no intrinsic value.

The cost of each PBR 15 strike option is entirely explained by the remaining time value. If the stock price does not fall below 15, the SEP, OCT, and NOV put option values will erode to 0 as they approach their expiration dates. The erosion of the options value with time is approximated by the theta. The daily thetas (Theta/365) for the PBR puts and calls are given in Exhibit 6. Notice, all the theta values in the table are negative. These values approximate the daily losses on the option positions as time passes, all else equal. The NOV 15 put (90 days) has a theta of –0.009 and the SEP 15 put (30 days) has a theta of –0.015. If the NOV 15 option is held for one day, and the price and volatility of the underlying do not change, the put value will decline by approximately 0.009 to approximately 1.45 (= 1.46 – 0.009).

The graph of the BSM theta function for the PBR NOV 15 option as it approaches maturity is shown in Exhibit 10. Notice how the rate of decline changes as maturity approaches. If the PBR price does not drop below 15, the NOV 15 put will expire out-of-the-money and the option price will gradually fall to 0. All else equal, the sum of the daily losses approximated by theta will explain the entire loss of 1.46 in option value over that time. The complex shape of the theta graph in Exhibit 10 results from the nature of the BSM theta formula, which includes terms to reflect the probability that the stock price will fall below the strike price during the remaining time. Note that if the price of PBR remains at 15.84 for the last 10 days to maturity, the BSM put option value will erode to 0 at varying rates averaging about –0.03/day. Assumptions of the BSM model explain the negative peak in theta around three days prior to maturity as the remaining time value rapidly decays to 0. Theta values might help the investor decide which maturity to choose. If he were to buy the cheaper SEP put, the daily erosion of value (–0.015) would be greater than for the more expensive NOV put (–0.009).

10 The deductible is 50,000 × (15.84 – 15.00) with a strike price of 15. With a strike price of 14, the deductible would be 50,000 × (15.84 – 14.00), or 50,000 more.

Exhibit 10 PBR 15 Put Theta over Time



Given the four- to six-week time horizon for the shock event anticipated by the portfolio manager, the OCT put seems appropriate, but there is still the potential to lose the premium without realizing any benefit. With a 0.99 premium for the OCT 15 put and 50,000 shares to protect, the cost to the account would be almost 50,000. One advantage of the NOV option is that although it is more expensive, it has the smallest daily loss of value, as captured by theta. This option also has a greater likelihood of not having expired before the news hits. Also, although the portfolio manager could hold onto the put position until its expiration, she might find it preferable to close out the option prior to maturity and recover some of the premium paid.[11]

3.2.2 *Profit and Loss at Expiration*

Exhibit 11 shows the profit and loss diagram for the protective put.[12] The stock can rise to any level, and the position would benefit fully from the appreciation; the maximum gain is unlimited. On the downside, losses are "cut off" once the stock price falls to the exercise price. With a protective put, the maximum loss is the depreciation to the exercise price plus the premium paid, or $S_0 - X + p_0$. At the option expiration, the value of the protective put is the greater of the stock price or the exercise price. The reason is because the stock can rise to any level but has a floor value of the put exercise price. In symbols,

$$\text{Value of Protective Put at Expiration} = S_T + \text{Max}[(X - S_T),0]. \quad (3)$$

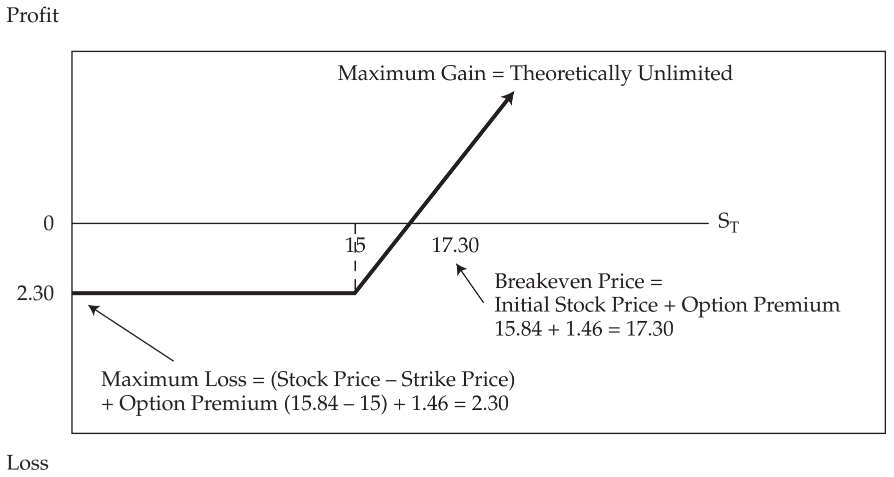
11 A price shock to the underlying asset might increase the market's expectations of future volatility, thereby likely increasing the put premium. By selling the option early, the investor would capture this increase. Also, once the adverse event occurred, there may be no reason to continue to hold the insurance. If the investor no longer needs it, he should cancel it and get part of the purchase price back. In other words, he should sell the put and recapture some of its cost.

12 Note that the profit and loss diagram for a protective put has a shape similar to a long call position, which is the result of put–call parity. Long the asset and long the put is equivalent to long a call plus long a risk-free bond.

The profit or loss at expiration is the ending value minus the beginning value. The initial value of the protective put is the starting stock price minus the put premium. In symbols,

$$\text{Profit of Protective Put at Expiration} = S_T + \text{Max}[(X - S_T),0] - S_0 - p_0. \quad (4)$$

Exhibit 11 Protective Put P&L Diagram: Stock at 15.84, Buy 15 Put at 1.46



To break even, the underlying asset must rise by enough to offset the price of the put that was purchased. The breakeven point is the initial stock price plus the option premium. In symbols, Breakeven Price = $S_0 + p_0$.

In summary:

$$\begin{aligned} \text{Maximum gain} &= S_T - S_0 - p_0 = \text{Unlimited} \\ \text{Maximum loss} &= S_0 - X + p_0 \\ \text{Breakeven price} &= S_0 + p_0 \\ \text{Expiration value} &= S_T + \text{Max}[(X - S_T),0] \\ \text{Profit at expiration} &= S_T + \text{Max}[(X - S_T),0] - S_0 - p_0 \end{aligned}$$

EXAMPLE 4

Characteristics of Protective Puts

S_0 = Stock price when option position opened = 25.00
X = Option exercise price = 20.00
S_T = Stock price at option expiration = 31.33
p_0 = Put premium paid = 1.15

1 Which of the following correctly calculates the gain with the protective put?

A $S_T - S_0 - p_0 = 31.33 - 25.00 - 1.15 = 5.18$

B $S_T - S_0 + p_0 = 31.33 - 25.00 + 1.15 = 7.48$

C $S_T - X - p_0 = 31.33 - 20.00 - 1.15 = 10.18$

2 Which of the following correctly calculates the breakeven stock price with the protective put?

- **A** $S_0 - p_0 = 25.00 - 1.15 = 23.85$
- **B** $S_0 + p_0 = 25.00 + 1.15 = 26.15$
- **C** $S_T + p_0 = 31.33 + 1.15 = 32.48$

3 Which of the following correctly calculates the maximum loss with the protective put?

- **A** $S_0 - X + p_0 = 25.00 - 20.00 + 1.15 = 6.15$
- **B** $S_T - X - p_0 = 31.33 - 20.00 - 1.15 = 10.18$
- **C** $S_0 - p_0 = 25.00 - 1.15 = 23.85$

Solution to 1:

A is correct. If the stock price is above the put exercise price at expiration, the put will expire worthless. The profit is the gain on the stock ($S_T - S_0$) minus the cost of the put. Note that the maximum profit with a protective put is theoretically unlimited, because the stock can rise to any level and the entire profit is earned by the stockholder.

Solution to 2:

B is correct. Because the option buyer pays the put premium, she does not begin to make money until the stock rises by enough to recover the premium paid.

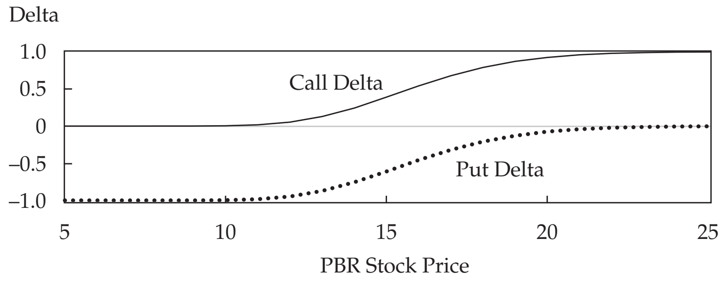
Solution to 3:

A is correct. Once the stock falls to the put exercise price, further losses are eliminated. The investor paid the option premium, so the total loss is the "deductible" plus the cost of the insurance.

3.3 Equivalence to Long Asset/Short Forward Position

All investors who consider option strategies should understand that some options are more sensitive to changes in the underlying asset than others. As we have seen, this relationship is measured by delta, an indispensable tool to an options user. Because a long call increases in value and a long put decreases in value as the underlying asset increases in price, call deltas range from 0 to 1 and put deltas range from 0 to –1. (Naturally, the signs are reversed for short positions in these options.) A long position in the underlying asset has a delta of 1.0, whereas a short position has a delta of –1.0. When the share price is close to the strike price, a rough approximation is that a long ATM option will have a delta that is approximately 0.5 (for a call) or –0.5 (for a put). Exhibit 12 shows the delta for the PBR SEP 16 put and call versus share price. As the stock price moves toward 16 (the strike price), the call option delta is approximately 0.52 and the put delta is –0.48. In general, Call Delta – Put Delta = 1 for options on the same underlying with the same BSM model inputs.

Exhibit 12 Delta of PBR Options vs. Stock Price



Delta can be applied to a portfolio as well. Suppose on the Tokyo Stock Exchange, Honda Motor Company stock sells for ¥3,500. A portfolio contains 100 shares, and the manager writes one exchange-traded covered call contract with a ¥3,500 strike. The delta of the 100-share position will be 100 × +1 = +100. Because the call is at the money, meaning that the stock price and exercise price are equal, it will have a delta of approximately 0.5. The portfolio, however, is short one call contract. From the perspective of the portfolio, the delta of the short call contract is –0.5 × 100 = –50. A short call *loses* money as the underlying price rises. So, this covered call has a **position delta** (which is an overall or portfolio delta) of 50, consisting of +100 points for the stock and –50 points for the short call. Compare this call with a protective put, in which someone buys 100 shares of stock and one contract of an ATM put. Its position delta would also be 50: +100 points for the stock and –50 points for the long put.

Finally, consider a long stock position of 100 shares and a short forward position of 50 shares. Because futures and forwards on non-dividend-paying stocks are essentially proxies for the stock, their deltas are also 1.0 for a long position and –1.0 for a short position. In this example, the short forward position "cancels" half the long stock position, so the position delta is also 50. These examples show three different positions: an ATM covered call, an ATM protective put, and a long stock/short forward position that all have the same delta. For small movements in the price of the underlying asset, these positions will show very similar gains and losses.

3.4 Writing Puts

If someone writes a put option and simultaneously deposits an amount of money equal to the exercise price into a designated account, it is called writing a **cash-secured put**.[13] This strategy is appropriate for someone who is bullish on a stock or who wants to acquire shares at a particular price. The fact that the option exercise price is escrowed provides assurance that the put writer will be able to purchase the stock if the option holder chooses to exercise. Think of the cash in a cash-secured put as being similar to the stock part of a covered call. When an investor sells a covered call, she takes on the obligation to sell a stock, and this obligation is covered by ownership in the shares. When a put option is sold to create a new position, the obligation that accompanies this position is to purchase shares. In order to cover the obligation to purchase shares, the portfolio should have enough cash in the account to make good on this obligation. The short put position is covered or secured by cash in the account.

13 This strategy is also called a *fiduciary put*. When someone writes a put but does not escrow the exercise price, it is sometimes called a *naked put*. Note that this is a slightly different use of the adjective "naked" than with a naked call. When writing a naked call, the call writer does not have the underlying *asset* to deliver if the call is exercised. When an investor writes a naked put, he has not set aside the *cash* necessary to buy the asset if the put is exercised.

Now consider two slightly different scenarios using the price data from Exhibit 6. In the first scenario, one investor might be bullish on PBR and is interested in buying the stock at a cheaper price. With the stock at 15.84, she writes the SEP 15 put for 0.65, which is purchased by another investor who is bearish on PBR stock. The option writer will keep the option premium regardless of what the stock price does. If the stock is below 15 at expiration, however, the put would be exercised and the option writer would be obliged to purchase shares from the option holder at the exercise price of 15.

Possible small (and independent) changes to the variables from Exhibit 6 are simulated in Exhibit 13 for the *long* PBR SEP 15 put position. The long put is illustrated here for simplicity—these statistics for the long put position should also help the put writer to understand the risks and returns for her position, because a short position is simply the mirror image of the long position. The initial values are 15.84 for the stock and 0.65 for the put, and the put buyer has acquired a delta of –0.335 and a gamma of 0.136.[14]

As demonstrated in change #1, if the stock price rises by 0.10 from 15.84 to 15.94, the long (short) put will lose (gain) approximately –0.335 × 0.10 = –0.0335 (+0.0335), as the put value drops from 0.65 to approximately 0.617 (≈ 0.6165 = 0.65 – 0.0335). Remember, this approximation is good for only a small change in the underlying share price. As the stock price rises, the long put's initial delta, –0.335, will change at a rate of gamma, 0.136, so the delta then becomes –0.321.

Exhibit 13 Long PBR SEP 15 PUT, Greeks and Put Price Changes for Small, Independent Changes in Inputs

	Stock Price (S)	Delta (Δ)	Gamma (Γ)	Option Price (p)
Initial Values	15.84	–0.335	0.136	0.65
Change #1: Stock Price Increases by 0.10, from 15.84 to 15.94				
$\boldsymbol{\Delta S = +0.10}$ $\Delta t = 0$ $\Delta Vol = 0$	**15.94**	Δ changes at rate of Γ, so: $\boldsymbol{\Delta_1 \approx \Delta_0 + (\Gamma \times \Delta S)}$ **–0.321 ≈** **–0.335 + (0.136 × 0.10)**	Γ changes slightly to 0.133	$\boldsymbol{p_1 \approx p_0 + (\Delta_0 \times \Delta S)}$ ***0.617*** **≈** **0.65 + (–0.335 × 0.10)**
Change #2: Time to Expiration Changes by 1 Day, from 30 to 29 Days				
$\Delta S = 0$ $\boldsymbol{\Delta t}$ **= 1 day (to 29 Days)** $\Delta Vol = 0$	15.84	–0.335	0.136	$\boldsymbol{p_1 \approx p_0 + (\Theta \times \Delta t)}$ ***0.635*** **≈** **0.65 + (–0.015 × 1)**
Change #3: Implied Volatility Increases by 1 Percentage Point, from 58.44% to 59.44%				
$\Delta S = 0$ $\Delta t = 0$ $\boldsymbol{\Delta Vol}$ **= +1% (to 59.44%)**	15.84	–0.335	0.136	$\boldsymbol{p_1 \approx p_0 + (\nu \times \Delta Vol)}$ ***0.667*** **≈** **0.65 + (0.017 × 1)**

The long SEP 15 put position also has a theta of –0.015 and a vega of +0.017.[15] As time decays, the long (short) put option will lose (gain) value at a rate of theta, so the value of long (short) position will decrease (increase) by approximately 0.015/per day. As demonstrated in change #2 (which is separate and independent from change

14 The put writer (short position) will have a delta of –(–0.335) = +0.335.

15 All else equal, a long put loses time value as it approaches expiration (negative theta). All else equal, a long put increases in value as the volatility is increased (positive vega). In the case of a short put, the signs are reversed.

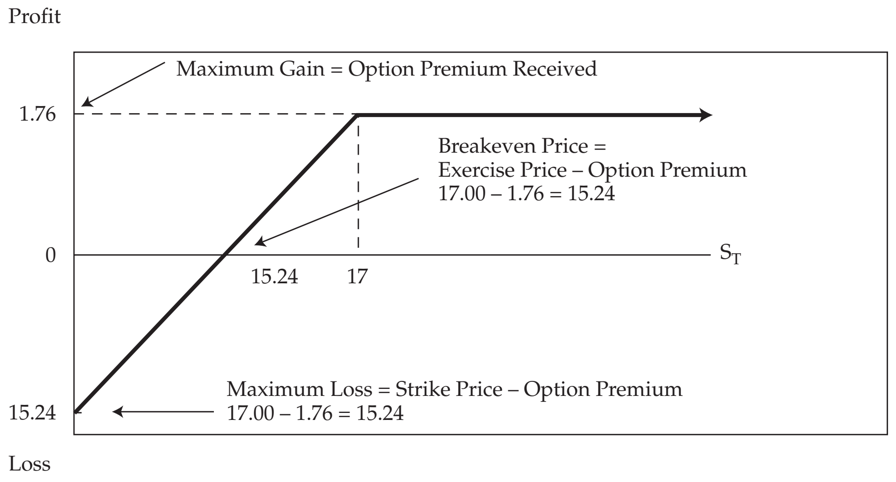
#1), all else equal, the long put value would drop from about 0.65 to 0.635 as the put moves one day closer to expiration (from 30 to 29 days). If the implied volatility of the SEP 15 put were to increase by 1% (from 58.44% to 59.44%), all else equal, the option price would increase by 0.017 to approximately 0.667, as demonstrated in change #3. The increase in volatility would benefit the put holder at the expense of the writer, because the short put position would lose 0.017.

If the stock is above 15 at expiration, the put option will expire unexercised. At the expiration date, the put writer will either keep the premium or have PBR shares put to her at 15. Because the put writer was bullish on PBR and wanted to purchase it at a cheaper price, she may be happy with this result. Netting out the option premium received by the put writer would make her effective purchase price 15.00 – 0.65 = 14.35.

In another scenario, an institutional investor might be interested in purchasing PBR. Suppose the investor wrote the SEP 17 put for 1.76. This strategy will have slightly different values for the Greeks compared with the previous strategy. The delta of the SEP 17 short put position will be +0.62, gamma will be –0.140, and theta will equal +0.016. This position will be more sensitive to changes in the stock price than the SEP 15 put. If the PBR share price increases 0.10 from 15.84 to 15.94, the put writer will now profit by approximately +0.62 × 0.10 = 0.062. The higher strike price makes the short SEP 17 put a more bullish position than the SEP 15 put. This dynamic is reflected in the larger delta for the short SEP 17 put at +0.620 (versus +0.335 for the short SEP 15 put).

If the stock is below 17 at expiration, the SEP 17 puts will be exercised and the investor (i.e., put writer) will pay 17 for the shares, resulting in a net price of 17.00 – 1.76 = 15.24. Anytime someone writes an option, the maximum gain is the option premium received, so in this case, the maximum gain is 1.76. The maximum loss when writing a put occurs when the stock falls to zero. The option writer pays the exercise price for worthless stock but still keeps the premium. In this example, the maximum loss would be 17.00 – 1.76 = 15.24. Exhibit 14 shows the corresponding profit and loss diagram.

Exhibit 14 Short Put P&L Diagram: Write SEP 17 Put at 1.76



Note the similar shape of the covered call position in Exhibit 9 and the short put in Exhibit 14. Writing a covered call and writing a put are very similar with regard to their risk and reward characteristics.[16]

3.5 Risk Reduction Using Covered Calls and Protective Puts

Covered calls and protective puts may both be viewed as risk-reducing or hedging strategies. In the case of a covered call, some price uncertainty is eliminated for price increases. For a protective put, the price uncertainty is eliminated for price decreases. The risk reduction can be understood by considering hedge statistics.

3.5.1 *Covered Calls*

Consider the individual who owns 100 shares of a PBR stock at 15.84. The long position has a delta of +100. Suppose the investor now writes a NOV 17 call contract against this entire position. These options have a delta of 0.475. This covered call position has a position delta of (100 × +1.0) – (100 × 0.475) = +52.5. A position delta of 52.5 is equivalent (for small changes) to owning 52.5 shares of the underlying asset. An investor can lose more money on a 100-share position than on a 52.5-share position. Even if the stock declines to nearly zero, the loss is reduced only by the amount of the option premium received. Viewed this way, the covered call position is less risky than the underlying asset held alone. The lower position delta will work against the investor if the share price increases. A PBR share price above 17 would result in the shares getting called away, and portfolio gains per share are limited to 2.60 = $(X - S_0) + c_0$ = (17 – 15.84) + 1.44.

3.5.2 *Protective Puts*

Similar logic applies to the use of protective puts. An investor who buys a put is essentially buying insurance on the stock. An investor owning PBR stock could purchase a NOV 15 put with an option delta of –0.359. The position delta from 100 shares of PBR stock and one NOV 15 put contract would be +100 + (–0.359 × 100) = +64.1 For small changes in price, the protective put portfolio reduces the risk of the 100-share PBR position to the equivalent of a 64.1 share position. This insurance lasts only until NOV. One buys insurance to protect against a risk, and the policyholder should not feel bad if the risk event does not materialize and he does not get to use the insurance. Stated another way, a homeowner should be happy if the fire insurance on his house goes unused. Still, we do not want to buy insurance we do not need, especially if it is expensive. Continually purchasing puts to protect against a possible stock price decline will result in lower volatility in the overall portfolio, but the trade-off between premium cost and risk reduction must be carefully considered. Such continuous purchasing of puts to protect against a possible stock price decline is an expensive strategy that would wipe out most of the long-term gain on an otherwise good investment. The occasional purchase of a protective put to manage a temporary situation, however, can be a sensible risk-reducing activity.

3.5.3 *Buying Calls and Writing Puts on a Short Position*

The discussion on protective puts (Stock + Put) and covered calls (Stock – Call) describes risk-reduction strategies for investors with long positions in the underlying asset. How can investors reduce risk when they are short the underlying asset? The short investor is worried the underlying stock will go up and profits if the underlying

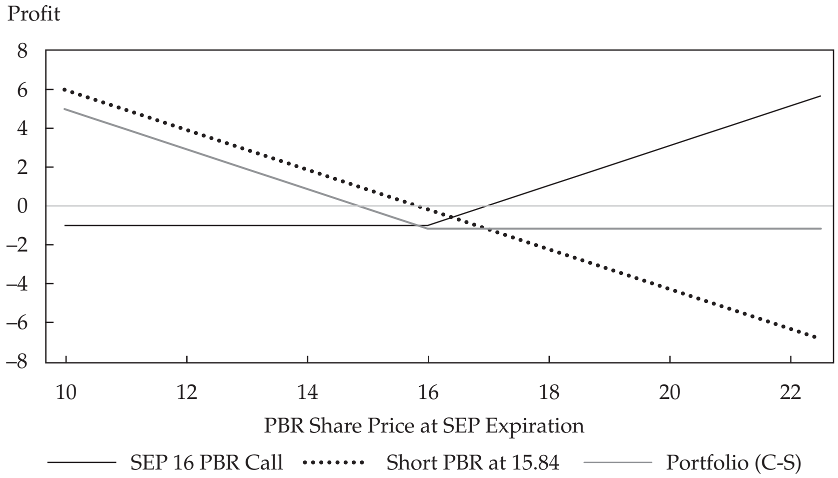
16 The two strategies are very similar due to put–call parity. Recall that P = C – S + PV of X, implying that –P ≈ –C + S (ignoring PV of X), thus showing that a short put payoff profile is similar to that of a covered call.

stock goes down. To offset the risks of a short position, an investor may purchase a call. The new portfolio will be (Call – Stock). The long call will offset portfolio losses when the share price increases.

To generate income from option premiums, the investor may also sell a put. As the stock drops in value, the investor profits from the short stock position, but the portfolio (– Put – Stock) gains will be reduced by the short put. When the share price increases, the short position loses money. The put expires worthless, meaning the investor will keep the put premium. The loss on the short position can still be substantial but is somewhat reduced by the put option premium.

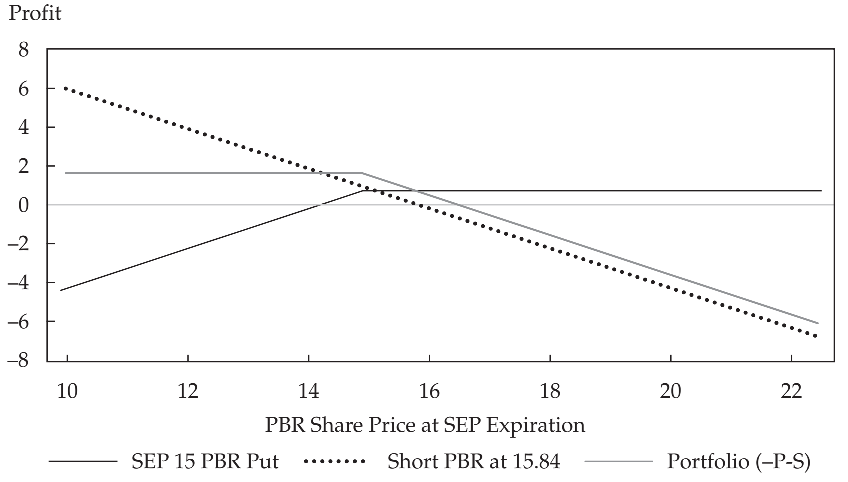
Let us consider these two scenarios using the price data from Exhibit 6. In both cases, the investor is bearish on PBR and shorts the stock at 15.84. In the first case, she purchases the SEP 16 call for 0.97. As the share price increases above 16, the payoff from the call will act to offset losses in the short position. Exhibit 15 illustrates this dynamic. As the share price increases, portfolio losses never exceed 1.13. The profit on the short stock position plus the profit from the in-the-money call equals $(15.84 - S) + [(S - 16) - 0.97] = -1.13$. If the share price decreases, the investor profits from the short but loses the call premium of 0.97. The delta from the short PBR shares is –1. The SEP 16 call delta is 0.516. The overall portfolio delta is still negative at –0.484, making this a bearish strategy. The investor is also long vega from purchasing the call, 0.018, and the position is exposed to time decay, because theta is –0.018 per day. So, she is hoping to profit from increased downside volatility from the short PBR shares while the long call cushions losses from increased upside volatility.

Exhibit 15 P&L of Long PBR SEP 16 Call and Short PBR Stock



In the second scenario, the investor writes the SEP 15 put for 0.65 and collects the put premium. The upside protection from the long call in the first scenario is not provided by writing a put. The short stock position can have potentially unlimited losses. As shown in Exhibit 16, the potential gain from a falling PBR price now belongs to the put owner. The maximum gain from this strategy is given by the profit on the short stock position plus the profit from the out-of-the-money short put, which equals $(15.84 - S) - [(15 - S) - 0.65] = 1.49$. Losses from the short stock position will be cushioned only by the 0.65 premium collected from writing the put. The delta of the short PBR shares is –1, and the delta of the short put is –(–0.335), so the position delta is –1 + 0.335 = –0.665. The investor is bearish and hoping to profit from a downward price move. She is also short vega from writing the put, (–0.017), and benefits from time decay, as theta of the short put is +0.015 (= −[−0.015]). So, she is hoping for reduced volatility to give her an opportunity to collect the put premium without losing from the short on PBR shares.

Exhibit 16 P&L of Short PBR SEP 15 Put and Short PBR Stock



EXAMPLE 5

Risk-Reduction Strategies

Janet Reiter is a US-based investor who holds a limited partnership investment in a French private equity firm. She has received notice from the firm's general partner of an upcoming capital call. Reiter plans to purchase €1,000,000 in three months to meet the capital call due at that time. The current exchange rate is US$1.20/€1, but Reiter is concerned the euro will strengthen against the US dollar. She considers the following instruments to reduce the risk of the planned purchase:

- A three-month USD/EUR call option (to buy euros) with a strike rate X = US$1.25/€1 and costing US$0.02/€1
- A three-month EUR/USD put option (to sell dollars) with a strike rate X = €0.8080/US$1 priced at €0.0134/US$1
- A three-month USD/EUR futures contract (to buy euros) with f_0 = US$1.2052/€1

1 Discuss the position required in each instrument to reduce the risk of the planned purchase.

2 Reiter purchases call options for US$20,000, and the exchange rate increases to US$1.29/€1 (EUR currency strengthens) over the next three months. The effective price Reiter pays for her 1,000,000 EUR purchase is closest to:

   A US$1,270,000.

   B US$1,290,000.

C US$1,310,000.

3 Calculate the price Reiter will pay for the EUR using the three instruments if the exchange rate in three months falls to US$1.10/€1 (EUR currency weakens).

Solution to 1:

Reiter could purchase a €1,000,000 call option struck at US$1.25/€1 for US$20,000. If the EUR price were to increase above US$1.25, she would exercise her right to buy EUR for US$1.25. She would also benefit from being able to purchase EUR at a cheaper price should the exchange rate weaken. A call on the euro is like a put on the US dollar. So, a put to sell dollars struck at an exchange rate of X = €0.8000/US$1 can be viewed as a call to buy Euro at an exchange rate of US$1/€0.8000 = US$1.25/€1. Reiter could also buy a put option on USD struck at X = €0.8080/US$1 which would allow her to sell US$1,237,624 (= €1,000,000/[€0.8080/$1]) to receive the €1,000,000 should the dollar weaken below that level. This would cost her €0.0134/US$1 × US$1,237,624 = €16,584 or US$20,525 upfront. If USD appreciated against the EUR, Reiter would still be able to benefit from the lower cost to purchase the EUR. She could instead enter a long position in a three-month futures contract at US$1.2052. Reiter would have the obligation to purchase €1,000,000 at US$1.2052 regardless of the exchange rate in three months. The futures position requires a margin deposit, but no premium is paid.

Solution to 2:

A is correct. At an exchange rate of US$1.29/€1, the call with strike of X = US$1.25/€1 will be exercised. Including the call premium (US$0.02/€1), the price effectively paid for the euros is US$1.27/€1 × €1,000,000 = US$1,270,000.

Solution to 3:

Both the call and the put options will expire unexercised and Reiter benefits from the lower rate by purchasing €1,000,000 for US$1,100,000. However, she will lose the premiums she paid for the options. For the futures contract, she pays US$1.2052/€1 or US$1,205,200 for €1,000,000 regardless of the more favorable rate.

SPREADS AND COMBINATIONS

4

Option spreads and combinations can be useful option strategies. We first consider money spreads, in which the two options differ only by exercise price. The investor buys an option with a given expiration and exercise price and sells an option with the same expiration but a different exercise price. Of course, the options are on the same underlying asset. The term *spread* is used here because the payoff is based on the difference, or spread, between option exercise prices. For a bull or bear spread, the investor buys one call and writes another call option with a different exercise price, or the investor buys one put and writes another put with a different exercise price.[17] Someone might, for instance, buy a NOV 16 call and simultaneously write a NOV 17

17 One important exception to the typical option spread is a *butterfly spread*, which is essentially two simultaneous spreads and can be done using only calls or only puts.

call, or one might buy a SEP 17 put and write a SEP 15 put. An option combination typically uses both puts and calls. The most important option combination is the straddle, on which we focus in this reading. We will investigate spreads first.

4.1 Bull Spreads and Bear Spreads

Spreads are classified in two ways: by market sentiment and by the direction of the initial cash flows. A spread that becomes more valuable when the price of the underlying asset rises is a **bull spread**; a spread that becomes more valuable when the price of the underlying asset declines is a **bear spread**. Because the investor buys one option and sells another, there is typically an initial net cash outflow or inflow. If establishing the spread requires a cash payment by the investor, it is referred to as a debit spread. Debit spreads are effectively long because the long option value exceeds the short option value. If the spread initially results in a cash inflow to the investor, it is referred to as a credit spread. Credit spreads[18] are effectively short because the short option value exceeds the long option value. Any of these strategies can be created with puts or calls. The motivation for a spread is usually to place a directional bet, giving up part of the profit potential in exchange for a lower cost of the position. Some examples will help make this clear.

4.1.1 *Bull Spread*

Regardless of whether someone constructs a bull spread with puts or with calls, the strategy requires buying one option and writing another with a *higher* exercise price. Because the higher exercise price call is less expensive than the lower strike, a call bull spread involves an initial cash outflow (debit spread). A bull spread created from puts also requires the investor to write the higher-strike option and buy the lower-strike one. Because the higher-strike put is more expensive, a put bull spread involves an initial cash inflow (credit spread).

Let's consider a call bull spread. Suppose, for instance, an investor thought it likely that by the September option expiration, PBR would rise to around 17 from its current level of 15.84. Based on the price data in Exhibit 6, what option strategy would capitalize on this anticipated price movement? If he were to buy the SEP 15 call for 1.64 and the stock rose to 17 at expiration, the call would be worth $S_T - X = 17 - 15 = 2$. If the price of the option was 1.64, the profit is 0.36. The maximum loss is the price paid for the option, or 1.64. If, instead, an investor bought the SEP 16 call for 0.97, at an expiration stock price of 17, the call would be worth 1.00 for a gain of 0.03. A spread could make more sense with the following option values. If he believes the stock will not rise above 17 by September expiration, it may make sense to "sell off" the part of the return distribution above that price. The investor would receive 0.51 for each SEP 17 call sold.

The value of the spread at expiration (V_T) depends on the stock price at expiration S_T. For a bull spread, the investor buys the low strike option (struck at X_L) and sells the high strike option (struck at X_H), so that:

$$V_T = \text{Max}(0, S_T - X_L) - \text{Max}(0, S_T - X_H). \quad (5)$$

Therefore, the value depends on the terminal stock price S_T:

$$V_T = 0 - 0 = 0 \text{ if } S_T \le X_L$$
$$V_T = S_T - X_L - 0 = S_T - X_L \text{ if } X_L < S_T < X_H$$
$$V_T = S_T - X_L - (S_T - X_H) = X_H - X_L \text{ if } S_T \ge X_H$$

18 The use of the term credit spread has a different interpretation than in fixed income investing. For bond investors, the credit spread is a measure of compensation for the bond's default risk.

The profit is obtained by subtracting the initial outlay for the spread from the foregoing value of the spread at expiration. To determine the initial outlay, recall that a call option with a lower exercise price will be more expensive than a call option with a higher exercise price. Because we are buying the call with the lower exercise price (for c_L) and selling the call with the higher exercise price (for c_H), the call we buy will cost more than the call we sell ($c_L > c_H$). Hence, the spread will require a net outlay of funds. This net outlay is the initial value of the position, $V_0 = c_L - c_H$, which we call the net premium. The profit is:

$$\Pi = \text{Max}(0,S_T - X_L) - \text{Max}(0,S_T - X_H) - (c_L - c_H). \quad (6)$$

In this manner, we see that the profit is the profit from the long call, $\text{Max}(0,S_T - X_L) - c_L$, plus the profit from the short call, $-\text{Max}(0,S_T - X_H) + c_H$. Broken down into ranges, the profit is as follows:

$\Pi = -c_L + c_H$ if $S_T \le X_L$
$\Pi = S_T - X_L - c_L + c_H$ if $X_L < S_T < X_H$
$\Pi = X_H - X_L - c_L + c_H$ if $S_T \ge X_H$

If S_T is below X_L, the strategy will lose a limited amount of money. When both options expire out of the money, the investor loses the net premium, $c_L - c_H$. The profit on the upside, if S_T is at least X_H, is also limited to the difference in strike prices minus the net premium.

Consider two alternatives for the call purchase leg of the bull spread: 1) buy the SEP 15 call or 2) buy the SEP 16 call instead. Which is preferred? With Alternative 1, the SEP 15 call costs 1.64. Writing the SEP 17 call brings in 0.51, so the net cost is 1.64 – 0.51 = 1.13. Traders would refer to this position as a PBR SEP 15/17 bull call spread. The maximum profit would occur at or above the exercise price of 17 because all gains above this level belong to the owner of the PBR SEP 17 call. At an underlying price of 17 or higher, from the trader's perspective, the position is worth 2, which represents the price appreciation from 15 to 17 (i.e., the difference in strikes). The maximum profit is

$$\Pi = X_H - X_L - c_L + c_H = 17 - 15 - 1.64 + 0.51 = 0.87.$$

Another way to look at it is that at a price above 17, the trader exercises the long call, buying the stock at 15, and is forced to sell the stock at 17 to the holder of his short call.

With Alternative 2, the investor buys the SEP 16 call and pays 0.97 for it. Writing the SEP 17 call brings in 0.51, so the net cost would be 0.97 – 0.51 = 0.46. At an underlying price of 17 or higher, the spread would be worth 1.00, so the maximum profit is

$$\Pi = X_H - X_L - c_L + c_H = 17 - 16 - 0.97 + 0.51 = 0.54.$$

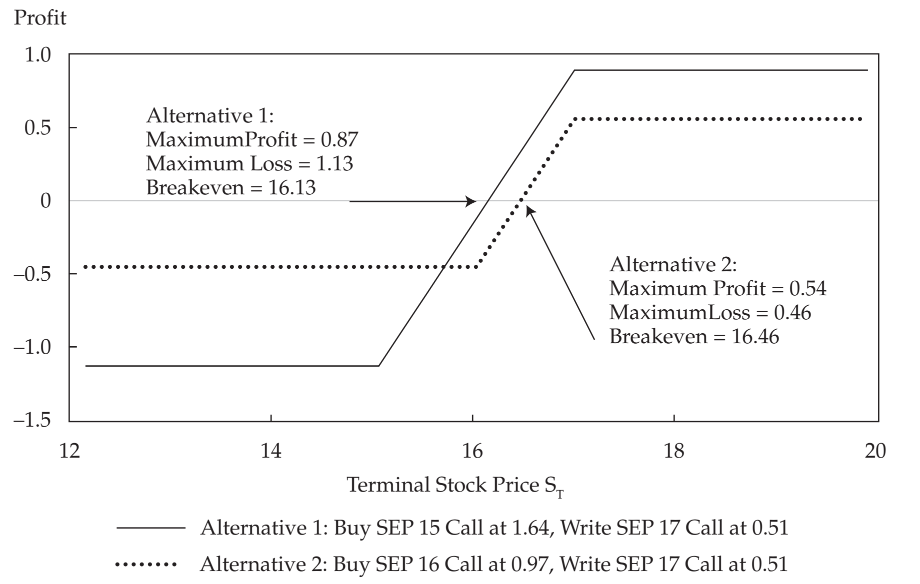
Exhibit 17 compares the profit and loss diagrams for these two alternatives.

To determine the breakeven price with a spread, find the underlying asset price that will cause the exercise value of the two options combined to equal the initial cost of the spread. A spread has two exercise prices. There are also two option premiums. Mathematically, the breakeven price for a call bull spread can be derived from $\Pi = S_T^* - X_L - c_L + c_H = 0$ and is

$$S_T^* = X_L + c_L - c_H,$$

which represents the lower exercise price plus the cost of the spread. In the examples here, Alternative 1 costs 1.13 (= 1.64 – 0.51). The breakeven $S_T^* = X_L + c_L - c_H = 15 + 1.64 - 0.51 = 16.13$. If at option expiration the stock is 16.13, the 15-strike option would be worth 1.13 and the 17-strike call would be worthless. The breakeven price S_T^* is 15.00 + 1.13 = 16.13, as Exhibit 17 shows.

Exhibit 17 Bull Spreads: Current PBR Stock Price = 15.84



Which of the alternatives is preferable? There is no clear-cut answer. As Exhibit 17 shows, the maximum loss for alternative 1 is 1.64 – 0.51= 1.13, compared with a maximum loss of 0.97 – 0.51 = 0.46 for Alternative 2. However, Alternative 1 is potentially more profitable for a move above 17 and has a lower breakeven price.

With Alternative 1, the breakeven point of 16.13 is less than 2% above the current level of 15.84, whereas with Alternative 2, reaching the breakeven point requires almost a 4% rise in the stock price. There is some additional information in Exhibit 6 the investor may wish to consider. The SEP 15/17 spread involves buying the SEP15 call with implied volatility of 64.42% and selling the SEP 17 call option with implied volatility of 51.07%. The investor may believe the SEP 15 call being purchased is relatively expensive compared with the SEP 17 call being sold. The PBR SEP 16/17 involves buying a SEP 16 call at a cost of 0.97 with an implied volatility of 55.92%. The investor may believe the SEP 16 call represents a better value than the SEP 15 call and so may choose the PBR SEP 16/17 spread.

We can calculate the Greek values for the spread. For example, using Exhibit 6, we see the theta of the PBR SEP 15/17 spread is –0.004 = –0.019 – (–0.015), and the theta of the PBR SEP 16/17 is –0.003 = –0.018 – (–0.015). Therefore, the SEP 16/17 should experience slightly less erosion of value resulting from time decay. The investor may also consider the delta and gamma that each spread would add to her PBR position. The delta of the PBR SEP 15/17 spread is +0.306 = 0.657 – 0.351, and the delta of the PBR SEP 16/17 spread is +0.165 = 0.516 – 0.351. From the current PBR price of 15.84, the long position in the PBR 15 call will make the SEP 15/17 PBR spread slightly more sensitive to an increase in share price than the SEP 16/17 spread. For the SEP 15/17, we have gamma = –0.034 = 0.125 – 0.159 and for the SEP 16/17 gamma = –0.003 = 0.156 – 0.159. The more negative gamma value for the SEP 15/17 spread means that the position delta will decrease at a faster rate than the SEP 16/17 spread as the price of PBR shares increase. By carefully selecting the expiration and exercise prices for the options for the spread, an investor can choose the risk–return mix that most closely matches her investment outlook.

4.1.2 *Bear Spread*

With a bull spread, the investor buys the lower exercise price and writes the higher exercise price. It is the opposite with a bear spread: buy the higher exercise price and sell the lower. Because puts with higher exercise prices are (all else equal) more expensive, a put bear spread will result in an initial cash outflow (be a debit spread). For a call bear spread, the investor buys a higher exercise price call and sells the lower exercise price call. Because the higher exercise price call being purchased is less expensive than the lower strike being sold, a call bear spread will result in an initial cash inflow (credit spread).

If a trader believed PBR stock would be below 15 by the November expiration, one strategy would be to buy the PBR NOV 16 put at 1.96 and write the NOV 15 put at 1.46. This spread has a net cost of 0.50; this amount is the maximum loss, and it occurs at a PBR stock price of 16 or higher. The maximum gain is also 0.50, which occurs at a stock price of 15 or lower. (A useful way to see this result is to realize that reversing the signs of the trades leaves the horizontal axes in a diagram like Exhibit 17 intact, but it flips the profit/loss and cost lines vertically! A debit from buying a spread must be consistent with the seller of the same spread receiving a credit.) Finding the breakeven price uses the same logic as with a bull spread: find the underlying asset price at which the exercise value equals the initial cost. Let p_L represent the lower-strike put premium and p_H the higher-strike put premium. Mathematically, the value of this bear spread position at expiration is:

$$V_T = \text{Max}(0, X_H - S_T) - \text{Max}(0, X_L - S_T). \quad (7)$$

Broken down into ranges, we have the following relations:

$$V_T = X_H - S_T - (X_L - S_T) = X_H - X_L \text{ if } S_T \le X_L$$
$$V_T = X_H - S_T - 0 = X_H - S_T \text{ if } X_L < S_T < X_H$$
$$V_T = 0 - 0 = 0 \text{ if } S_T \ge X_H$$

To obtain the profit, we subtract the initial outlay. Because we are buying the put with the higher exercise price and selling the put with the lower exercise price, the put we are buying is more expensive than the put we are selling. The initial value of the bear spread is $V_0 = p_H - p_L$. The profit is, therefore, $V_T - V_0$, which is:

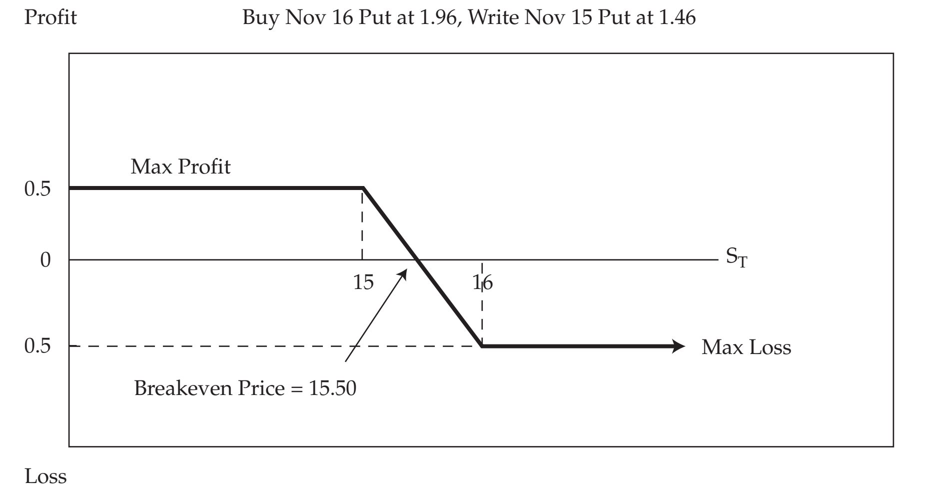
$$\Pi = \text{Max}(0, X_H - S_T) - \text{Max}(0, X_L - S_T) - (p_H - p_L). \quad (8)$$

We see that the profit is that on the long put, $\text{Max}(0, X_H - S_T) - p_H$, plus the profit from the short put, $-\text{Max}(0, X_L - S_T) + p_L$. Broken down into ranges, the profit is as follows:

$$\Pi = X_H - X_L - p_H + p_L \text{ if } S_T \le X_L$$
$$\Pi = X_H - S_T - p_H + p_L \text{ if } X_L < S_T < X_H$$
$$\Pi = -p_H + p_L \text{ if } S_T \ge X_H$$

The breakeven point, $S_T^* = X_H - p_H + p_L$, sets the profit equal to zero between the strike prices. In this example, 16 – 1.96 + 1.46 = 15.50. That is, at a stock price of 15.50 on the expiration day, the 16-strike put would be worth 0.50 and the 15-strike put would be worthless. Exhibit 18 shows the profit and loss for a NOV 15/16 bear spread.[19]

Exhibit 18 Bear Spread: Current PBR Stock Price = 15.84



4.1.3 *Refining Spreads*

It is not necessary that both legs of a spread be established at the same time or maintained for the same period. Options are very versatile, and positions can typically be quickly adjusted as market conditions change. Here are a few examples of different tactical adjustments an option trader might consider.

4.1.3.1 Adding a Short Leg to a Long Position Consider Carlos Aguila, a trader who in September paid a premium of 1.50 for a NOV 40 call when the underlying stock was selling for 37. A month later, in October, the stock has risen to 48. He observes the following premiums for one-month call options.

Strike	Premium
40	8.30
45	4.42
50	1.91

This position has become very profitable. The call he bought is now worth 8.30. He paid 1.50, so his profit at this point is 8.30 – 1.50 = 6.80. He thinks the stock is likely to stabilize around its new level and doubts that it will go much higher. Aguila

19 Bull spreads can also be created with puts, and bear spreads can also be created with calls. In both cases, the result is a credit spread with an initial cash inflow. Recall that American exercise–style options may be exercised at any time prior to expiration. Bull spreads with American puts have an additional risk, which is that the short put could be exercised early when the long put is not yet in the money. If the bull spread uses American calls and the short call is exercised, the long call is deeper in the money, which offsets that risk. A similar point can be applied to bear spreads using calls. Bear spreads with American calls have increased risk, because the short call may be exercised early when the long call may not yet be in the money. Thus, with American options, bull spreads with calls and bear spreads with puts are generally preferred but, of course, not required.

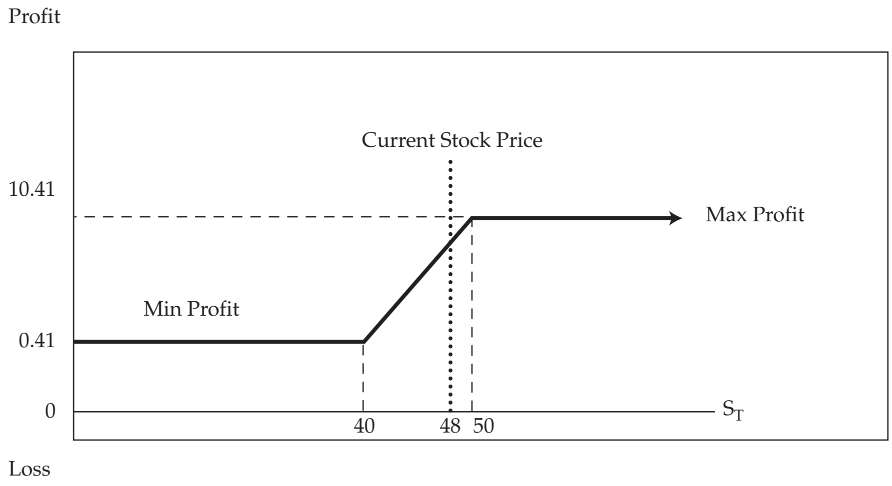
is considering writing a call option with an exercise price of either 45 or 50, thereby converting his long call position into a bull spread. Looking first at the NOV 50 call, he notes that the 1.91 premium would more than cover the initial cost of the NOV 40 call. If he were to write this call, the new profit and loss diagram would look like Exhibit 19. To review, consider the following points:

- At stock prices of 50 or higher, the exercise value of the spread is 10.00. The reason is because both options would be in the money, and a call with an exercise price of 40 would always be worth 10 more at exercise than a call with an exercise price of 50. The initial cost of the call with an exercise price of 40 was 1.50, and there would be a 1.91 cash inflow after writing the call with an exercise price of 50. The profit is 10.00 – 1.50 + 1.91 = 10.41.
- At stock prices of 40 or lower, the exercise value of the spread is zero; both options would be out of the money. The initial cost of the call with an exercise price of 40 was 1.50, and there would be a 1.91 cash inflow after writing the call with an exercise price of 50. The profit is 0 – 1.50 + 1.91 = 0.41.
- Between the two strike prices (40 and 50), the exercise value of the spread rises steadily as the stock price increases. For every unit increase up to the higher strike price, the exercise value of this spread increases by 1.0.

For instance, if the stock price remains unchanged at 48, the exercise value of the spread is 8.00. The reason is because the call with an exercise price of 40 would be worth 8.00 and the call with an exercise price of 50 would be worthless. The initial cost of the 40-strike call was 1.50, and there would be a 1.91 cash inflow when the 50-strike call was written. The profit is 8.00 – 1.50 + 1.91 = 8.41.

Now assume that he has written the NOV 50 call. Aguila needs to be careful how he views this new situation. No matter what happens to the stock price between now and expiration, the position is profitable, relative to his purchase price of the calls with an exercise price of 40. If the stock were to fall by any amount from its current level, however, he would have an opportunity loss. His profit would decrease progressively if the price trended back to 40. Aguila would be correct in saying that the bull spread will make a profit of at least 0.41. But, writing the NOV 50 call only partially hedges against a decline in the value of his new strategy. The position can still lose about 96% of its maximum profit, because only about 4% (0.41/10.41) has been hedged.

Exhibit 19 Spread Creation: Buy a Call with Exercise Price of 40 at 1.50; Write a Call Later with Exercise Price of 50 at 1.91



4.1.3.2 Spreads and Delta A spread strategy may be adapted to a changing market view. Suppose the market has been rising, and Lars Clive, an options trader, expects this trend to continue. Hypothetical company ZKQ currently sells for $44. Suppose Clive buys a NOV 45 call for 5.25. He computes the delta of this call as +0.55 and gamma as +0.028. Initially, Clive will profit at a rate of 0.55 for an increase of $1 in the price of ZKQ stock. For small changes, the delta of his position will increase at a rate of 0.028 for an increase of $1 in the price of ZKQ shares.

Three days later, the stock price has risen to $49, the value of the NOV 45 call has increased to 8.18, and the call delta has increased to +0.68. For the NOV 45 call, the option price increased by 2.93 (= 8.18 – 5.25) instead of by 2.75 (= 5 × 0.55, the stock price change multiplied by the initial delta value). Because delta is changing at a rate gamma, the approximation works best for small changes in share prices. With the stock at $49, a higher-strike NOV 50 call sells for 5.74 and has a delta of +0.55. Now Clive establishes a 45/50 bull call spread by writing the NOV 50 call. Clive is less bullish at the price of 49, and his 45/50 spread portfolio now has a delta of +0.13 = +0.68 – 0.55.

Now suppose another five days pass and the stock price falls to 45. The new option values would be 5.41 for the NOV 45 call and 3.55 for the NOV 50 call. Clive closes out the NOV 50 short call by buying it back. He sold the call for 5.74 and bought it back for 3.55, so he makes 5.74 – 3.55 = 2.19, or 2.19 per contract. He still holds the long position in the NOV 45 call, and his portfolio delta increases to +0.57.

Another four days pass, and ZKQ has risen to 48. The new price for the NOV 50 call is 4.71 with a delta of 0.51. Clive owns the NOV 45 with a price of 7.10 and a delta of 0.66. He then decides to write a NOV 50 call and lower his position delta to 0.15 (= 0.66 – 0.51).

At this point, Clive has had two cash outflows totaling 8.80: the initial 5.25 plus the 3.55 to buy back the NOV 50 call. He has two cash inflows totaling 10.45: the premium income of 5.74 and then 4.71 from the two instances of writing the NOV 50 calls. Exhibit 20 provides a summary of the results of Clive's trades. Because the inflows of 10.45 exceed the outflows of 8.80, he has a resulting profit and loss diagram similar to the plot in Exhibit 19 that we saw in the previous example. Clive's timing was excellent—in each case, he increased his portfolio delta prior to an increase in ZKQ stock and decreased delta before the share price decreased. The important point is that increasing portfolio delta will result in greater profits (losses) when the underlying asset value increases (decreases).

Exhibit 20 Spreads and Deltas: A Summary of Results of Clive's Trades

Day	ZKQ Price	Activity	Portfolio Delta	Cash Out	Cash In
1	44	Buy NOV 45 call	0.55	5.25	–
4	49	Sell NOV 50 call	0.13 (= 0.68 – 0.55)	–	5.74
9	45	Buy NOV 50 call	0.57	3.55	–
13	48	Sell NOV 50 call	0.15 (= 0.66 – 0.51)	–	4.71
Total				**8.80**	**10.45**
Net Inflow					**1.65**

Spreads are primarily a directional play on the underlying asset's spot price (and also potentially on its volatility); still, spread traders can attempt to take advantage of changes in price, and it is easy to create a hypothetical example like this one. There obviously is no guarantee that any assumed price trend will continue. In fact, in actual practice, the excellent results shown in Exhibit 20 are exceedingly difficult to achieve. Still, the experienced option user knows to look for opportunistic plays that arise from price swings.

EXAMPLE 6

Spreads

Use the following information to answer questions 1 to 3 on spreads.

S_0 = 44.50

OCT 45 call = 2.55, OCT 45 put = 2.92

OCT 50 call = 1.45, OCT 50 put = 6.80

1 What is the maximum gain with an OCT 45/50 bull call spread?

A 1.10

B 3.05

C 3.90

2 What is the maximum loss with an OCT 45/50 bear put spread?

A 1.12

B 3.88

C 4.38

3 What is the breakeven price with an OCT 45/50 bull call spread?

A 46.10

B 47.50

C 48.88

Solution to 1:

C is correct. With a bull spread, the maximum gain occurs at the high exercise price. At an underlying price of 50 or higher, the spread is worth the difference in the strike prices, or 50 – 45 = 5. The cost of establishing the spread is the price paid for the lower-strike option minus the price received for the higher-strike option: 2.55 – 1.45 = 1.10. The maximum gain is 5.00 – 1.10 = 3.90.

Solution to 2:

B is correct. With a bear spread, an investor buys the higher exercise price and writes the lower exercise price. When this strategy is done with puts, the higher exercise price option costs more than the lower exercise price option. Thus, the investor has a debit spread with an initial cash outlay, which is the most he can lose. The initial cash outlay is the cost of the OCT 50 put minus the premium received from writing the OCT 45 put: 6.80 – 2.92 = 3.88.

Solution to 3:

A is correct. An investor buys the OCT 45 call for 2.55 and sells the OCT 50 call for 1.45, for a net cost of 1.10. She breaks even when the position is worth the price she paid. The long call is worth 1.10 at a stock price of 46.10, and the OCT 50 call will expire out of the money and thus be worthless. The breakeven price is the lower exercise price of 45 plus the 1.10 cost of the spread, or 46.10.

4.2 Straddle

A long **straddle** is an option combination in which one buys *both* puts and calls, with the same exercise price and same expiration date, on the same underlying asset.[20] If someone *writes* both options, it is a short straddle. Because a long call is bullish and a long put is bearish, this strategy may seem illogical. When the Greeks are considered, the trader's position becomes clearer. The classic example is in anticipation of some event in which the outcome is uncertain but likely to significantly affect the price of the underlying asset, regardless of how the event is resolved.

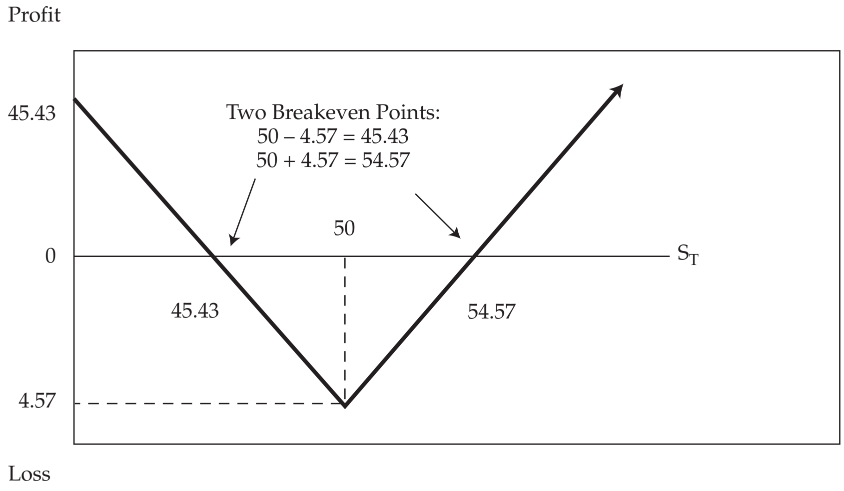
A straddle is an example of a directional play on the underlying volatility, expressing the view that volatility will either increase or decrease from its current level. A profitable outcome from a long straddle, however, usually requires a significant price movement in the underlying asset. The straddle buyer pays the premium for two options, so to make a profit, the underlying asset must move either above or below the option exercise price by at least the total amount spent on the straddle. As an example, suppose in the next few days there is a verdict expected in a liability lawsuit against an automobile manufacturer. An investor expects the stock to move sharply one way or the other once the verdict is revealed. When the exercise price is chosen close to the current stock price, the straddle is neither a bullish nor a bearish strategy—the delta of the straddle is close to zero. With any other exercise price, there may be a directional bias (non-zero delta) because one of the options will be in the money and one will be out of the money. If the price increases (decreases) significantly, the delta of the call will approach +1 (0), and the put delta will approach 0 (–1), making the delta of the position approximately +1 (–1).

Experienced option traders know that it is difficult to make money with a straddle. In the example, other people will also be watching the court proceedings. The market consensus will predict higher volatility once the verdict is announced, and option prices rise when volatility expectations rise. This increased volatility means that both the puts and the calls become expensive well before the verdict is revealed, and the long straddle requires the purchase of both options. To make money, the straddle buyer must be correct in his view that the "true" underlying volatility is higher than the market consensus. Essentially, the bet is that the straddle buyer is right and the other market participants, on average, are wrong by underestimating volatility.

Suppose the underlying stock sells for 50, and an investor selects 30-day options with an exercise price of 50. The call sells for 2.29 and the put for 2.28, for a total investment of 4.57. At prices above 50, the call is in the money. At prices below 50, the put is in the money. For the straddle to be profitable, one of these two options must be profitable enough to pay for the costs of both the put and call. To recover this cost, the underlying asset must either rise or fall by at least 4.57, as shown by the breakeven points in Exhibit 21.

20 If someone buys puts and calls with different exercise prices, the position is called a *strangle*.

Exhibit 21 Long Straddle: Current Stock Price = 50; Buy 50-Strike Call at 2.29, Buy 50-Strike Put at 2.28



The straddle portfolio and Greeks are shown in Exhibit 22. The long straddle initially has a very low delta (+0.069 for this example) with a high gamma (0.139). The trader does not initially favor an increase or a decrease in the share price but knows the delta may quickly change. Once a direction (increase or decrease in the underlying price) asserts itself, the trader's position will take on a non-zero delta value. The trader's view can be better understood from a vega perspective. The long straddle will be profitable only if the stock price moves enough to recover both premiums. The short straddle writer collects the put and call premiums but will lose if the stock price moves more than 4.57 away from the strike price. The long (short) straddle trade is said to be long (short) volatility. The long straddle is a bet that increased volatility will move the stock price strongly above or below the strike price. The sensitivity of the straddle to changes in volatility is measured by vega. As shown in Exhibit 22, vega for our long straddle is +0.114, meaning the portfolio will profit by approximately 0.114 from increased volatility of 1% in the underlying. A stock price change large enough to cause the price of one option to exceed the cost of the combined premiums is needed to make the straddle trade profitable. A large increase in the underlying price will cause the delta of the call option to approach +1 and the delta of the put to approach 0. A large decrease in the underlying price will cause the delta of the call to drop to 0 and the put delta to approach –1.

Exhibit 22 Long and Short Straddle Greeks

	Call	Put	Long Straddle = Call + Put	Short Straddle = –Call + –Put
Cost	2.29	2.28	4.570	–4.570
Delta	0.534	–0.465	0.069	–0.069
Gamma	0.072	0.067	0.139	–0.139
Vega	0.057	0.057	0.114	–0.114
Theta	–0.039	–0.036	–0.075	0.075
Implied Volatility	38%	41%	–	–

Theoretically, the stock can rise to any level, so the maximum profit with the long call is unlimited. If the stock declines, it can fall to no lower than zero. If that happens, the long put would be worth 50. Subtracting the 4.57 cost of the straddle gives a maximum profit of 45.43 from a stock drop. The value of a straddle at expiration is the combined value of the call and the put:

$$V_T = \text{Max}(0,S_T - X) + \text{Max}(0,X - S_T). \tag{9}$$

Broken down into ranges,

$V_T = X - S_T$ if $S_T < X$, and
$V_T = S_T - X$ if $S_T > X$.

The profit is $V_T - V_0$, or $\Pi = \text{Max}(0,S_T - X) + \text{Max}(0,X - S_T) - c_0 - p_0$. **(10)**

Broken down into ranges,

$\Pi = X - S_T - c_0 - p_0$ if $S_T < X$, and
$\Pi = S_T - X - c_0 - p_0$ if $S_T > X$.

As can be seen in Exhibit 21, the straddle has two breakeven points. The lower breakeven for the straddle is $S_{TL}^* = X - c_0 - p_0$, and the upper breakeven is $S_{TH}^* = X + c_0 + p_0$.

For the straddle buyer, the worst outcome is if the stock closes exactly at 50, meaning both the put and the call would expire worthless. At any other price, one of the options will have a positive exercise value. Note that at expiration, the straddle is not profitable if the stock price is in the range 45.43 to 54.57. The long straddle shown in Exhibit 21 requires more than a 9% price move in one month to be profitable. A trader who believed such a move was unlikely might be inclined to *write* the straddle, in which case the profit and loss diagram in Exhibit 21 is reversed, with a maximum gain of 4.57 and a theoretically unlimited loss if prices rise. The risk of a long straddle is limited to the amount paid for the two option positions. The straddle can also be understood in terms of theta. As shown in Exhibit 22, theta of the long straddle is –0.075. All else equal, the long put and call positions will lose their time value as expiration approaches. The long straddle buyer is betting on a large price move in the underlying prior to expiration. If the stock price does not change significantly, the short straddle, which has a positive theta, will benefit from the erosion of time value of the short put and call positions.

4.3 Collars

A **collar** is an option position in which the investor is long shares of stock and then buys a put with an exercise price below the current stock price and writes a call with an exercise price above the current stock price.[21] Collars allow a shareholder to acquire downside protection through a protective put but reduce the cash outlay by writing a covered call. By carefully selecting the options, an investor can often offset most of the put premium paid by the call premium received. Using a collar, the profit and loss on the equity position is limited by the option positions.

For equity investors, the collar typically entails ownership of the underlying asset and the purchase of a put, which is financed with the sale of a call. In a typical investment or corporate finance setting, an interest rate collar may be used to hedge interest rate risk on floating-rate assets or liabilities. For example, a philanthropic foundation funds the grants it makes from income generated by its investment portfolio of floating-rate securities. The foundation's chief investment officer (CIO) wants

21 A collar is also called a *fence* or a *hedge wrapper*.

to hedge interest rate risk (the risk of rates falling on its floating securities) by buying an interest rate floor (a portfolio of interest rate puts) and paying for it by writing a cap (a portfolio of interest rate calls). Should the rates on the portfolio fall, the long floor will provide a lower limit for the income generated by the portfolio. To finance the floor purchase, the foundation sells a cap. The cap will limit the income generated from the floating rate portfolio in the event the floating rate rises. The CIO is still holding a floating-rate securities portfolio but has restricted the returns using the collar. By setting both a minimum and a maximum portfolio return, the CIO may be better able to plan funding requests.

4.3.1 *Collars on an Existing Holding*

A zero-cost collar involves the purchase of a put and sale of a call with the same premium. In Exhibit 6, for instance, the NOV 15 put costs 1.46 and the NOV 17 call is 1.44, very nearly the same. A collar written in the over-the-counter market can be easily structured to provide a precise offset of the put premium with the call premium.[22]

The value of the collar at expiration is the sum of the value of the underlying asset, the value of the long put (struck at X_1), and the value of the short call (struck at X_2):

$$V_T = S_T + \text{Max}(0,X_1 - S_T) - \text{Max}(0,S_T - X_2), \text{ where } X_2 > X_1. \tag{11}$$

The profit is the profit on the underlying share plus the profit on the long put and the short call so that:

$$\Pi = S_T + \text{Max}(0,X_1 - S_T) - \text{Max}(0,S_T - X_2) - S_0 - p_0 + c_0. \tag{12}$$

Broken down into ranges, the total profit on the portfolio is as follows:

$\Pi = X_1 - S_0 - p_0 + c_0$ if $S_T \le X_1$
$\Pi = S_T - S_0 - p_0 + c_0$ if $X_1 < S_T < X_2$
$\Pi = X_2 - S_0 - p_0 + c_0$ if $S_T \ge X_2$

Consider the risk–return trade-off for a shareholder who previously bought PBR stock at 12 and now buys the NOV 15 put for 1.46 and simultaneously writes the NOV 17 covered call for 1.44. Exhibit 23 shows a profit and loss worksheet for the three positions. Exhibit 24 shows the profit and loss diagram.

Exhibit 23 Collar P&L: Stock Purchased at 12, NOV 15 Put Purchased at 1.46, NOV 17 Call Written at 1.44

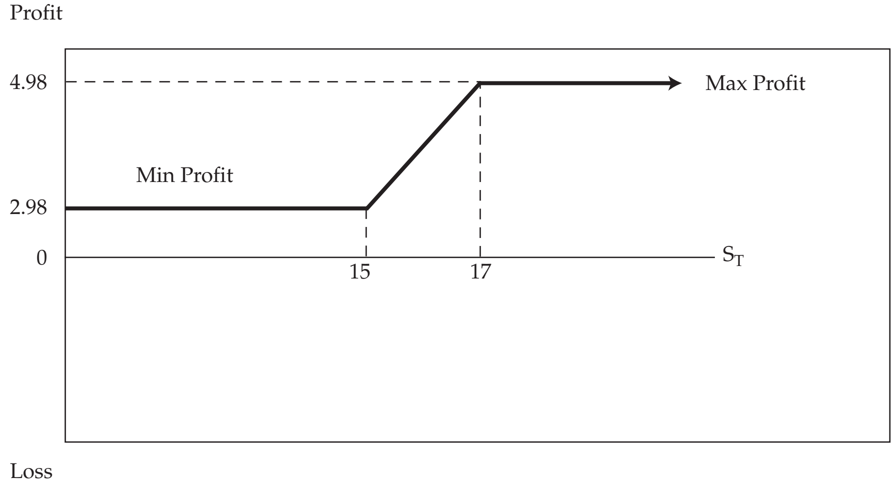
Stock price at expiration	5	10	15	16	17	20
Profit/loss from long stock	−7.00	−2.00	3.00	4.00	5.00	8.00
Profit/loss from long 15 put	8.54	3.54	−1.46	−1.46	−1.46	−1.46
Profit/loss from short 17 call	1.44	1.44	1.44	1.44	1.44	−1.56
Total	2.98	2.98	2.98	3.98	4.98	4.98

22 Most collars are structured so that the call and put premiums completely offset each other. If the investor starts with the put at a specific exercise price, he then sells a call that has the same premium. There is one specific call with the same premium, and it has a particular exercise price, which is above the exercise price of the put. An algorithm can be used to search for the exercise price on the call that has the same premium as that of the put, which is then the call that the investor should sell. Most collars are structured and transacted in the over-the-counter market because the exercise price on the call must be a specific one. Exchange-traded options have standardized exercise prices, whereas the exercise prices of over-the-counter options can be set at whatever the investor wants.

At or below the put exercise price of 15, the collar realizes a profit of $X_1 - S_0 - p_0 + c_0 = 15 - 12 - 1.46 + 1.44 = 2.98$. At or above the call exercise price of 17, the profit is constant at $X_2 - S_0 - p_0 + c_0 = 17 - 12 - 1.46 + 1.44 = 4.98$.

In this example, because the stock price had appreciated before establishing the collar, the position has a minimum gain of at least 2.98 as shown in Exhibit 24. Investors typically establish a collar on a position that is already outstanding.

Exhibit 24 Collar P&L Diagram: Stock Purchased at 12, NOV 15 Put Purchased at 1.46, NOV 17 Call Written at 1.44

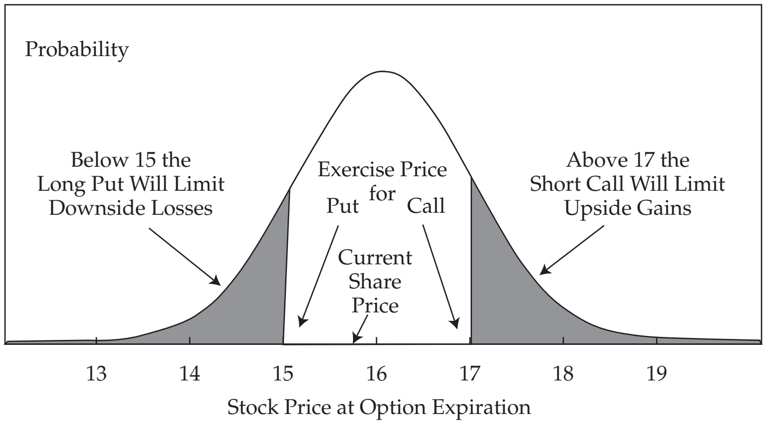


4.3.2 *The Risk of a Collar*

We have already discussed the risks of covered calls and protective puts. The collar is essentially the simultaneous holding of both of these positions. See Exhibit 25 for the return distribution of a collar. A collar sacrifices the positive part of the return distribution in exchange for the removal of the adverse portion. With the short call option, the option writer sold the right side of the return distribution, which includes the most desirable outcomes. With the long put, the investor is protected against the left side of the distribution and the associated losses. The option premium paid for the put is largely and, often precisely, offset by the option premium received from writing the call. The collar dramatically narrows the distribution of possible investment outcomes, which is risk reducing. In exchange for the risk reduction, the return potential is limited.

The risks of the collar can be understood in terms of the Greeks from Exhibit 6. For example, with a long share the delta of the portfolio = +1. With a collar, the portfolio delta is equal to the delta of the share plus the delta of the long NOV 15 put (–0.359) and short NOV 17 call (–0.475), so the portfolio delta = +1 + (–0.359) + (–0.475) = +0.166. Portfolio gamma, which equals put gamma minus call gamma, will be close to zero, –0.011 (= 0.075 – 0.086). By writing a call and buying a put, the investor reduces the portfolio's delta at a price of 15.84 from +1 to +0.166 and the gamma is very close to zero. If the stock price moves outside the range depicted in Exhibit 25, the delta of the position will approach zero over time. If the share price moves above 17, the NOV 17 call approaches a delta of +1, and the put will approach a delta of 0. The collar is short the call, so above 17 the portfolio delta (long stock with delta = +1 plus a short call with delta = –1) will approach zero. At prices below 15, the NOV 17 call will have a delta approaching 0, but the long put approaches a delta of –1, so the portfolio delta will again approach zero (long stock with delta = +1 plus the long put with delta = −1). The portfolio's sensitivity to changes in the stock price will be limited, as shown in Exhibit 25.

Exhibit 25 Collars and Return Distribution: Stock at 15.84, Write NOV 17 Call and Buy NOV 15 Put



As the chosen put and call exercise prices move successively farther in opposite directions from the current price, the combined collar position begins to replicate the underlying gain/loss pattern of a long position in the underlying security. Conversely, as the chosen strike prices approach and meet each other, the expected returns and volatility become less and less equity-like and eventually converge on those of a risk-free, fixed income return to the time horizon. Thus, a collar position is, economically, intermediate between pure equity and fixed-income exposure.

4.3.3 *The Risk of Spreads*

Note that the shape of the profit and loss diagram for the bull spread in Exhibit 17 is similar to that of the collar in Exhibit 24. The upside return potential is limited, but so is the maximum loss. As with the risk–return tradeoff with the collar, an option spread takes the tails of the distribution out of play and leaves only price uncertainty between the option exercise prices. Looking at this scenario another way, if someone were to simply buy a long call, the maximum gain would be unlimited and the maximum loss would be the option premium paid. If someone decides to convert this to a spread, doing so limits the maximum gain while simultaneously reducing the total cost.

4.4 Calendar Spread

A strategy in which one sells an option and buys the same type of option but with different expiration dates, on the same underlying asset and with the same strike, is commonly referred to as a **calendar spread**. When the investor buys the more distant call and sells the near-term call, it is a long calendar spread. The investor could also buy a near-term call and sell a longer-dated one, known as a short calendar spread. Calendar spreads can also be done with puts; the investor would still buy a long-maturity put and sell a near-term put with the same strike and underlying to create a long calendar spread. As discussed previously, a portion of the option premium is time value. Time value decays over time and approaches zero as the option expiration date nears. Taking advantage of this time decay is a primary motivation behind a calendar spread. Time decay is more pronounced for a short-term option than for one with a long time until expiration. A calendar spread trade seeks to exploit this characteristic by purchasing a longer-term option and writing a shorter-term option.

Here is an example of how someone might use a calendar spread. Suppose XYZ stock is trading at 45 a share in August. XYZ has a new product to be introduced to the public early the following year. A trader believes this new product introduction will have a positive effect on the share price. Until the excitement associated with this announcement starts to affect the stock price, the trader believes that the stock will languish around the current level. See the option prices, deltas and thetas in Exhibit 26. Based on the bullish outlook for the stock going into January, the trader purchases the XYZ JAN 45 call with a theta (indicator of daily price erosion) of –0.014 for a price of 3.81. Noting that the near-term price forecast is neutral, the trader also decides to sell the XYZ SEP 45 call for 1.55. The theta for the XYZ SEP 45 Call is –0.029. The position costs 2.26 (= 3.81 – 1.55) to create and has an initial theta of +0.015 (= –0.014 – (–0.029)). If the stock price of XYZ remains constant over the next 30 days, the XYZ SEP 45 call will lose time value more rapidly than the JAN 45 call. The delta of calendar spread equals the delta of the JAN 45 call less the delta of the SEP 45 call and will be very low (Delta = +0.041 = 0.572 – 0.531).

Now move forward to the September expiration and assume that XYZ is trading at 45. The September option will now expire with no value, which is a good outcome for the calendar spread trader. The value of the position (now just the XYZ JAN 45 call) is 3.48, a gain of 1.22 over the position cost of 2.26. If the trader still believes that XYZ will stay around 45 into October before starting to move higher, the trader may continue to execute this strategy. An XYZ OCT 45 call might be sold for 1.55 with the hope that it also expires with no value.

Exhibit 26 Calendar Spread Call Option Prices, Deltas, and Thetas

150 days until January option expiration. Underlying stock price = 45

Exercise Price	SEP	OCT	JAN
40	5.15	5.47	6.63
45	1.55	2.19	3.81
50	0.22	0.62	1.99
		Delta	
40	0.975	0.902	0.800
45	0.531	0.545	0.572
50	0.121	0.217	0.363
		Theta (daily)	
40	–0.007	–0.011	–0.011
45	–0.029	–0.020	–0.014
50	–0.014	–0.014	–0.013

Just before September option expiration. Underlying stock price = 45

Exhibit 26 (Continued)

Exercise Price	SEP	OCT	JAN
40	5.00	5.15	6.39
45	0	1.55	3.48
50	0	0.22	1.69

In this example, the calendar spread trader has a directional opinion on the stock but does not believe that the price movement is imminent. Rather, the trader sees an opportunity to capture time value in one or more shorter-lived options that are expected to expire worthless.

A short calendar spread is created by purchasing the near-term option and selling a longer-dated option. Thetas for in-the-money calls may provide motivation for a short calendar spread. Assume a trader purchases the XYZ SEP 40 call with a theta of –0.007 for a price of 5.15. The trader sells the OCT 40 call with a theta of –0.011 for 5.47 to offset the cost of the SEP 40 call. The position nets the trader a cash inflow of 0.32 (= 5.47 – 5.15), and the initial position theta is slightly positive –0.007 – (–0.011) = +0.004.

If the stock price of XYZ remains at 45 (above the strike of 40) at the SEP expiration, the XYZ OCT 40 call will lose time value more rapidly than the SEP 40 call. The trader may close the position at the SEP expiration and make a profit of 0.17 = 0.32 + (5 – 5.15). Note that the profit consists of the 0.32 initial inflow plus the net cost of selling the SEP 40 call (at 5.00) and buying the OCT 40 call (at 5.15). In the event of a larger move, the position values will vary. For a large down move, for example an extreme case in which XYZ loses all of its value (so S = 0 at expiration), the long and the short call positions will be approximately worthless and the profit on the spread will be around 0.32 (= 0.32 + [0 – 0])). For a smaller down move to the strike price (S = 40 at expiration), the short calendar spread may result in a loss. If the XYZ stock price were to fall to 40 at the SEP expiration, the long position in the SEP 40 call would expire worthless but the OCT 40 call would still have a BSM model value of about 1.00 (not shown in Exhibit 26). This scenario would result in a loss of 0.68 = 0.32 + (0 – 1) to close the position. The writer of a calendar spread would typically be looking for a large move away from the strike price in either direction.

In sum, a big move in the underlying market or a decrease in implied volatility will help a short calendar spread, whereas a stable market or an increase in implied volatility will help a long calendar spread. Thus, calendar spreads are sensitive to movement of the underlying but also sensitive to changes in implied volatility.

IMPLIED VOLATILITY AND VOLATILITY SKEW

5

An important factor in the current price of an option is the outlook for the future volatility of the underlying asset's price, the **implied volatility**. Implied volatility is not observable per se, but it is derived from an option pricing model—such as the Black–Scholes–Merton (BSM) model—and it is value that equates the model price of an option to its market price. Note that all other input variables to the BSM model, including the option's strike price, the price of the underlying, the time to option expiration, and the risk-free interest rate, are observable. Implied volatilities incorporate investors' expectations about the future course of financial asset prices and the level of market uncertainty associated with them.

Implied volatilities for options on a specific asset may differ with strike price (i.e., moneyness), side (i.e., put or call), and time to expiration. In particular, out-of-the-money (OTM) puts typically command higher implied volatilities than ATM or OTM calls. This phenomenon is attributed to investors' reassessments of the probabilities of negative "fat-tailed" market events such as the 2007–2009 global financial crisis.

Implied volatility is often compared with **realized volatility** (i.e., historical volatility), which is the square root of the realized variance of returns and measures the range of past price outcomes for the underlying asset. To calculate the historical volatility for the given option, stock, or equity index, a series of past prices is needed. For example, to calculate the volatility of the S&P 500 Index over the past month (i.e., 21 trading days), it is necessary to first calculate the daily percentage change for each day's index closing price. This is done using the following formula, where P_t is the closing price and P_{t-1} is the prior day's closing price: $(P_t - P_{t-1})/P_{t-1}$. The next step is to apply the standard deviation formula you learned in Level I Quantitative Methods to the daily percentage change data to calculate the standard deviation (i.e., volatility) of the S&P 500 for the selected period, which in this case is the past month.

The standard deviation over the past month is then annualized by multiplying by the square root of the number of periods in a year. Because we assume the average number of trading days in a year and in a month are 252 and 21 (excluding weekends and holidays), respectively, the formula is:

$$\sigma_{Annual}(\%) = \sigma_{Monthly}(\%)\sqrt{\frac{252}{21}} \tag{13}$$

Note that this example uses one month of daily return data, but the process is equally applicable to any other period.

Obviously, we cannot use the previous formula for realized volatility, which is based on past prices, to obtain implied volatility, which is the expected volatility of future prices of the underlying asset. Instead, the one-month annualized implied volatility can be derived from the current price of an option maturing in one month by using the BSM model. Once the one-month annualized implied volatility is obtained, it can then be converted into an estimate of the volatility expected on the underlying asset over the 21-day life of the option. This expected monthly volatility is given by the one-month annualized implied volatility divided by the square root of the number of 21-day periods in a 252-day trading year, as follows:

$$\sigma_{Monthly}(\%) = \sigma_{Annual}(\%)\Big/\sqrt{\frac{252}{21}} \tag{14}$$

When option prices are compared within or across asset classes or relative to their historical values, they are assessed by their implied volatility. Exhibit 27 shows a comparison of the one-month annualized (ATM) implied volatility at a given point in time for options across three European equity indexes (Euro Stoxx 50, FTSE MIB, and DAX). The DAX shows the lowest implied volatility among the three indexes.

Exhibit 27 One-Month Annualized Implied Volatility

Underlying Index	Implied Volatility	Three-Year Low	Three-Year High
Euro Stoxx 50	9.56	9.0	17.9
FTSE MIB	14.22	11.0	21.7
DAX	9.29	7.3	13.9

Using the one-month annualized implied volatility for DAX index options of 9.29%, the volatility expected to materialize in the DAX index over the next month (21 trading days) can be calculated as follows:

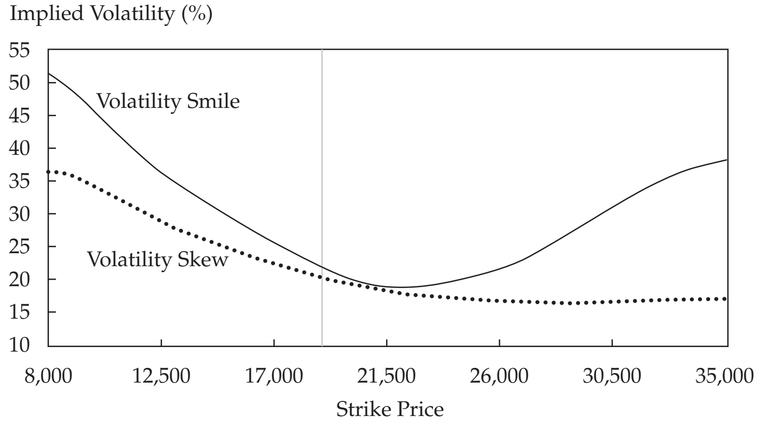
$$\sigma_{Monthly}(\%) = 9.29\% \Big/ \sqrt{\frac{252}{21}} = 2.68\%$$

So, for example, if an investor buys an ATM one-month (21-day) straddle using puts and calls on the DAX, in order for the strategy to be profitable at expiration, the index must move up or down by at least 2.68%. The investor can compare this price movement needed to reach breakeven with the DAX's realized volatility over similar time horizons in the past. If such a price change is considered reasonable, then the investor can elect to implement the strategy.

The implied volatility of ATM options, calculated from the options' market prices using the BSM model, remains the simplest way to measure the prevailing volatility level. The BSM model assumes that volatility is constant, and notably, before the 1987 stock market crash, there was little volatility skew in equity index markets. Today, however, options prices on several asset classes display persistent volatility skew and, in some circumstances, volatility smile. The implied volatilities of options of a given expiration are thus dependent on their strike prices.

Exhibit 28 plots implied volatility (y-axis) against strike price (x-axis) for options on the same underlying, the FTSE MIB (trading at 19,000), with the same expiration. When the implied volatilities priced into both OTM puts and calls trade at a premium to implied volatilities of ATM options (those with strike price at 19,000), the curve is U-shaped and is called a **volatility smile**, because it resembles the shape of a smile. The more common shape of the implied volatility curve, however, is a **volatility skew**, where the implied volatility increases for OTM puts and decreases for OTM calls, as the strike price moves away from the current price. This shape persists across asset classes and over time because investors have generally less interest in OTM calls whereas OTM put options have found universal demand as portfolio insurance against a market sell-off.

Exhibit 28 Implied Volatility Curves for Three-Month Options on FTSE MIB



The extent of the skew depends on several factors, including investor sentiment and the relative supply/demand for puts and calls, among others. Several theoretical models try to use these factors to forecast skew variation. However, these models do not lead to unique predictions. In general, we can say that when the implied volatility is significantly higher (relative to historical levels) for puts with strike prices below the underlying asset's price, it means that there is an imbalance in the supply and demand for options. In fact, when investors are looking to hedge the underlying asset, the demand for put options exceeds that for call options. Option traders, who meet this excess demand by selling puts, increase the relative price of these options, thereby raising the implied volatility. A sharp increase in the level of the skew, accompanied with a surge in the absolute level of implied volatility, is an indicator that market sentiment is turning bearish. In contrast, higher implied volatilities (relative to historical levels) for calls with strike prices above the underlying asset's price indicate that investors are bullish and the demand for OTM calls to take on upside exposure is strong.

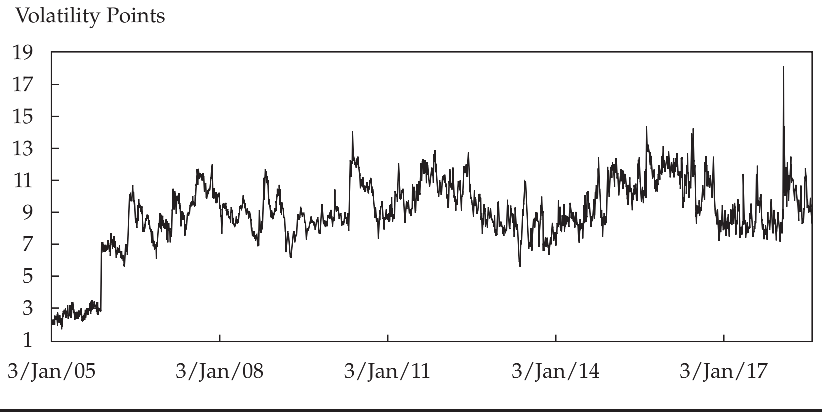
To better understand how to measure the volatility skew, consider Exhibit 29, which shows the levels of implied volatility at different degrees of moneyness for options expiring in three months on equity indexes where liquid derivatives markets exist. The 90% moneyness option is a put with strike (X) equal to 90% of the current underlying price (S); thus X/S = 90%. The 110% moneyness of the call is calculated similarly. Also shown is the skew, calculated as the difference between the implied volatilities of the 90% put and the 110% call.

Exhibit 29 Implied Volatilities and Skew for Three-Month Options

	Implied Volatility by Moneyness			90%–110%
Index	**ATM**	**Put: 90%**	**Call: 110%**	**Volatility Skew**
Nikkei 225	12.9	18.9	12.4	6.5
S&P 500	10.3	17.7	9.4	8.3
Euro Stoxx 50	12.3	17.8	9.3	8.5
DAX	14.5	20.0	11.0	9.0

For most asset classes, the level of option skew varies over time. Exhibit 30 presents the skew on the S&P 500, measured as the difference between the implied volatilities of options with 90% (puts) and 110% (calls) moneyness, and with three months to expiration.

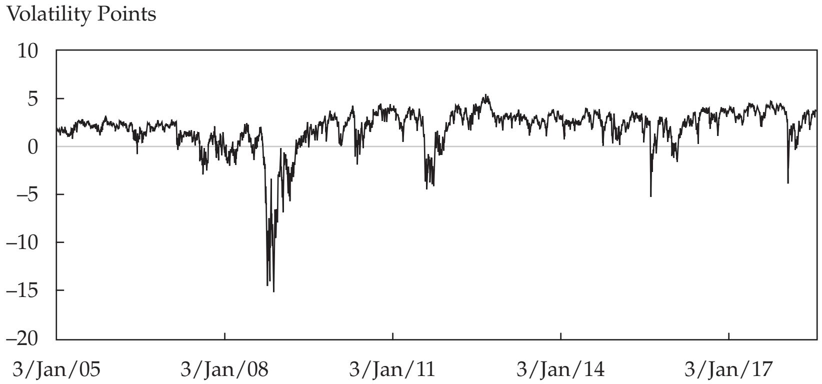
Exhibit 30 90% Put–110% Call Implied Volatility Skew for Three-Month Options on S&P 500



There are trading strategies that attempt to profit from the existence of an implied volatility skew and from changes in its shape over time. A common strategy is to take a long or short position in a **risk reversal**, which is then delta hedged. A combination of long (short) calls and short (long) puts on the same underlying with the same expiration is a long (short) risk reversal. In particular, when a trader thinks that the put implied volatility is too high relative to the call implied volatility, she creates a long risk reversal, by selling the OTM put and buying the same expiration OTM call. The options position is then delta-hedged by selling the underlying asset. The trader is not aiming to profit from the movement in the overall level in implied volatility. In fact, depending on the strikes of the put and the call, the trade could be vega-neutral. For the trade to be profitable, the trader expects that the call will rise more (or decrease less) in implied volatility terms relative to the put.

Typically, implied volatility is not constant across different maturities, which means that options with the same strike price but with different maturities display different implied volatilities. This determines the **term structure of volatility**, which is often in contango, meaning that the implied volatilities for longer-term options are higher than for near-term ones. When markets are in stress and de-risking sentiment prevails, however, market participants demand short-term options, pushing up their prices and causing the term structure of volatility to invert. Exhibit 31 shows, for options on the S&P 500, a common indicator watched by market participants: the spread between the implied volatilities of 12-month and 3-month ATM options. Values below zero indicate that the term structure is inverted with 3-month options having a higher implied volatility than the 12-month options. In periods when equity markets experience large sell-offs, such as during the 2007–2009 global financial crisis, the term structure of implied volatility typically shows significant inversion. In such periods, the general level of equity volatility and skew also remain high.

Exhibit 31 12M–3M Implied Volatility Term Structure of S&P 500 Options



The **implied volatility surface** can be thought of as a three-dimensional plot, for put and call options on the same underlying asset, of days to expiration (x-axis), option strike prices (y-axis), and implied volatilities (z-axis). It simultaneously shows the volatility skew (smile) and the term structure of implied volatility. Considering that implied volatility varies across different option maturities and displays skew, the implied volatility surface is typically not flat as the BSM model may suggest. By observing the implied volatility surface, one can infer changes in market expectations. Several studies have focused on ways to extract information embedded in option market prices. The skew can provide insight into market participants' perceptions about the price movement of the underlying asset over a specified horizon. The general interpretation is that the shape of the volatility skew reflects varying degrees of market participants' fear about future market stress.

6 INVESTMENT OBJECTIVES AND STRATEGY SELECTION

6.1 The Necessity of Setting an Objective

Every trade is based on an outlook on the market. With stocks and most assets, one thinks about the direction of the market: Is it going up or down, or is it stable? When dealing with options, it is not enough to think about the market *direction*; it is also important to think about the Greeks beyond delta: gamma, theta, and vega. Where option valuation is concerned, what matters is not only the direction in which the asset underlying the derivative contract is headed but also the volatility of the underlying and even other investors' perception of that volatility. The investor's investment objective may not be achieved if one of these factors moves in an undesired direction. Gamma could lead to a faster loss or gain, depending on whether the investor is short or long the option, whereas theta could lead to a loss despite the underlying asset moving in the right direction. Vega could rise or fall if market expectations of implied volatility change, leading to a loss or profit for the options position. Furthermore, the option premium paid (if long) or received (if short) must be considered when calculating a position's total profit and loss at maturity. For example, in a simple call option purchase, the underlying asset must go up enough so that the call option reaches breakeven by overcoming the premium paid for the call.

Moreover, with the introduction of volatility-based derivatives, investors increasingly view these investments as a way to protect their portfolios against downside risk and also as a method to improve their portfolios' efficiency. When considering hedging strategies, it is important to differentiate between situations in which the investor's goal is to benefit from rising volatility (long volatility)—for example, in hedging a long stock position—and situations in which the investor wants to benefit from falling volatility (short volatility)—for example, by writing a short straddle position.

Derivatives are used by portfolio managers, traders, and corporations to adjust their risk exposures, to achieve a specific investment objective, or even to infer market expectations in the short term (for example, inferring market expectations for central banks' interest rate decisions). The main advantage of derivatives is that they allow two parties with differing needs and market views to adjust quickly without having to enter into potentially costly and difficult trades in the underlying. Another advantage of using derivatives instead of investing in the physical underlying securities is leverage. The fact that investors can take on a large exposure to the underlying asset by putting up only a fraction of the amount of risk capital is an important feature of derivatives. Liquidity is another key aspect favoring derivatives usage in many markets—for example, the ability to buy or sell credit protection using index credit derivatives (CDS) instead of trading the actual underlying, and likely less liquid, bonds provides a huge liquidity advantage to traders and investors. In sum, given an actual or anticipated portfolio of equities, bonds, rates, currencies, or other assets; a market outlook and a timeframe; and an understanding of the benefits and limitations of derivatives, it is important to set realistic investment objectives, be they for hedging, for taking direction bets, or for capturing arbitrage opportunities.

6.2 Criteria for Identifying Appropriate Option Strategies

Investors use derivatives to achieve a target exposure based on their outlook for the underlying asset. Exhibit 32 shows one way of looking at the interplay of direction and volatility. The strategies identified are most profitable given the expected change in implied volatility and the outlook for the direction of movement of the underlying asset.

Exhibit 32: Choosing Options Strategies Based on Direction and Volatility of the Underlying Asset

		Outlook on the Trend of Underlying Asset: Bearish	Trading Range/ Neutral View	Bullish
Expected Move in Implied Volatility	**Decrease**	*Write calls*	*Write straddle*	*Write puts*
	Remain Unchanged	*Write calls and buy puts*	*Calendar spread*	*Buy calls and write puts*
	Increase	*Buy puts*	*Buy straddle*	*Buy calls*

Consider an investor who is bearish about a market. If he expects that implied volatility will increase as the market sells off, then he will buy a put to protect his investments. If instead he believes that volatilities are expected to fall, writing a call would likely be a profitable strategy. Investors need to keep in mind, however, that the two strategies have two different payoffs and risk management implications. As we have seen previously, a position in which the investor writes the call and buys the put is a collar, and it is often associated with holding a long position in the underlying asset. Investors use collars against a long stock position to hedge risk and smooth volatility. In fact, by selling a covered call while purchasing a protective put, the investor establishes a combined position with fixed downside protection while still providing some opportunity for profits.

Now consider an investor who has a bullish view. Buying calls is an option strategy that will allow the investor to benefit if her outlook is correct and implied volatility increases. When implied volatilities are expected to fall, writing a put represents an alternative strategy to take advantage of a bullish market view with declining volatility. If this happens, the position will likely be profitable, because as the stock rises and implied volatility decreases, the short put moves farther out of the money and its price will decrease. The combined position in which the investor is long calls and short puts (i.e., a long risk reversal) is used to implement a bullish view (the investor buys the calls) while lowering the cost (the investor sells the puts) of the long position in the underlying asset that will be established upon exercising the options.

Investors can also decide to sell puts when they want to buy a stock only if the price declines below a determined target price (the strike price of the puts will be the same as this target price). In this case, by selling the put options when implied volatilities are elevated (and the puts are expensive), the investor can realize an effective stock purchase price that is less than the target (strike) price by the size of the premium received.

The purchase of call or put spreads tends to be most appropriate when the investor has a bullish view (call bull spread) or a bearish view (put bear spread) but the underlying market is not clearly trending upward or downward. Furthermore, such spreads are a way to reduce the total cost, given that the spread is normally constructed by buying one option and writing another. Importantly, if the implied volatility curve is skewed, with the implied volatility of OTM puts relatively higher than for nearer-to-the-money options, the cost of a bearish spread is even lower. This is because in the put bear spread, the lower exercise price, more OTM (but relatively more expensive) put is sold and the higher exercise price, nearer-to-the-money (but relatively less expensive) put is purchased.

Now suppose that the market is expected to trade in range. Again, the investor should consider volatility. Suppose he believes the current consensus estimate of volatility implied in option prices is too low and the rate of the change in underlying prices will increase—that is, vega will increase. If the investor is neutral on market direction, the appropriate strategy will be a long straddle, because this strategy takes advantage of an increase in the long call or long put option prices in response to realization of the expected surge in volatility, vega, and gamma. At expiry, the long straddle will be profitable if the price of the call (put) is greater (less) than the upper (lower) breakeven price. In contrast, an investor who expects the market to trade in range and volatility to fall may want to write the straddle instead.

We now consider a strategy that combines a longer-term bullish/bearish outlook on the underlying asset with a near-term neutral outlook. This approach is the calendar spread (or time spread), a strategy using two options of the same type (puts or calls) and same strike price but with different maturity dates. Typically, a long calendar spread—wherein the shorter-maturity option is sold and the longer-maturity option is purchased—is a long volatility trading strategy because the longer-term option has a higher vega than the shorter-term option. The maximum profit is obtained when the short-term option expires worthless, then implied volatility surges, increasing the price of the remaining long-term option. Although the delta for a calendar spread is approximately zero, gamma is not, so the main risk for the calendar strategy is that the underlying stock price moves too fast and too far from the strike prices. For this reason, the calendar spread is typically implemented in option markets characterized by low implied volatility when the underlying stock is expected to remain in a trading range, but only until the maturity of the short-term option.

7 USES OF OPTIONS IN PORTFOLIO MANAGEMENT

This section uses "mini cases" to illustrate some of the ways in which different market participants use derivative products to solve a problem or to alter a risk exposure. Note that with the wide variety of derivatives available, there are almost always multiple ways in which derivatives might logically be used in a particular situation. These mini cases cover only a few of them.

7.1 Covered Call Writing

Carlos Rivera is a portfolio manager in a small asset management firm focusing on high-net-worth clients. In mid-April, he is preparing for an upcoming meeting with Parker, a client whose daughter is about to marry. Parker and her husband have just decided to pay for their daughter's honeymoon and need to raise $30,000 relatively quickly. The client's portfolio is 70% invested in equities and 30% in fixed income and is by policy slightly aggressive. Currently the Parkers are "asset rich and cash poor," having largely depleted their cash reserves prior to the wedding expenses. The recently revised investment policy statement permits most option activity except the writing of naked calls.

Parker's account contains 5,000 shares of Manzana (MNZA) stock, a stock that she is considering selling in the near future. Rivera's firm has a bearish market outlook for MNZA shares over the next six months. Rivera reviews information on the 44-day exchange-listed options, which expire in May (shown in Exhibit 33). He is considering writing MNZA calls, which will accomplish two objectives. First, the sale of calls will generate the required cash for his client. Secondly, the sale will reduce the delta of Parker's account in line with his firm's bearish short-term outlook for MNZA shares. The current delta of Parker's MNZA position is 5,000(+1) or +5,000. Exhibit 33 contains call and put price information for May MNZA options with strike prices close to the current market price of MNZA shares (S_0 = $169).

Exhibit 33 Manzana Inc. May Options With 44 Days to Expiration, MNZA Stock = $169

Call Premium	Call Delta	Exercise Price	Put Premium	Put Delta	Put or Call Vega
12.55	0.721	160	3.75	–0.289	0.199
9.10	0.620	165	5.30	–0.384	0.224
6.45	0.504	170	7.69	–0.494	0.234
4.03	0.381	175	10.58	–0.604	0.225
2.50	0.271	180	14.10	–0.702	0.199

Discuss the factors that Rivera should consider and the strategy he should recommend to Parker.

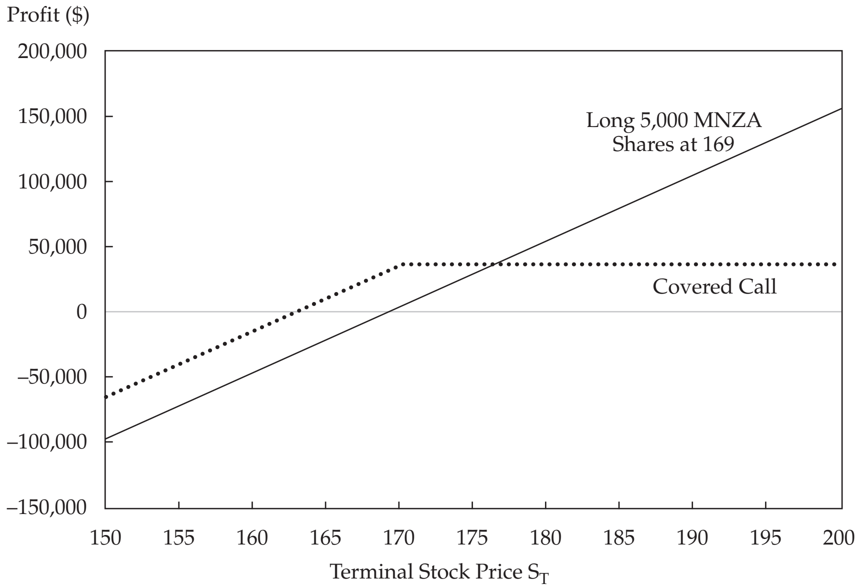
Solution:

To generate cash, Rivera will want to write options. The account permits the writing of covered calls. Manzana options trade on an organized exchange with a standard contract size of 100 shares per contract. With 5,000 shares in the account, 50 call contracts would be covered.

If Rivera were to write the MAY 180 calls, doing so would not generate the required cash, $2.50 × 100 × 50 = $12,500. Writing the MAY 165 calls would generate more than enough income: $9.10 × 100 × 50 = $45,500. However, the May 165 call is in the money. Although the firm's outlook is bearish for the shares, Rivera feels there is a high likelihood of Parker's MNZA shares being called away at expiration. Writing the May 175 call would generate only $4.03 × 100 × 50 = $20,150. Although Rivera believes the 175 call would not be exercised, the cash generated would be only about two-thirds of the client's projected need. The May 170 call would generate $6.45 × 100 × 50 = $32,250, which looks good from a cash-generation perspective. The current price of MNZA shares is 169, so there is a considerable risk that MNZA shares will sell above that level at expiration. If MNZA stock trades above the strike price at the May expiration, then Parker would be exposed to having her shares called at 170. Given the firm's bearish outlook for MNZA shares and, as stated previously, "Parker is considering selling the stock in the near future," this risk might be acceptable. Using the May 170 call option data from Exhibit 33, the delta of Parker's MNZA position would be reduced from +5,000 to 5,000 × (+1 – 0.504) = +2,480.[23] The profit graph for the recommended sale of 50 May 170 call contracts against Parker's 5,000 share long position at 169 is shown in Exhibit 34.

23 Delta for the short calls will approach –1 if the stock price moves strongly above 170 close to maturity. The likelihood of the shares being called away in that scenario would push the position delta to 0 (= +5000 from the shares, –5000 for the short ITM calls).

Exhibit 34 Profit and Loss for MNZA May 170 Covered Call (S_0 = 169, c_0 = 6.45)



The $32,250 generated by the call option sales is Parker's to keep. There are two risks, however, that Rivera should point out to Parker using Exhibit 34. The first risk is that his outlook for MNZA shares might be incorrect. The reduced delta may cost his client a potential gain on the long position. If MNZA shares increase above 170, the profits will go to the call owner. Parker's MNZA shares may be called away at 170, limiting her profit to the option premium of $32,500 plus the $5,000 from selling her MNZA shares at a profit of $1 (= $170 – $169) as shown in Exhibit 34.[24] The second risk is that to write the covered call, Parker must continue to hold 5,000 MNZA shares. If the firm's bearish outlook is correct, the shares may drop in value during the next month, resulting in a loss on the long stock position. The loss would be cushioned somewhat by the 6.45 call premium, but a drop of more than 3.8% (below 162.55 = 169 – 6.45; 6.45/169 = 3.8%) results in an overall loss on the position. After Rivera explains the risks to Parker, she elects to write the MNZA 170 calls.

7.2 Put Writing

Oscar Quintera is the chief financial officer for Tres Jotas, a private investment firm in Buenos Aires. He wants to purchase 50,000 MNZA shares for the firm, but at the current price he considers MNZA shares to be a bit expensive. The current share price is $169, and Quintera is willing to buy the stock at a price not higher than $165. Quintera decides to write out-of-the-money puts on MNZA shares.

Discuss the outcome of the transaction, a short position in MNZA May 165 puts, assuming two scenarios:

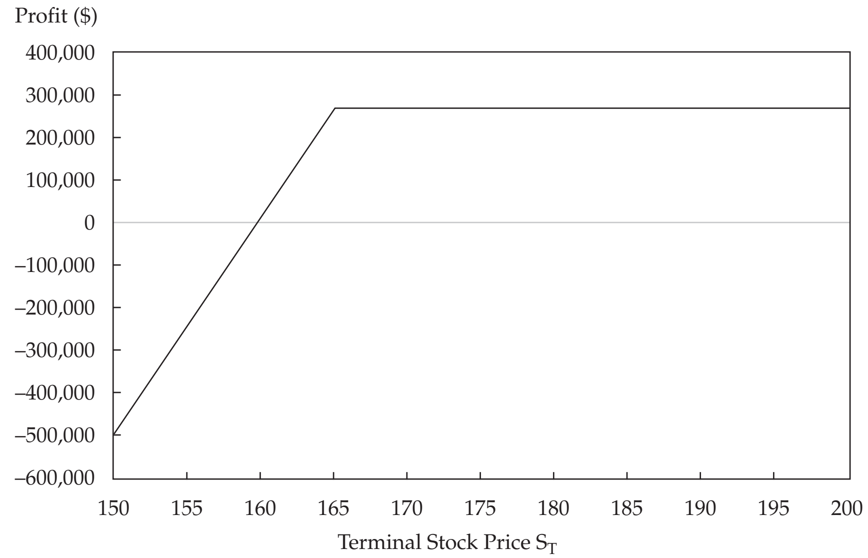
- Scenario A: MNZA is $163 per share on the option expiration day.
- Scenario B: MNZA is $177 per share on the option expiration day.

24 Note that if the shares are called away at 170, there may also be tax consequences for Parker.

Solution:

Quintera can write OTM puts to effectively "get paid" to buy the stock. He sells puts and the firm keeps the cash regardless of what happens in the future. If the stock is above the exercise price at expiration, the put options will not be exercised. Otherwise, the option is exercised, Quintera purchases the stock and, as desired, Tres Jotas becomes an owner of the stock. Exhibit 33 shows the options information for 44-day MAY put options. Because his target price is 165, Quintera writes 500 May MNZA 165 put contracts and receives premium income of 500 × 100 × \$5.30 = \$265,000. The company keeps these funds regardless of future stock price movements. But, the firm is obligated to buy stock at \$165 if the put holder chooses to exercise. By writing the puts, Quintera has established a bullish position in MNZA stock. The delta of this MNZA position is –500 × 100 × –0.384 = +19,200, the equivalent of a long position in 19,200 MNZA shares. The portfolio profit on the short put is shown in Exhibit 35.

Exhibit 35 Short Position Profit for 500 MNZA May 165 Put Contracts



Scenario A: The stock is \$163 per share on the option expiration day. With an exercise price of 165, the put is in the money and will be exercised. Quintera will be assigned to buy 50,000 shares at the exercise price of 165. The cost is 50,000 × \$165 = \$8,250,000. Quintera is satisfied with the outcome, because the firm keeps the premium income of \$265,000, so the net cost of purchase is \$8,250,000 – \$265,000 = \$7,985,000. On 50,000 shares, this means the *effective purchase price* is \$7,985,000/50,000 = \$159.70, which is below the maximum \$165 price Quintera was willing to pay. If the price of MNZA shares drops below 165, the effective purchase price will always be $X - p$ = 165 – 5.30 = \$159.70. This is the breakeven point for the short put position. At prices below the breakeven amount, Quintera would have been better off not writing the put and just buying MNZA shares outright. For example, if the MNZA price fell to \$150, Quintera would have been obligated to buy shares at 165, \$15 more than the market price. When the \$5.30 premium is considered, the \$15 difference would amount to a loss of \$9.70 per share or \$485,000 which can be seen in Exhibit 35.

Scenario B: The stock price is \$177 on the option expiration day. With an exercise price of 165.00, the MNZA puts are out of the money and would not be exercised. Tres Jotas keeps the \$265,000 premium received from writing the option. This approach adds to the company's profitability, but Tres Jotas did not acquire the MNZA shares and experienced an opportunity cost relative to an outright purchase of the stock at $169. Any price above 165, will result in earning the premium of $265,000, as can be seen in Exhibit 35.

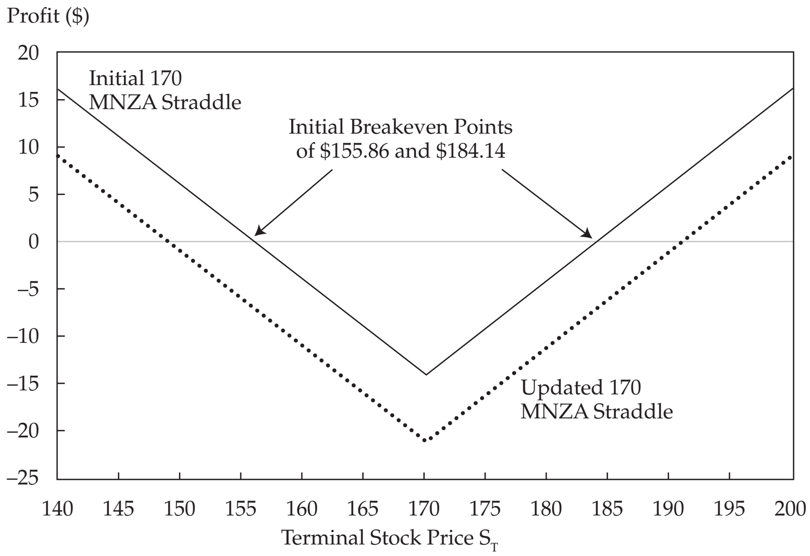
7.3 Long Straddle

Katrina Hamlet has been following Manzana stock for the past year. She anticipates the announcement of a major new product soon, but she is not sure how the critics will react to it. If the new product is praised, she believes the stock price will increase dramatically. If the product does not impress, she believes the share price will fall substantially. Hamlet has been considering trading around the event with a straddle. The stock is currently priced at $169.00, and she is focused on close-to-the-money (170) calls and puts selling for 6.45 and 7.69, respectively. Her initial strategy is presented as Exhibit 36.

Hamlet expects that the stock will move at least 10% either way once the product announcement is made, making the straddle strategy potentially appropriate. The vega of her position would be 0.234 + 0.234= +0.468, meaning a 1% move in the options' volatility would result in a gain of about $0.468 in the value of the straddle. The straddle's delta would be approximately zero, at +0.01 (Call Delta + Put Delta = (0.504 + [−0.494]). This strategy is long volatility. After the market close, Hamlet hears a news story indicating that the product will be unveiled at a trade show in two weeks. The following morning after the market opens, she goes to place her trade and finds that although the stock price remains at $169.00, the option prices have adjusted upward to $10.20 for the call and $10.89 for the put.

Discuss whether the new option premiums have any implications for Hamlet's intended straddle strategy.

Exhibit 36 Long Manzana Straddle



Solution:

Hamlet is betting on a substantial price movement in the underlying MNZA shares to make money with this trade. That price movement, up or down, must be large enough to recover the two premiums paid. In her earlier planning, that total was \$6.45 + \$7.69 = \$14.14. She expects at least a 10% price movement, which on a stock selling for \$169.00 would be an increase of \$16.90. This price movement would be sufficient to recover the \$14.14 cost of the straddle and make her strategy profitable. The breakeven points were \$155.86 and \$184.14, as shown in Exhibit 36.

The news report about the imminent product unveiling, however, has increased the implied volatility in the options, from about 30% to about 45%, raising their prices and making it more difficult to achieve the new breakeven points. After the news report, Hamlet finds the MAY 170 call now costs \$10.20 and the MAY 170 put is trading for \$10.89, so the MAY 170 straddle costs \$21.09 (\$10.20 + \$10.89) to implement. Relating back to the vega she calculated the day before, Hamlet computed an initial vega (pre-announcement) of +0.468 for the straddle. Now she sees the approximate 15 percentage point rise in implied volatility (to 45%) in both the put and call. According to her initial vega calculation, she would expect an increase of 15 × 0.468 = \$7.02 in her straddle value after the announcement. The announcement increased the price of the straddle by \$6.95 (= 21.09 – 14.14), which is very close to the \$7.02 increase predicted by the vega calculation. To reach the new breakeven points (170 ± 21.09), she now needs the stock to move by more than 12%, a larger move than 10% from the current level of 169. Given that Hamlet expects only a 10% price movement, she decides against executing this straddle trade.

EXAMPLE 7

Straddle Analytics

Use the following information to answer Questions 1 to 3 on straddles.

XYZ stock price = 100.00

100-strike call premium = 8.00

100-strike put premium = 7.50

Options expire in three months

1 If Yelena Strelnikov, a portfolio manager, buys a straddle on XYZ stock, she is *best* described as expecting a:

A higher volatility market.

B lower volatility market.

C stable volatility market.

2 This strategy will break even at expiration stock prices of:

A 92.50 and 108.50.

B 92.00 and 108.00.

C 84.50 and 115.50.

3 Reaching an upside breakeven point implies an annualized rate of return on XYZ stock *closest* to:

A 16%.

B 31%.

C 62%.

Solution to 1:

A is correct. A straddle is directionally neutral in terms of price; it is neither bullish nor bearish. The straddle buyer wants higher volatility and wants it quickly but does not care in which direction the price of the underlying moves. The worst outcome is for the underlying asset to remain stable.

Solution to 2:

C is correct. To break even, the stock price must move enough to recover the cost of both the put and the call. These premiums total to \$15.50, so the stock must move up at least to \$115.50 or down to \$84.50.

Solution to 3:

C is correct. The price change to a breakeven point is 15.50 points, or 15.5% on a 100 stock. This is for three months. Ignoring compounding, this outcome is equivalent to an annualized rate of 62% on XYZ stock, found by multiplying by 12/3 (15.5% × 4 = 62%).

7.4 Collar

Bernhard Steinbacher has a client with a holding of 100,000 shares in Tundra Corporation, currently trading for €14 per share. The client has owned the shares for many years and thus has a very low tax basis on this stock. Steinbacher wants to safeguard the position's value because the client does not want to sell the shares. He does not find exchange-traded options on the stock. Steinbacher wants to present a way in which the client could protect the investment portfolio from a decline in Tundra's stock price.

Discuss an option strategy that Steinbacher might recommend to his client.

Solution:

In the over-the-counter market, Steinbacher might buy a put and then write an out-of-the money call. This strategy is a collar. The put provides downside protection below the put exercise price, and the call generates income to help offset the cost of the put. The investor decides the strike prices of the put and the call to achieve a specific level of downside protection, while still keeping some benefit from an increase in the stock price. When the strike of the call is set so that the call premium (to be received) exactly offsets the put premium (to be paid), then the position is called a "zero-cost collar." Recalling Exhibit 25 and the underlying return distribution, this strategy effectively sells the right tail of the distribution, which represents potential large gains, in exchange for eliminating the left tail, which represents potential large losses.

7.5 Calendar Spread

Ivanka Dubois is a professional advisor to high-net-worth investors. She expects little price movement in the Euro Stoxx 50 in the next three months but has a bearish long-term outlook. The consensus sentiment favoring a flat market shows no signs of changing over the next few months, and the Euro Stoxx 50 is currently trading at 3500. Exhibit 37 shows prices for two put options with strike price of 3500 that are available on the index. Both options have the same implied volatility.

Exhibit 37 3,500 Strike Put Options on Euro Stoxx 50

	Option A	Option B
Current Price	€119	€173
Time to Maturity	3 months	6 months

1 Discuss how can Dubois take advantage of her out-of-consensus view.

2 Analyze four scenarios that Dubois might likely face for the Stoxx 50 index at the expiry of the three-month option (these scenarios are provided at the beginning of the Solution to 2).

Solution to 1:

Dubois's view is best implemented with a long position in a calendar spread that combines a longer-term bearish outlook on the underlying asset with a near-term neutral outlook. She is bearish long-term and so would buy a calendar put spread. A long calendar spread is a long volatility trading strategy whereby the maximum profit is obtained when the short-term at the money option expires worthless with the underlying almost unchanged.

Dubois can implement a put calendar spread trade by selling the three-month put option (A) for €119 and buying the six-month same strike put option (B) at the price for €173. Therefore, the cost of establishing this strategy is a net debit of €54 per contact (given by €173 – €119). Remember, Dubois has a bearish long-term outlook. If the put calendar spread is not profitable at the expiry of the three-month put, the short option expires worthless and then she owns the longer-term option free and clear. Thus, Dubois has managed to lower the cost of purchasing a longer-term put option, which could be kept for hedging her portfolio's downside risk.

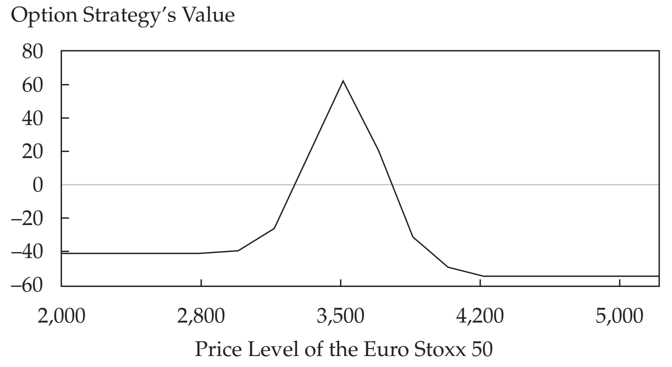
Solution to 2:

If the put calendar spread position is held until the expiry of the three-month put, then Dubois might likely face one of the four following scenarios for the Euro Stoxx 50. In the first three scenarios, the implied volatility is assumed to remain constant:

- Scenario 1: The index is still trading at 3500 as expected.
- Scenario 2: The index has increased and is trading at 4200.
- Scenario 3: The index has decreased and is trading at 3000.
- Scenario 4: The index has decreased and is trading at 3000, but the implied volatility has significantly increased.

Scenario 1: The Euro Stoxx 50 is still trading at 3500 as expected. The three-month put option expires worthless, and the original longer-term six-month option, which now has three months remaining to expiration, is worth €119 (because the implied volatility has remained constant). The total cost of the calendar spread was €54, and Dubois can sell the remaining put to a dealer for a profit of €65 (given by €119 – €54). As can be seen in Exhibit 38, which shows the profit and loss diagram for the calendar spread at the time of the expiration of the three-month put, this corresponds to the level of maximum payoff for this strategy.

Exhibit 38 P&L for 3,500 Strike Calendar Spread at Expiration of Three-Month Put

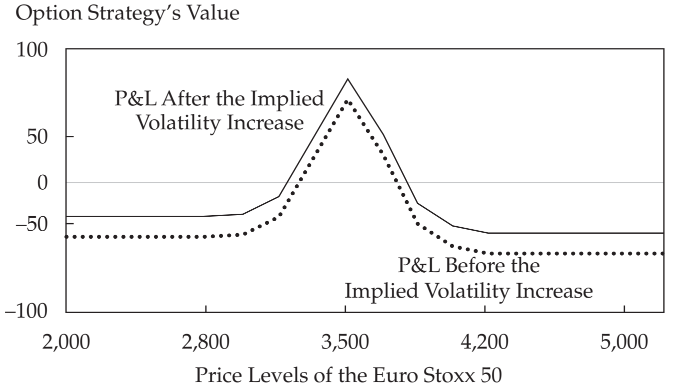


Scenario 2: The Euro Stoxx 50 has increased and is trading at 4200. The three-month put option expires worthless. Also, the value of the six-month put is near zero, and if Dubois unwinds her (long) put option position she will lose all €54 (given by €173 – €119), the cost of the put calendar spread.

Scenario 3: The Euro Stoxx 50 index has decreased and is trading at 3000. Dubois must pay €500 (€3,500 – €3,000) to settle the (short) three-month put option at expiration. The (long) put option with three months remaining to expiration is deep in the money and, assuming volatility is still unchanged, it is worth €515 (given by Intrinsic Value of €500 + €15 of Time Value). If Dubois sells this put to a dealer, she will lose €39 (= €515 – €500 – €54) on the put calendar spread.

Scenario 4: The Euro Stoxx 50 has decreased and is trading at 3000, and the implied volatility has significantly increased. Dubois must pay €500 (€3,500 – €3,000) to settle the (short) three-month put option at expiration. The (long) put option with three months remaining to expiration is deep in the money and, assuming volatility has increased, it is worth €530 (given by Intrinsic Value of €500 + €30 of Time Value). If Dubois sells this put to a dealer, she will realize a loss of €24 (= €530 – €500 – €54) on the put calendar spread. Exhibit 39 adds the profit and loss diagram for the calendar spread at the time of the expiration of the three-month put, assuming that implied volatility of the six-month put has significantly increased.

Exhibit 39 P&L for 3,500 Strike Calendar Spread at Expiration of Three-Month Put Assuming an Increase in Implied Volatility



7.6 Hedging an Expected Increase in Equity Market Volatility

Jack Wu is a fund manager who oversees a stock portfolio valued at US$50 million that is benchmarked to the S&P 500. He expects an imminent significant correction in the US stock market and wants to profit from an anticipated jump in short-term volatility to hedge his portfolio's tail risk.

The VIX Index is currently at 14.87, and the front-month VIX futures trades at 15.60. Wu observes the quotes shown in Exhibit 40 for options on the VIX (these options have same implied volatility). It is important to note that VIX option prices reflect the VIX futures prices. Given that the VIX futures trade at 15.60 while the spot VIX is 14.87, the call is at the money while the put is out of the money by 5.45% (= [14.75 – 15.60]/15.60).

At maturity, the options' payoffs will depend on the settlement price of the relevant VIX futures contracts. The options will expire one month from now, and the contract size is 100.

Exhibit 40 Options on VIX Index

	Call Option	Put Option
Option Strike	15.60	14.75
Option Price	2.00	1.55

Discuss the following:

1 A strategy Wu can implement to hedge tail risk in his equity portfolio, by taking advantage of his expected increase in volatility while lowering his hedging cost

2 Profit and loss on the strategy at options expiration

3 Relevant issues and advantages of this strategy

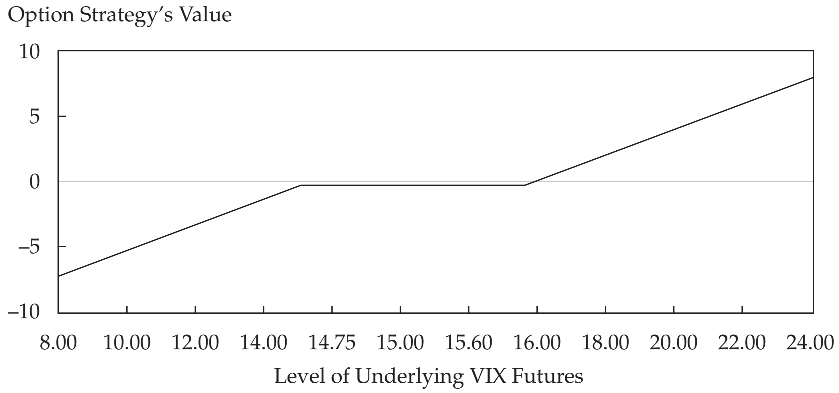
Solution to 1:

Wu decides to purchase the 15.60 call on the VIX and, to partially finance the purchase, he sells an equal number of the 14.75 VIX puts. The total cost of the options strategy is 0.45 (= 2.00 – 1.55) per contract.

Solution to 2:

At maturity, the options' payoffs will depend on the settlement price of the relevant VIX futures. Exhibit 41 shows the profit and loss diagram for the option strategy at the time of the options' expiration. In particular, the horizontal axis shows the values corresponding to the relevant VIX futures contracts.

Exhibit 41 Profit and Loss of the VIX Options Strategy



In this case, at the expiry the strategy will be profitable if volatility spikes up (as anticipated) and the VIX futures increase above 16.05. This is calculated as the call strike of 15.60 plus the net cost of the options (15.60 + 0.45). Above this level, the strategy will gain proportionally. In contrast, Wu's option strategy will lose proportionally to its exposure to the short puts if the VIX futures' settlement price is below 14.75 (put strike).

Solution to 3:

The hedge ratio that determines the number of calls to buy could be determined based on regression and scenario analysis on the portfolio's profit and loss versus rates of increase in implied volatility during significant stock market sell-offs in the past. Of course, a risk is that past correlations may not be indicative of future correlations. Importantly, the relative advantage of implementing this long volatility hedging strategy by purchasing calls on the VIX over buying VIX futures depends on the difference in leverage available, the difference in payoff profiles (asymmetrical for options and symmetrical for futures), and the shape of the volatility futures term structure, as well as the cost of the options compared with the cost of the index futures.

7.7 Establishing or Modifying Equity Risk Exposure

In this section, we examine some examples in which investors use derivatives for establishing an equity risk exposure, for risk management, or for implementing tactical asset allocation decisions. The choice of derivative that will satisfy the investment goal depends on the outlook for the underlying asset, the investment horizon, and expectations for implied volatility over that horizon.

7.7.1 *Long Call*

Armando Sanchez is a private wealth advisor working in London. He expects the shares of Markle Co. Ltd. will move from the current price of £60 a share to £70 a share over the next three months, thanks to an increase of positive news flows regarding the company's new fintech services. He also expects that the implied volatilities of options on Markle's stock will stay almost unchanged over the same period. Prices for three-month call options on the stock are shown in Exhibit 42 (note that each call contract represents one share). For his high-net-worth clients whose investment policy statements allow the use of derivatives, Sanchez plans to recommend that they purchase the call option that, based on the budget they intend to spend for implementing the strategy, would maximize profits if the stock price increases to £70 a share or more over the next three months.

Exhibit 42 Three-Month Call Options on Markle Co. Ltd.

	Option A	Option B	Option C
Strike	£58.00	£60.00	£70.00
Price	£4.00	£3.00	£0.40
Delta	0.6295	0.5227	0.1184
Gamma	0.0304	0.0322	0.0160

Discuss the option strategy that Sanchez should recommend to his clients.

Solution: Sanchez has a bullish view because he anticipates a nearly 17% price increase in Markle shares over the next three months, from the current price of £60. He expects that implied volatilities of the options on Markle shares will stay unchanged, making the purchase of options a profitable strategy if his outlook materializes within the given timeframe.

The best strategy would be a long position in the £60 strike calls (option B). The breakeven price of the position is £63 (£60 + £3), so at option expiry, the overall position would profitable at any stock price above £63. In contrast, the breakeven price of the 58-strike call (option A) is £62 (£58 + £4) and for the 70-strike call (option C) the breakeven is £70.40 (£70 + £0.40). Therefore, Sanchez would not use option C to implement his strategy because the breakeven price is above his target price of £70/share.

Given the £60 strike call has a lower price (premium) than the £58 strike call, Sanchez's clients can purchase more of these lower-priced options for a given investment size. Moreover, the 60-strike call offers the largest profit potential per unit of premium paid if the stock price increases to £70 (as expected).

Call strike £58: (£70 – £62)/£4 = 2.0

Call strike £60: (£70 – £63)/£3 = 2.3

Purchasing the £60 strike call (option B) is the most profitable strategy given that Sanchez's expectations are realized. A position in the £60 strike call has a lower delta (= 0.5227) compared with the £58 strike call (delta = 0.6295), so at current prices of the underlying, the change in value of the £60 strike call is lower. If Markle's stock reaches £70 per share during the life of the option, however, the £60 strike call will benefit from having a larger gamma (= 0.0322) compared with the £58 strike call (gamma = 0.0304).

7.7.2 *Risk Management: Protective Put Position*

Investors use protective puts, collars, and equity swaps against a long stock position to hedge market risk. Here we turn to a practical application of protective puts.

Eliot McLaire manages a Glasgow-based hedge fund that holds 100,000 shares of Relais Corporation, currently trading at €42.00.

Situation A: Before Relais Corporation's quarterly earnings release: Relais has a quarterly earnings announcement scheduled in one week. Although McLaire expects an earnings increase, he believes the company will miss the consensus earnings estimate, in which case he expects that the maximum drawdown from the current price of €42.00 would be 10%. He would like to protect the fund's position in the company for several days around the earnings announcement while keeping the cost of the protection to a minimum. Exhibit 43 provides information on options prices for Relais Corporation. Note that each put contract represents one share.

Exhibit 43 One-Month Put Options on Relais Corporation

	Option A	Option B	Option C
Strike	€40.00	€42.50	€45.00
Price	€1.45	€1.72	€3.46
Delta	–0.4838	–0.5385	–0.7762
Gamma	0.0462	0.0460	0.0346

1 Discuss an options strategy that McLaire can implement to hedge his fund's portfolio against a short-term decline in the share price of Relais Corp.

Solution to 1: McLaire can purchase a protective put with the intent of selling it soon after the earnings announcement. He expects that the maximum drawdown from the current price of €42.00 will be 10%, to €37.80. This expectation narrows the choice of put options based on the following breakeven prices:

Put strike 40.0 (option A): €40.00 – €1.45 = €38.55

Put strike 42.5 (option B): €42.50 – €1.72 = €40.78

Put strike 45.0 (option C): €45.00 – €3.46 = €41.54

The put with strike price of 42.50 (option B) best fits the objective of keeping the cost of adequate protection to a minimum. This is because the 40-strike put (option A) offers limited protection because it is profitable only below €38.55, offering a profit of just €0.75 if the stock falls to €37.80. Furthermore, the 42.50-strike put offers a larger profit per unit of premium paid than the 45.00-strike put if the stock price decreases to €37.80.

Put strike 42.5: (€40.78 – €37.80)/€1.72 = 1.73

Put strike 45.0: (€41.54 – €37.80)/€3.46 = 1.08

The 42.50 strike put has a lower delta (= –0.5385) in absolute value terms than the 45.0 strike put (delta = –0.7762), but it has more gamma. If Relais Corporation's stock falls to €37.80 per share during the life of the option, a position in the 42.50 strike put will benefit from having a larger gamma (= 0.0460) compared with the 45.0 strike put (gamma = 0.0346).

Therefore, McLaire purchases 100,000 of the 42.50-strike puts at €1.72 for a total cost of €172,000.

If Relais Corporation's soon-to-be announced earnings miss the market's expectations, the stock is likely to fall, thereby increasing the long put value and partially offsetting the loss on the stock. If the earnings meet market expectations, then the put may be sold at a price near its purchase price. If the earnings are better than expected and the stock price rises, then the put will decline in value. McLaire would no longer need the "insurance," and he would sell the put position, thereby recovering part of the purchase price.

Situation B: One week later, just after Relais Corporation's earnings release: McLaire holds the 100,000 puts with the exercise price of €42.50. Seven days have passed since the options' purchase; Relais has just released its earnings, and they turn out to be surprisingly good. Earnings beat the consensus estimate, and immediately after the announcement the stock price rises by 5% to €44.10. Exhibit 44 shows the options' prices on the day of the announcement, after the stock price has increased to €44.10 (the implied volatility remains unchanged).

Exhibit 44 23-Day Put Options on Relais

	Option A	Option B	Option C
Strike	€40.00	€42.50	€45.00
Price	€0.15	€0.66	€1.85
Delta	–0.0923	–0.3000	–0.5916
Gamma	0.0218	0.0460	0.0514
Price Change	–90%	–62%	–47%
Loss on 100,000 Puts from Price Change	€130,000	€106,000	€161,000

2 Discuss how the strategy fared and how McLaire should proceed, assuming earnings beat the consensus estimate and Relais's stock price rises by 5% to €44.10.

Solution to 2: The 42.50-strike put held by McLaire has 23 days to expiration. The price has declined from €1.72 to €0.66 (–62%), for a total loss of €106,000 (= [€1.72 – €0.66] × 100,000). This is less than the loss McLaire would have incurred if he had purchased the other options. At the same time the value of the 100,000 Relais shares held by the fund has increased by €210,000 (= ($44.10 – $42.00) × 100,000). Now that the earnings announcement has been made, McLaire no longer needs the protection from the put options, so he should sell them and recover €66,000 from the original €172,000 put purchase price.

SUMMARY

This reading on options strategies shows a number of ways in which market participants might use options to enhance returns or to reduce risk to better meet portfolio objectives. The following are the key points.

- Buying a call and writing a put on the same underlying with the same strike price and expiration creates a synthetic long position (i.e., a synthetic long forward position).
- Writing a call and buying a put on the same underlying with the same strike price and expiration creates a synthetic short position (i.e., a synthetic short forward position).
- A synthetic long put position consists of a short stock and long call position in which the call strike price equals the price at which the stock is shorted.
- A synthetic long call position consists of a long stock and long put position in which the put strike price equals the price at which the stock is purchased.
- Delta is the change in an option's price for a change in price of the underlying, all else equal.
- Gamma is the change in an option's delta for a change in price of the underlying, all else equal.
- Vega is the change in an option's price for a change in volatility of the underlying, all else equal.
- Theta is the daily change in an option's price, all else equal.

- A covered call, in which the holder of a stock writes a call giving someone the right to buy the shares, is one of the most common uses of options by individual investors.
- Covered calls can be used to change an investment's risk–reward profile by effectively enhancing yield or reducing/exiting a position when the shares hit a target price.
- A covered call position has a limited maximum return because of the transfer of the right tail of the return distribution to the option buyer.
- The maximum loss of a covered call position is less than the maximum loss of the underlying shares alone, but the covered call carries the potential for an opportunity loss if the underlying shares rise sharply.
- A protective put is the simultaneous holding of a long stock position and a long put on the same asset. The put provides protection or insurance against a price decline.
- The continuous purchase of protective puts maintains the upside potential of the portfolio, while limiting downside volatility. The cost of the puts must be carefully considered, however, because this activity may be expensive. Conversely, the occasional purchase of a protective put to deal with a bearish short-term outlook can be a reasonable risk-reducing strategy.
- The maximum loss with a protective put is limited because the downside risk is transferred to the option writer in exchange for the payment of the option premium.
- With an option spread, an investor buys one option and writes another of the same type. This approach reduces the position cost but caps the maximum payoff.
- A bull spread expresses a bullish view on the underlying and is normally constructed by buying a call option and writing another call option with a higher exercise price (both options have same underlying and same expiry).
- A bear spread expresses a bearish view on the underlying and is normally constructed by buying a put option and writing another put option with a lower exercise price (both options have same underlying and same expiry).
- With either a bull spread or a bear spread, both the maximum gain and the maximum loss are known and limited.
- A long (short) straddle is an option combination in which the investor buys (sells) puts and calls with the same exercise price and expiration date. The long (short) straddle investor expects increased (stable/decreased) volatility and typically requires a large (small/no) price movement in the underlying asset in order to make a profit.
- A collar is an option position in which the investor is long shares of stock and simultaneously writes a call with an exercise price above the current stock price and buys a put with an exercise price below the current stock price. A collar limits the range of investment outcomes by sacrificing upside gain in exchange for providing downside protection.
- A long (short) calendar spread involves buying (selling) a long-dated option and writing (buying) a shorter-dated option of the same type with the same exercise price. A long (short) calendar spread is used when the investment outlook is flat (volatile) in the near term but greater (lesser) price movements are expected in the future.
- Implied volatility is the expected volatility an underlying asset's price and is derived from an option pricing model (i.e., the Black–Scholes–Merton model) as the value that equates the model price of an option to its market price.

- When implied volatilities of OTM options exceed those of ATM options, the implied volatility curve is a volatility smile. The more common shape is a volatility skew, in which implied volatility increases for OTM puts and decreases for OTM calls, as the strike price moves away from the current price.
- The implied volatility surface is a 3-D plot, for put and call options on the same underlying, showing expiration time (*x*-axis), strike prices (*y*-axis), and implied volatilities (*z*-axis). It simultaneously displays volatility skew and the term structure of implied volatility.
- Options, like all derivatives, should always be used in connection with a well-defined investment objective. When using options strategies, it is important to have a view on the expected change in implied volatility and the direction of movement of the underlying asset.

PRACTICE PROBLEMS

The following information relates to Questions 1–10

Aline Nuñes, a junior analyst, works in the derivatives research division of an international securities firm. Nuñes's supervisor, Cátia Pereira, asks her to conduct an analysis of various option trading strategies relating to shares of three companies: IZD, QWY, and XDF. On 1 February, Nuñes gathers selected option premium data on the companies, presented in Exhibit 1.

Exhibit 1 Share Price and Option Premiums as of 1 February (share prices and option premiums in €)

Company	Share Price	Call Premium	Option Date/Strike	Put Premium
		9.45	April/87.50	1.67
IZD	93.93	2.67	April/95.00	4.49
		1.68	April/97.50	5.78
		4.77	April/24.00	0.35
QWY	28.49	3.96	April/25.00	0.50
		0.32	April/31.00	3.00
		0.23	February/80.00	5.52
XDF	74.98	2.54	April/75.00	3.22
		2.47	December/80.00	9.73

Nuñes considers the following option strategies relating to IZD:

Strategy 1: Constructing a synthetic long put position in IZD

Strategy 2: Buying 100 shares of IZD and writing the April €95.00 strike call option on IZD

Strategy 3: Implementing a covered call position in IZD using the April €97.50 strike option

Nuñes next reviews the following option strategies relating to QWY:

Strategy 4: Implementing a protective put position in QWY using the April €25.00 strike option

Strategy 5: Buying 100 shares of QWY, buying the April €24.00 strike put option, and writing the April €31.00 strike call option

Strategy 6: Implementing a bear spread in QWY using the April €25.00 and April €31.00 strike options

Finally, Nuñes considers two option strategies relating to XDF:

Strategy 7: Writing both the April €75.00 strike call option and the April €75.00 strike put option on XDF

Strategy 8: Writing the February €80.00 strike call option and buying the December €80.00 strike call option on XDF

1 Strategy 1 would require Nuñes to buy:

A shares of IZD.

B a put option on IZD.

C a call option on IZD.

2 Based on Exhibit 1, Nuñes should expect Strategy 2 to be *least* profitable if the share price of IZD at option expiration is:

A less than €91.26.

B between €91.26 and €95.00.

C more than €95.00.

3 Based on Exhibit 1, the breakeven share price of Strategy 3 is *closest* to:

A €92.25.

B €95.61.

C €95.82.

4 Based on Exhibit 1, the maximum loss per share that would be incurred by implementing Strategy 4 is:

A €2.99.

B €3.99.

C unlimited.

5 Strategy 5 is *best* described as a:

A collar.

B straddle.

C bear spread.

6 Based on Exhibit 1, Strategy 5 offers:

A unlimited upside.

B a maximum profit of €2.48 per share.

C protection against losses if QWY's share price falls below €28.14.

7 Based on Exhibit 1, the breakeven share price for Strategy 6 is *closest* to:

A €22.50.

B €28.50.

C €33.50.

8 Based on Exhibit 1, the maximum gain per share that could be earned if Strategy 7 is implemented is:

A €5.74.

B €5.76.

C unlimited.

9 Based on Exhibit 1, the *best* explanation for Nuñes to implement Strategy 8 would be that, between the February and December expiration dates, she expects the share price of XDF to:

A decrease.

B remain unchanged.

C increase.

10 Over the past few months, Nuñes and Pereira have followed news reports on a proposed merger between XDF and one of its competitors. A government antitrust committee is currently reviewing the potential merger. Pereira expects the share price to move sharply upward or downward depending on whether the committee decides to approve or reject the merger next week. Pereira asks Nuñes to recommend an option trade that might allow the firm to benefit from a significant move in the XDF share price regardless of the direction of the move.

The option trade that Nuñes should recommend relating to the government committee's decision is a:

A collar.

B bull spread.

C long straddle.

The following information relates to Questions 11–16

Stanley Kumar Singh, CFA, is the risk manager at SKS Asset Management. He works with individual clients to manage their investment portfolios. One client, Sherman Hopewell, is worried about how short-term market fluctuations over the next three months might impact his equity position in Walnut Corporation. Although Hopewell is concerned about short-term downside price movements, he wants to remain invested in Walnut shares because he remains positive about its long-term performance. Hopewell has asked Singh to recommend an option strategy that will keep him invested in Walnut shares while protecting against a short-term price decline. Singh gathers the information in Exhibit 2 to explore various strategies to address Hopewell's concerns.

Another client, Nigel French, is a trader who does not currently own shares of Walnut Corporation. French has told Singh that he believes that Walnut shares will experience a large move in price after the upcoming quarterly earnings release in two weeks. French also tells Singh, however, that he is unsure which direction the stock will move. French asks Singh to recommend an option strategy that would allow him to profit should the share price move in either direction.

A third client, Wanda Tills, does not currently own Walnut shares and has asked Singh to explain the profit potential of three strategies using options in Walnut: a long straddle, a bull call spread, and a bear put spread. In addition, Tills asks Singh to explain the gamma of a call option. In response, Singh prepares a memo to be shared with Tills that provides a discussion of gamma and presents his analysis on three option strategies:

Strategy 1: A long straddle position at the $67.50 strike option

Strategy 2: A bull call spread using the $65 and $70 strike options

Strategy 3: A bear put spread using the $65 and $70 strike options

Exhibit 2 Walnut Corporation Current Stock Price: $67.79
Walnut Corporation European Options

Exercise Price	Market Call Price	Call Delta	Market Put Price	Put Delta
$55.00	$12.83	1.00	$0.24	–0.05
$65.00	$3.65	0.91	$1.34	–0.29
$67.50	$1.99	0.63	$2.26	–0.42
$70.00	$0.91	0.37	$3.70	–0.55
$80.00	$0.03	0.02	$12.95	–0.76

Note: Each option has 106 days remaining until expiration.

11 The option strategy Singh is *most likely* to recommend to Hopewell is a:

A collar.

B covered call.

C protective put.

12 The option strategy that Singh is *most likely* to recommend to French is a:

A straddle.

B bull spread.

C collar.

13 Based on Exhibit 2, Strategy 1 is profitable when the share price at expiration is *closest* to:

A $63.00.

B $65.24.

C $69.49.

14 Based on Exhibit 2, the maximum profit, on a per share basis, from investing in Strategy 2, is *closest* to:

A $2.26.

B $2.74.

C $5.00.

15 Based on Exhibit 2, and assuming the market price of Walnut's shares at expiration is $66, the profit or loss, on a per share basis, from investing in Strategy 3, is *closest* to:

A $2.36.

B $1.64.

C $2.64.

16 Based on the data in Exhibit 2, Singh would advise Tills that the call option with the *largest* gamma would have a strike price *closest* to:

A $ 55.00.

B $ 67.50.

C $ 80.00.

SOLUTIONS

1 C is correct. To construct a synthetic long put position, Nuñes would buy a call option on IZD. Of course, she would also need to sell (short) IZD shares to complete the synthetic long put position.

2 A is correct. Strategy 2 is a covered call, which is a combination of a long position in shares and a short call option. The breakeven point of Strategy 2 is €91.26, which represents the price per share of €93.93 minus the call premium received of €2.67 per share ($S_0 - c_0$). So, at any share price less than €91.26 at option expiration, Strategy 2 incurs a loss. If the share price of IZD at option expiration is greater than €91.26, Strategy 2 generates a gain.

3 A is correct. Strategy 3 is a covered call strategy, which is a combination of a long position in shares and a short call option. The breakeven share price for a covered call is the share price minus the call premium received, or $S_0 - c_0$. The current share price of IZD is €93.93, and the IZD April €97.50 call premium is €1.68. Thus, the breakeven underlying share price for Strategy 3 is $S_0 - c_0$ = €93.93 – €1.68 = €92.25.

4 B is correct. Strategy 4 is a protective put position, which is a combination of a long position in shares and a long put option. By purchasing the €25.00 strike put option, Nuñes would be protected from losses at QWY share prices of €25.00 or lower. Thus, the maximum loss per share from Strategy 4 would be the loss of share value from €28.49 to €25.00 (or €3.49) plus the put premium paid for the put option of €0.50: $S_0 - X + p_0$ = €28.49 – €25.00 + €0.50 = €3.99.

5 A is correct. Strategy 5 describes a collar, which is a combination of a long position in shares, a long put option with an exercise price below the current stock price, and a short call option with an exercise price above the current stock price.

6 B is correct. Strategy 5 describes a collar, which is a combination of a long position in shares, a long put option, and a short call option. Strategy 5 would require Nuñes to buy 100 QWY shares at the current market price of €28.49 per share. In addition, she would purchase a QWY April €24.00 strike put option contract for €0.35 per share and collect €0.32 per share from writing a QWY April €31.00 strike call option. The collar offers protection against losses on the shares below the put strike price of €24.00 per share, but it also limits upside to the call strike price of €31.00 per share. Thus, the maximum gain on the trade, which occurs at prices of €31.00 per share or higher, is calculated as $(X_2 - S_0) - p_0 + c_0$, or (€31.00 – €28.49) – €0.35 + €0.32 = €2.48 per share.

7 B is correct. Strategy 6 is a bear spread, which is a combination of a long put option and a short put option on the same underlying, where the long put has a higher strike price than the short put. In the case of Strategy 6, the April €31.00 put option would be purchased and the April €25.00 put option would be sold. The long put premium is €3.00 and the short put premium is €0.50, for a net cost of €2.50. The breakeven share price is €28.50, calculated as $X_H - (p_H - p_L)$ = €31.00 – (€3.00 – €0.50) = €28.50.

8 B is correct. Strategy 7 describes a short straddle, which is a combination of a short put option and a short call option, both with the same strike price. The maximum gain is €5.76 per share, which represents the sum of the two option premiums, or $c_0 + p_0$ = €2.54 + €3.22 = €5.76. The maximum gain per share is realized if both options expire worthless, which would happen if the share price of XDF at expiration is €75.00.

9 C is correct. Nuñes would implement Strategy 8, which is a long calendar spread, if she expects the XDF share price to increase between the February and December expiration dates. This strategy provides a benefit from the February short call premium to partially offset the cost of the December long call option. Nuñes likely expects the XDF share price to remain relatively flat between the current price €74.98 and €80 until the February call option expires, after which time she expects the share price to increase above €80. If such expectations come to fruition, the February call would expire worthless and Nuñes would realize gains on the December call option.

10 C is correct. Nuñes should recommend a long straddle, which is a combination of a long call option and a long put option, both with the same strike price. The committee's announcement is expected to cause a significant move in XDF's share price. A long straddle is appropriate because the share price is expected to move sharply up or down depending on the committee's decision. If the merger is approved, the share price will likely increase, leading to a gain in the long call option. If the merger is rejected, then the share price will likely decrease, leading to a gain in the long put option.

11 C is correct. A protective put accomplishes Hopewell's goal of short-term price protection. A protective put provides downside protection while retaining the upside potential. Although Hopewell is concerned about the downside in the short term, he wants to remain invested in Walnut shares because he is positive on the stock in the long term.

12 A is correct. The long straddle strategy is based on expectations of volatility in the underlying stock being higher than the market consensus. The straddle strategy consists of simultaneously buying a call option and a put option at the same strike price. Singh could recommend that French buy a straddle using near at-the-money options ($67.50 strike). This allows French to profit should the Walnut stock price experience a large move in either direction after the earnings release.

13 A is correct. The straddle strategy consists of simultaneously buying a call option and buying a put option at the same strike price. The market price for the $67.50 call option is $1.99, and the market price for the $67.50 put option is $2.26, for an initial net cost of $4.25 per share. Thus, this straddle position requires a move greater than $4.25 in either direction from the strike price of $67.50 to become profitable. So, the straddle becomes profitable at $67.50 – $4.26 = $63.24 or lower, or $67.50 + $4.26 = $71.76 or higher. At $63.00, the profit on the straddle is positive.

14 A is correct. The bull call strategy consists of buying the lower-strike option and selling the higher-strike option. The purchase of the $65 strike call option costs $3.65 per share, and selling the $70 strike call option generates an inflow of $0.91 per share, for an initial net cost of $2.74 per share. At expiration, the maximum profit occurs when the stock price is $70 or higher, which yields a $5.00 per share payoff ($70 – $65) on the long call position. After deduction of the $2.74 per share cost required to initiate the bull call spread, the profit is $2.26 ($5.00 – $2.74).

15 B is correct. The bear put spread consists of buying a put option with a high strike price ($70) and selling another put option with a lower strike price ($65). The market price for the $70 strike put option is $3.70, and the market price for the $65 strike put option is $1.34 per share. Thus, the initial net cost of the bear spread position is $3.70 – $1.34 = $2.36 per share. If Walnut shares are $66

at expiration, the $70 strike put option is in the money by $4.00, and the short position in the $65 strike put expires worthless. After deducting the cost of $2.36 to initiate the bear spread position, the net profit is $1.64 per contract.

16 B is correct. The $67.50 call option is approximately at the money because the Walnut share price is currently $67.79. Gamma measures the sensitivity of an option's delta to a change in the underlying. The largest gamma occurs when options are trading at the money or near expiration, when the deltas of such options move quickly toward 1.0 or 0.0. Under these conditions, the gammas tend to be largest and delta hedges are hardest to maintain.

READING

16

Swaps, Forwards, and Futures Strategies

by Barbara Valbuzzi, CFA

Barbara Valbuzzi, CFA (Italy).

LEARNING OUTCOMES

Mastery	*The candidate should be able to:*
☐	**a.** demonstrate how interest rate swaps, forwards, and futures can be used to modify a portfolio's risk and return;
☐	**b.** demonstrate how currency swaps, forwards, and futures can be used to modify a portfolio's risk and return;
☐	**c.** demonstrate how equity swaps, forwards, and futures can be used to modify a portfolio's risk and return;
☐	**d.** demonstrate the use of volatility derivatives and variance swaps;
☐	**e.** demonstrate the use of derivatives to achieve targeted equity and interest rate risk exposures;
☐	**f.** demonstrate the use of derivatives in asset allocation, rebalancing, and inferring market expectations.

INTRODUCTION

1

There are many ways in which investment managers and investors can use swaps, forwards, futures, and volatility derivatives. The typical applications of these derivatives involve modifying investment positions for hedging purposes or for taking directional bets, creating or replicating desired payoffs, implementing asset allocation and portfolio rebalancing decisions, and even inferring current market expectations. The following table shows some common uses of these derivatives in portfolio management and the types of derivatives used by investors and portfolio managers.

Common Uses of Swaps, Forwards, and Futures	Typical Derivatives Used
Modifying Portfolio Returns and Risk Exposures (Hedging and Directional Bets)	Interest Rate, Currency, and Equity Swaps and Futures; Fixed-Income Futures; Variance Swaps
Creating Desired Payoffs	Forwards, Futures, Total Return Swaps
Performing Asset Allocation and Portfolio Rebalancing	Equity Index Futures, Government Bond Futures, Index Swaps
Inferring Market Expectations for Interest Rates, Inflation, and Volatility	Fed Funds Futures, Inflation Swaps, VIX Futures

It is important for an informed investment professional to understand how swaps, forwards, futures, and volatility derivatives can be used and their associated risk–return trade-offs. Therefore, the purpose of this reading is to illustrate ways in which these derivatives might be used in typical investment situations. Section 2 of this reading shows how swaps, forwards, and futures can be used to modify the risk exposure of an existing position. Section 3 provides a discussion on derivatives on volatility. Section 4 demonstrates a series of applications showing ways in which a portfolio manager might solve an investment problem with these derivatives. The reading concludes with a summary.

2 CHANGING RISK EXPOSURES WITH SWAPS, FUTURES, AND FORWARDS

Financial managers can use swaps, forwards, and futures markets to quickly and efficiently alter the underlying risk exposure of their asset portfolios or anticipated investment transactions. This section covers a variety of common examples that use swaps, futures, and forwards.

2.1 Managing Interest Rate Risk

2.1.1 *Interest Rate Swaps*

An interest rate swap is an over-the-counter (OTC) contract between two parties that agree to exchange cash flows on specified payment dates—one based on a *variable* (floating) interest rate and the other based on a *fixed* rate (the "swap rate")—determined at the time the swap is initiated. The swap tenor is when the swap is agreed to expire. Both interest rates are applied to the swap's notional value to determine the size of each payment. Normally, the resulting two payments (one fixed, one floating) are in the same currency but will not be equal, so they are typically netted, with the party owing the greater amount paying the difference to the other party. In this manner, a party that currently has a fixed (floating) risk or other obligation can effectively convert it into a floating (fixed) one.

Interest rate swaps are among the most widely used instruments to manage interest rate risk. In particular, they are designed to manage the risk on cash flows arising from investors' assets and liabilities. Interest rate swaps and futures can also be used to modify the risk and return profile of a portfolio. This is associated with managing a portfolio of bonds that generally involves controlling the portfolio's duration. Although futures are commonly used to make duration changes, swaps can also be used, and we shall see how in this reading. Finally, interest rate swaps are used by financial institutions to hedge the interest rate risk exposure deriving from the issuance of financial instruments sold to clients. Example 1 shows how an interest rate swap is used to convert floating-rate securities into fixed-rate securities. Here the firm initially expects continuing low interest rates, so it issues floating-rate bonds. But after concluding that rates are likely to increase, the firm seeks to convert its interest rate risk to a fixed obligation, even though doing so means making higher payments up front.

EXAMPLE 1

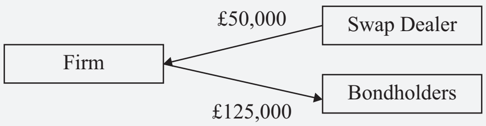
Using an Interest Rate Swap to Convert Floating-Rate Securities into Fixed-Rate Securities

An investment firm has sold £20 million of three-year floating-rate bonds that pay a semiannual coupon equal to the six-month market reference rate plus 50 bps. A few days later, the firm's outlook changes substantially, and it now expects higher rates in the future. The firm enters into an interest rate swap with a tenor of approximately three years and semiannual payments, where the firm pays a fixed par swap rate of 1.25% and receives the six-month reference rate. The swap settlement dates are the same as the coupon payment dates on the floating-rate bonds. At the first swap settlement date, the six-month reference rate is 0.75%.

Analysis:

At the first coupon payment and swap settlement date, the six-month reference rate is 0.75% (annualized). This means that on the swap the investment firm will make a net payment of £50,000 as follows:

- Receive based on the reference rate: 0.75% × £20 million × (180/360) = £75,000.
- Pay based on the fixed rate: 1.25% × £20 million × (180/360) = £125,000.
- Net payment *made* by the firm to swap dealer: £125,000 – £75,000 = £50,000.



At the same time, the first semiannual coupon payment on the securities will be (0.75% + 0.50%) × £20 million × (180/360) = £125,000.

The total payment made by the investment firm on the securities and the swap is £175,000 (= £125,000 + £50,000).

Now assume that as we move forward to the second coupon payment and swap settlement date, interest rates have increased and the six-month reference rate is 1.50%.

On the swap, the investment firm will receive a net payment of £25,000 as follows:

- Receive based on the new reference rate: 1.50% × £20 million × (180/360) = £150,000.
- Pay based on the fixed rate: 1.25% × £20 million × (180/360) = £125,000.
- Net payment *received* by the firm: £150,000 – £125,000 = £25,000.

The coupon payment on the securities will be (1.50% + 0.50%) × £20 million × (180/360) = £200,000.

The total payment made by the investment firm on the securities and the swap is again £175,000 (= £200,000 – £25,000).

The investment firm has effectively fixed its all-in borrowing costs. Since this fixed cost is synthesized by a combination of the underlying debt position and the derivative contract, it can be described as a synthetic fixed security.

Why should the investment firm decide to pay a fixed rate of 1.25%, on a semi-annual basis, for the remaining life of the securities when the reference rate is only 0.75% today? The reason is that the firm's outlook is now for higher rates in the future, as expressed by market participants in the upward-sloping yield curve. An upward-sloping yield curve reflects that investors require higher risk premium compensation for holding longer-term securities.

The agreed-on fixed rate on the swap is based on the term structure of rates at the time the deal is initiated. If the term structure changes, the new fixed rate agreed on by the counterparties on a swap with the same residual time to maturity as the original one will be different from the original rate. This means that the market value of the swap will become positive or negative. In particular, the investment firm in Example 1 has managed to fix the interest rate on future payments but has given away the opportunity to benefit from possible lower interest rates in the future. If the term structure of interest rates has a parallel shift downward, meaning that all rates across tenors decrease, the value of the swap will become negative from the perspective of the fixed-rate payer, depending on the new swap market fixed rate. The investment firm has managed to achieve the desired fixed profile of future cash flows, but it might incur a loss if the firm wants to unwind the interest rate swap before maturity. Alternatively, if rates rise, as now expected, the swap can be unwound at a profit by the same reasoning in reverse: The value of the swap becomes positive from the fixed-rate payer's view; fixed-rate payment paid is less than floating-rate payment received.

This explanation introduces the concepts of marking to market of the swap and how swaps can be used in fixed-income portfolio management with the objective to hedge the changes in value of a portfolio with fixed cash flows.

When a bond portfolio is fully hedged, its value is immunized with respect to changes in yields. This can be stated as $\Delta P = (N_s)(\Delta S)$, where ΔP is the change in the value of the bond portfolio and ΔS is the change in the value of the swap for a given change in interest rates. The notional principal of the swap (N_s) will be determined as $N_s = \Delta P/\Delta S$. To reduce changes in value of a fixed-rate portfolio, the manager will want to lower the overall duration by exchanging part of this fixed-rate income stream for a floating-rate stream. This can be done by entering an interest rate swap where the portfolio manager will pay the fixed rate and receive the floating rate.

It is important to keep in mind that most of the time, the hedging instrument and the asset or portfolio to be hedged are imperfect substitutes. The result is a market risk, called *basis risk* or *spread risk*—the difference between the market performance of the asset and the derivative instrument used to hedge it. When using an interest rate swap to hedge, it is possible that the changes in the underlying rate of the derivative contract, and thus in the value of the swap, do not perfectly mirror changes in the value of the bond portfolio.

Furthermore, the composition of the bond portfolio could bear additional market risks other than interest rate risk. For instance, suppose a portfolio of corporate bonds is hedged with an interest rate swap. In this case, even if interest rate risk is hedged, the investor is still exposed to credit spread risk.

The main underlying assumptions we will use are that the change in value of the bond portfolio can be approximated by using the concept of modified duration,[1] the yield curve is flat, and it is affected only by parallel shifts. Furthermore, we assume here that the portfolio and the derivative contract used to hedge are perfect substitutes.

A measure for the change in the value of the bond portfolio (ΔP) for a change in interest rates is given by the portfolio's modified duration, $MDUR_P$. The same measure calculated for the interest rate swap, $MDUR_S$, is used to determine the change in the value of the swap, ΔS. The target modified duration for the combined portfolio is $MDUR_T$, and MV_P is the market value of the bond portfolio.

By properly choosing the notional value and the tenor of the swap, the portfolio manager can achieve a combination of the existing portfolio and the interest rate swap that sets the overall portfolio duration to the target duration: $(MV_P)(MDUR_P) + (N_S)(MDUR_S) = (MV_P)(MDUR_T)$.

The equivalence $\Delta P = (N_S)(\Delta S)$ becomes $(MV_P)(MDUR_T - MDUR_P) = (N_S)(MDUR_S)$. To find the swap notional principal, N_S, we need to solve for the following formula:

$$N_S = \left(\frac{MDUR_T - MDUR_P}{MDUR_S}\right)(MV_P) \tag{1}$$

The modified duration of a swap ($MDUR_S$) is the net of the modified durations of the equivalent positions in fixed- and floating-rate bonds. Thus, the position of the pay-fixed party in a pay-fixed, receive-floating swap has the modified duration of a floating-rate bond minus the modified duration of a fixed-rate bond, where the floating- and fixed-rate bonds have cash flows equivalent to the corresponding cash flows of the swap. A pay-fixed, receive-floating swap has a negative (positive) duration from the perspective of a fixed-rate payer (receiver), because the duration of a fixed-rate bond is positive and larger than the duration of a floating-rate bond, which is near zero. Moreover, the negative duration of this position to the fixed-rate payer/floating-rate receiver makes sense in that the position would be expected to benefit from rising interest rates.

EXAMPLE 2

Using an Interest Rate Swap to Achieve a Target Duration

Consider a portfolio manager with an investment portfolio of €50 million of fixed-rate German bonds with an average modified duration of 5.5. Because he fears that interest rates will rise, he wants to reduce the modified duration of the portfolio to 4.5, but he does not want to sell any of the securities. One way to do this would be to add a negative-duration position by entering into an interest rate swap where he pays the fixed rate and receives the floating rate. A two-year interest rate swap has an estimated modified duration of –2.00 from the perspective of the fixed-rate payer.

Demonstrate how the manager can use this interest rate swap to achieve the target modified duration.

1 Although there are various duration measures, we are concerned here with modified duration, which is an approximate measure of how a bond price changes given a small change in the level of interest rates.

Solution:

The portfolio manager's goal is for the bonds and the swap to combine to create a portfolio with a market value of €50 million and a target modified duration of 4.5. This relationship can be expressed as follows:

$$€50{,}000{,}000(5.50) + (N_S)(MDUR_S) = €50{,}000{,}000(4.50),$$

where

N_S = Interest rate swap's notional principal

$MDUR_S$ = Interest rate swap's modified duration, set equal to –2.00

So, the notional principal of this interest rate swap that the manager should use is determined using Equation 1, as follows:

$$N_S = [(4.50 - 5.50)/(-2.00)] \times €50{,}000{,}000 = €25{,}000{,}000.$$

2.1.2 *Interest Rate Forwards and Futures*

The market in short-term interest rate derivatives is large and liquid, and the instruments involved are forward rate agreements (FRAs) and interest rate futures. A forward rate agreement is an OTC derivative instrument that is used mainly to hedge a loan expected to be taken out in the near future or to hedge against changes in the level of interest rates in the future. In fact, with advanced settled at maturity, an FRA will settle only the discounted difference between the interest rate agreed on in the contract and the actual rate prevailing at the time of settlement, applied on the notional amount of the contract. In general, managing short-term interest rate risk with an interest rate forward contract can also be done with an interest rate futures contract. Forwards, like swaps, are OTC instruments and are especially useful because they can be customized, but they do have counterparty risk. In contrast, exchange-traded interest rate futures contracts are standardized and guaranteed by a clearinghouse, so counterparty risk is virtually zero.[2]

Forward rate agreements and interest rate futures are widely used to hedge the risk associated with interest rates changing from the time a loan or a deposit is anticipated until it is actually implemented. Example 3 demonstrates how interest rate futures are used to lock in an interest rate.

EXAMPLE 3

Using Interest Rate Futures to Lock in an Interest Rate

Amanda Wright, the chief investment officer (CIO) of a US-based philanthropic foundation is expecting a donation of $30 million in two months' time from a member of the foundation's founding family. This significant donation will then be invested for three months and subsequently will be divided into smaller grants to be made to medical and educational institutions supported by the foundation. The current (i.e., spot) three-month reference rate is 2.40% (annualized). The CIO expects interest rates to fall, and she decides to hedge the rate on the deposit with Eurodollar futures.

2 Regulatory changes in global markets are moving both over-the-counter swaps and forward contracts toward a clearing process as well. The clearing process reduces the risk that one counterparty will default on its obligations (by requiring collateral for trades and by daily marking to market of open positions), and for this reason, the counterparty risk associated with each single trade is virtually zero. However, there is still the risk that a major counterparty will fail to carry out its obligations (e.g., Lehman Brothers), causing operational risks for investors.

To provide background information, Eurodollar futures are cash settled on the basis of the market reference rate for an offshore deposit having a principal value of $1 million and a three-month maturity. These contracts are quoted in terms of the "IMM index"[3] that is equal to 100 less the annualized yield on the security. A 1 bp (0.01% or 0.0001) change in the value of the futures contract equates to a $25.00 movement in the contract value. Thus, the basis point value (BPV) of a $1 million face value, 90-day money market instrument is given by

$$BPV = \text{Face value} \times \left(\frac{\text{Days}}{360}\right) \times 0.01\% = \$1{,}000{,}000 \times \left(\frac{90}{360}\right) \times 0.01\% = \$25$$

Analysis:

Wright buys 30 of the Eurodollar futures contracts at 97.60, locking in a forward rate of 2.40%. After two months, the donation is received and the CIO initiates the deposit at the then-lower spot rate of 2.10%. She unwinds the hedge at a futures price of 97.90, which is 30 bps higher than where the position was initiated.

The foundation will receive $180,000 from the deposit plus the hedge, as follows:

1. Interest obtained on the deposit: 2.10% × $30 million × (90/360) = $157,500.
2. Profit on the hedge is 30 bps (30 × $25 = $750), which for 30 contracts corresponds to $22,500 (= $750 × 30).

This corresponds to the return on an investment at the initial three-month reference rate of 2.40%, or 2.40% × $30 million × (90/360) = $180,000. This calculation demonstrates that by buying the Eurodollar futures, Wright did indeed lock in a forward rate of 2.40%.

Institutional investors and bond traders can decide to use interest rate futures or fixed-income futures (also referred to as "bond futures") contracts, which are longer dated, to hedge interest rate risk exposure. The choice will depend on the maturity of the bond or portfolio to be hedged. Since they are listed, interest rate futures have a limited number of maturities. Furthermore, the nearest months' contracts have higher liquidity than the longer tenors. For these reasons, interest rate futures (e.g., Eurodollar futures) are commonly used to hedge short-term bonds, with up to two to three years remaining to maturity. When using interest rate futures to hedge a short-term bond, an effective and widely adopted technique to construct the hedge is to use a strip of futures contracts. Having measured the responsiveness of the bond to an interest rate change, it is now necessary to measure the sensitivity of each cash flow to changes in the relevant forward rate. Then, one can calculate the number of futures contracts needed to hedge the interest rate exposure for each cash flow. Fixed-income futures contracts remain, however, the preferred instrument to hedge bond positions, given that their liquidity is very high. This is especially true for US Treasury bond futures.

2.1.3 *Fixed-Income Futures*

Portfolio managers that want to hedge the duration risk of their bond portfolios usually use fixed-income futures. They are standardized forward contracts listed on an exchange that have as underlying a basket of deliverable bonds with remaining maturities within a predefined range. The most liquid contracts include T-note and T-bond

3 The IMM, or International Monetary Market, was established as a division of CME many years ago. The distinction is seldom made today because CME operates as a unified entity, but references to IMM persist today.

futures listed on the Chicago Board of Trade or the Chicago Mercantile Exchange. Contracts expire in March, June, September, and December, and the underlying assets include Treasury bills, notes, and bonds. In Europe, the most liquid and most heavily traded fixed-income futures are traded on the Eurex, and these are the Euro-Bund (FGBL), Euro-Bobl (FGBM), and Euro-Schatz (FCBS).[4] These futures contracts have German federal government–issued bonds with different maturities as underlying. The Schatz is also known as the short bund futures contract because the maturities of the underlying bonds range from 21 to 27 months. In contrast, maturities of underlying bonds range from 4.5 years to 5.5 years for the Bobl futures contract and are even longer (between 10 years and 30 years) for the Bund futures contract.

Bond futures are used by hedgers to protect an existing bond portfolio against adverse interest rate movements and by arbitrageurs to gain from price differences in equivalent instruments.

A fixed-income futures contract has as its underlying reference assets a basket of deliverable bonds with a range of different coupon levels and maturity dates. Most futures contracts are closed before delivery or rolled into the next contract month. However, in the case of delivery, the futures contract seller has the obligation to deliver and the right to choose which security to deliver. For this reason, the duration of a futures contract is usually consistent with the forward behavior of the cheapest underlying deliverable bond. This is called the cheapest-to-deliver (CTD) bond, the eligible bond that the seller will most likely choose to deliver under the futures contract if he decides to deliver (rather than close out the futures position). The price sensitivity of the bond futures will, therefore, reflect the duration of the CTD bond.

Within the underlying basket of bonds, the seller will deliver the CTD bond, the one that presents the greatest profit or smallest loss at delivery. To provide a guide for choosing the CTD bond, the concept of the conversion factor (CF) has been introduced. Given that the short side has the option of delivering any eligible security, a conversion factor invoicing system that allows for a less biased comparison in choosing among deliverable bonds has been established. In fact, the amount the futures contract seller receives at delivery will depend on the conversion factor that, when multiplied by the futures settlement price, will generate a price at which the deliverable bond would trade if its coupon were the notional coupon of the futures contract specification (e.g., 6% coupon and 20 years to maturity). The principal invoice amount at maturity is given in the following equation:[5]

$$\text{Principal invoice amount} = (\text{Futures settlement price}/100) \times CF \times \text{Contract size.} \quad (2)$$

The cheapest-to-deliver bond is determined on the basis of duration, relative bond prices, and yield levels. In particular, a bond with a low (high) coupon rate, a long (short) maturity, and thus a long (short) duration will most likely be the CTD bond if the market yield is above (below) the notional yield of the fixed-income futures contract. The notional yield is usually in line with the prevailing interest rate.

The pricing discrepancy between the price of the cash security and that of the fixed-income futures is the basis. It is determined by the spot cash price less the futures price multiplied by the conversion factor. The possibility of physical delivery of the underlying asset guarantees convergence of futures and spot prices on the delivery date. In fact, the no-arbitrage condition requires the basis to be zero on the delivery date; otherwise, substantial arbitrage profits can be made. However, basis traders

4 "Bobl" comes from the German term "Bundesobligation," which corresponds to a federal government bond. "Schatz" is the English word for "Bundesschatzanweisungen," or "Schätze," which is two-year debt issued by the German federal government, whereas "Bunds" represent long-term obligations.

5 If there is accrued interest due on the CTD bond, the futures contract seller will receive the following at delivery: Total invoice amount = Principal invoice amount + Accrued interest.

look for arbitrage opportunities by capitalizing on relatively small pricing differences. If the basis is negative, a trader would make a profit by "buying the basis"—that is, purchasing the bond and shorting the futures. In contrast, the trader would make a profit by "selling the basis" when the basis is positive; in this case, she would sell the bond and buy the futures. Example 4 demonstrates how to determine the CTD bond for delivery under a Treasury bond futures contract.

EXAMPLE 4

Delivery on a Fixed-Income Futures Contract

A trader has sold 10-year US Treasury bond futures contracts expiring in June and now has the obligation to deliver and the right to choose which security to deliver (the CTD bond). The futures contract reference security is a US Treasury bond with 20 years to maturity and a coupon of 6%. The T-bond futures contract size is $100,000. The futures contract settlement price is $143.47. The trader now needs to determine which of the two bonds in the following table is cheapest to deliver.

	Bond A	Bond B
Cash Bond	T 4½ 02/15/36	T 5 05/15/37
Cash Dirty Price	$120.75	$128.50
Bond Purchase Value	$120,750	$128,500
Futures Settlement Price	143.47	143.47
Conversion Factor	0.8388	0.8883
Contract Size	$100,000	$100,000
Principal Invoice Amount	$120,342.64	$127,444.40
Delivery Gain/Loss	–$407.36 = $120,342.64 – $120,750	–$1,055.60 = $127,444.40 – $128,500

Analysis:

The trader will try to maximize the difference between the amount received upon delivery, given by the futures contract settlement price (divided by 100) times the conversion factor times $100,000, and the cost of acquiring the bond for delivery, given by its market price plus any accrued interest (i.e., the dirty price). Note that this example assumes no accrued interest.

The conversion factors for both bonds are less than 1 since both bonds have a coupon lower than 6%, the coupon for the futures contract standard. Bond A can be purchased for $120,750 and Bond B for $128,500, both per $100,000 face value. These purchase prices are compared with the amounts received upon delivery. Principal invoice amounts are calculated using Equation 2, as follows:

Principal invoice amount = (Futures settlement price/100) × CF × $100,000.

Bond A: 143.47/100 × 0.8388 × $100,000 = $120,342.64.

Bond B: 143.47/100 × 0.8883 × $100,000 = $127,444.40.

The cheapest to deliver is Bond A, the 4½% T-bond with a maturity date of 02/15/36, since the loss on delivering Bond A ($407.36) is less than the loss on delivering Bond B ($1,055.60).

Continuing with the previous analysis where we hedged a portfolio of fixed-rate securities, we now determine the hedge ratio (HR) expressed as the number of fixed-income futures contracts to be sold or purchased. The relation $\Delta P = (HR)(\Delta F)$ is still valid; note that we saw it previously in the context of swaps as $\Delta P = (N_s)(\Delta S)$, where ΔP is the change in the value of the bond portfolio and ΔF is the change in the value of the fixed-income futures. The "ideal" hedge balances any change in value in the cash securities with an equal and opposite-sign change in the futures' value.

With futures, however, we have to consider the cheapest-to-deliver bond price and the conversion factor. Because the basis of the CTD bond is generally closest to zero, any change in the futures price level (ΔF) will be a reflection of the change in the value of the CTD bond adjusted by its conversion factor. By considering the relative price movement of the bond futures contract to the cheapest-to-deliver bond, we have $\Delta F = \Delta CTD/CF$. By substituting into the equation $\Delta P = (HR)(\Delta F)$, the hedge ratio becomes

$$HR = \frac{\Delta P}{\Delta CTD}(CF) \tag{3}$$

In the case where the bond to hedge is the CTD, then a hedge ratio based on the conversion factor is likely to be quite effective (given that the price of a fixed-income futures contract tends to track closely with that of the cheapest-to-deliver bond).

However, for other securities with different coupons and maturities, the number of bond futures that are used to hedge against price changes of a fixed-rate bond is calculated on the basis of a duration-based hedge ratio. Moreover, the relationship between the bond's price and its yield can also be stated in terms of basis point value and the portfolio's target modified duration, $MDUR_T$, such that the portfolio's target basis point value (BPV_T) is

$$BPV_T = MDUR_T \times 0.01\% \times MV_P \tag{4}$$

In the special case where the objective is to completely hedge the portfolio, $BPV_T = 0$. The effect of the basis point value hedge ratio ($BPVHR$) is then conceptualized as $BPV_P + BPVHR \times BPV_F = 0$. Thus, $BPVHR = –BPV_P/BPV_F$, which uses the basis point value of the portfolio to be hedged (BPV_P) and that of the futures contract (BPV_F), where

$$BPV_P = MDUR_P \times 0.01\% \times MV_P \tag{5}$$

and

$$BPV_F = BPV_{CTD}/CF \tag{6}$$

In Equation 6, the numerator is BPV_{CTD}, the basis point value of the cheapest-to-deliver bond under the futures contract, and the denominator is CF, its conversion factor. The basis point value of the cheapest-to-deliver bond is determined, in a manner analogous to Equations 4 and 5, as

$$BPV_{CTD} = MDUR_{CTD} \times 0.01\% \times MV_{CTD} \tag{7}$$

where MV_{CTD} = (CTD price/100) × Futures contract size.

Finally, for small changes in yield, by substituting into the equation $BPVHR = –BPV_P/BPV_F$, where BPV_F becomes BPV_{CTD}/CF, in the special case of complete hedging, $BPVHR$ in terms of number of futures contracts is

$$BPVHR = \frac{-BPV_P}{BPV_{CTD}} \times \text{Conversion factor} \tag{8}$$

EXAMPLE 5

Hedging Bond Holdings with Fixed-Income Futures

A portfolio manager is holding €50 million (principal) in German bunds (DBRs) and wants to fully hedge the value of the bond investment against a rise in interest rates. The portfolio has a modified duration of 9.50 and a market value of €49,531,000. Moreover, the manager wishes to fully hedge the bond portfolio (so, $BPV_T = 0$) with a short position in Euro-Bund futures with a price of 158.33. The cheapest-to-deliver bond is the DBR 0.25% 02/15/27 that has a conversion factor of 0.619489. The size of the futures contract is €100,000.

Determine the following:

1 The BPV_P of the portfolio to be hedged
2 The BPV_{CTD} of the futures contract hedging instrument
3 The number of Euro-Bund futures contracts to sell to fully hedge the portfolio

Solution to 1:

The basis point value of the portfolio (BPV_P), stated in terms of the change in value for a 1 bp (0.01%) change in yield, is calculated using Equation 5 and information from the table below:

$$BPV_P = MDUR_P \times 0.01\% = MV_P$$

Portfolio Principal	€50,000,000
Portfolio Market Value	€49,531,000
Modified Duration	9.50

$$BPV_P = 9.50 \times 0.0001 \times €49{,}531{,}000 = €47{,}054.45.$$

Thus, the portfolio to be hedged has a BPV_P of €47,054.45 per €50 million notional.

Solution to 2:

The basis point value of the CTD bond underlying the futures contract (BPV_{CTD}) is calculated using Equation 7 and information from the table below:

$$BPV_{CTD} = MDUR_{CTD} \times 0.01\% \times MV_{CTD}$$

Futures Hedge	
Euro-Bund Futures Price	158.33
Contract Size	€100,000

Cheapest-To-Deliver Bond	
DBR 0¼ 02/15/27 Gov't.	
Modified Duration	8.623
Bond Price	98.14
Conversion Factor	0.619489

$$BPV_{CTD} = 8.623 \times 0.0001 \times [(98.14/100) \times €100{,}000] = €84.63.$$

So, the BPV of the CTD bond (BPV_{CTD}) is €84.63.

Solution to 3:

Using Equation 8, the Solutions to 1 and 2, and information from the preceding table, we have

$$BPVHR = \frac{-BPV_P}{BPV_{CTD}} \times CF = \frac{-€47{,}054.45}{€84.63} \times 0.619489 = -344.437 \approx -344$$

Therefore, the number of Euro-Bund futures to *sell* to fully hedge the portfolio is 344 contracts.

In the real world, however, the hedging results are imperfect because (1) the hedge is done with the cheapest-to-deliver bond, and since the CTD bond can change over the holding period, the duration of the futures contract can also change; (2) the relationship between interest rates and bond prices is not linear, owing to convexity; and (3) the term structure of interest rates often changes via non-parallel moves.

Reconsidering Example 2 from before, in which the manager whose portfolio has a modified duration of 5.5 years wants to lower the duration to 4.5 years, the general principle is the same. What needs to be determined is the number of futures contracts that are required to reduce the portfolio's modified duration to the target level. In this more general case, where $MDUR_T$ (and BPV_T) is non-zero, stated in terms of basis point value and *BPVHR*, we have $BPV_P + BPVHR \times BPV_F = BPV_T$.

Solving for *BPVHR* and substituting for BPV_F, we have the more general version of Equation 8:

$$\begin{aligned} BPVHR &= \left(\frac{BPV_T - BPV_P}{BPV_F}\right) \\ &= \left(\frac{BPV_T - BPV_P}{BPV_{CTD}/CF}\right) \\ &= \left(\frac{BPV_T - BPV_P}{BPV_{CTD}}\right) \times CF \end{aligned} \qquad (9)$$

EXAMPLE 6

Decreasing Portfolio Duration with Futures

Consider the portfolio manager from Example 5 who now decides to decrease the portfolio's modified duration from 9.50 to 8.50. The yield curve is flat. Additionally, we have already demonstrated that given the portfolio's market value of €49,531,000, the BPV_P is €47,054.50. Finally, assume the CTD bond underlying the Euro-Bund futures is the same as before, DBR 0.25% 02/15/27, with a BPV_{CTD} of €84.63 and a conversion factor of 0.619489.

Determine the following:

1 The BPV_T of the portfolio to be hedged

2 The number of Euro-Bund futures contracts to sell to reduce the portfolio's modified duration to 8.50

Solution to 1:

Using Equation 4 with a $MDUR_T$ of 8.50, the portfolio's target basis point value (BPV_T) will be

BPV_T = 8.50 × 0.0001 × €49,531,000 = €42,101.35.

Solution to 2:

To achieve the target modified duration of 8.50, the portfolio manager must implement a short position in Euro-Bund futures. Using the same cheapest-to-deliver bond with a BPV_{CTD} of €84.63 and a conversion factor of 0.619489, the number of Euro-Bund futures to sell to decrease the portfolio's duration is calculated using Equation 9:

$$BPVHR = \left(\frac{€42{,}101.35 - €47{,}054.50}{€84.63}\right) \times 0.619489$$
$$= -36.26 \approx -36 \text{ futures contracts}$$

Therefore, the number of Euro-Bund futures to *sell* to achieve the target portfolio duration of 8.50 is 36 contracts.

2.2 Managing Currency Exposure

Currency swaps, forwards, and futures can be used to effectively alter currency risk exposures. Currency risk is the risk that the value of a current or future asset (liability) in a foreign currency will decrease (increase) when converted into the domestic currency.

2.2.1 *Currency Swaps*

A currency swap is similar to an interest rate swap, but it is different in two ways: (1) The interest rates are associated with different currencies, and (2) the notional principal amounts may or may not be exchanged at the beginning and end of the swap's life.[6]

Currency swaps help the parties in the swap to hedge against the risk of exchange rate fluctuations and to achieve better rate outcomes. In particular, a **cross-currency basis swap** exchanges notional principals because the goal of the transaction is to issue at a more favorable funding rate and swap the amount back to the currency of choice. Firms that need foreign-denominated cash can obtain the funding in their local currency and then swap the local currency for the required foreign currency using a cross-currency basis swap. The swap periodically sets interest rate payments, mostly floating for floating, separately in two different currencies. The net effect is to use a loan in a local currency to take out a loan in a foreign currency while avoiding any foreign exchange risk. In fact, the exchange rate is fixed, as illustrated in Example 7.

EXAMPLE 7

Cross-Currency Basis Swap

Consider a Canadian private equity (PE) firm that is executing a leveraged buyout (LBO) of a small, struggling US-based electronics manufacturer. The goal is to turn around the company by implementing new robotics technology for making servers and infrastructure devices for "bitcoin mining." Exit from the LBO via initial public offering is expected in three years. To execute the LBO and provide working capital for US operations, the PE firm needs USD40 million. The rate on a US dollar loan is the semiannual US dollar reference floating rate plus 100 bps. The PE firm discovers that it can borrow more cheaply in the local Canadian market and decides to fund the LBO in Canadian dollars

6 Although an exchange of notional principals often occurs, the parties may agree not to do this. Some types of hedge transactions are designed to hedge only foreign interest cash flows and not principal payments, so a principal exchange on a currency swap would not be necessary.

(CAD) by borrowing CAD50 million for three years at the semiannual Canadian dollar reference floating rate plus 65 bps. Then it contacts a New York–based dealer and requests a quote for a three-year cross-currency basis swap with semiannual interest payments to exchange the CAD50 million into US dollars. The three-year CAD–USD cross-currency basis swap is quoted at −15 bps at a rate of USD/CAD 0.8000 (expressed as US dollars per 1 Canadian dollar). The swap agreement provides that both parties pay the semiannual reference floating rate, but the Canadian dollar rate also includes a "basis." Here the basis is the difference between interest rates in the cross-currency basis swap and those used to determine the forward exchange rates. If covered interest rate parity holds, a forward exchange rate is determined by the spot exchange rate and the interest rate differential between foreign and domestic currencies over the term of the forward rate. However, usually covered interest rate parity does not hold and thus gives rise to the basis.

The basis is quoted on the non-USD leg of the swap. "Paying" the basis would mean borrowing the other currency versus lending US dollars, whereas "receiving" the basis implies lending the other currency versus borrowing US dollars. The three-year CAD–USD cross-currency swap in this case is quoted at −15 bps. This means that the Canadian PE firm, the "lender" of the Canadian dollars in the swap, will receive the Canadian dollar reference rate, assumed to be 1.95%, minus 15 bps every six months in exchange for paying the US dollar reference rate for the US dollars it has "borrowed." Given that the PE firm pays the Canadian dollar floating rate plus 65 bps on its bank loan, the effective spread paid becomes 80 bps (= 65bps + 15 bps). This compares with a spread of 100 bps if instead it borrowed in US dollars.

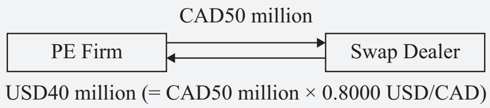
Analysis:

We now examine the cash flows in the cross-currency basis swap, where N is the notional principal of the Canadian dollar leg of the swap and S_0, agreed at the start, is the spot exchange rate for all payments (at inception, on interest payment dates, and at maturity). For the Canadian PE firm, this means that

N = CAD50 million and S_0= USD/CAD 0.8000.

Flows at the inception of the swap.

At inception, the Canadian PE firm delivers Canadian dollars (N) in exchange for US dollars (at a rate of $N \times S_0$).



At each payment date, the PE firm makes a floating-rate payment in US dollars and receives a floating-rate payment in Canadian dollars that is passed on to the local Canadian lender. At maturity, the PE firm returns the USD40 million to the dealer and in return receives the CAD50 million, which it uses to pay off its lender.

Periodic payments.

At each swap payment date, the Canadian PE firm receives interest on Canadian dollars (N) in exchange for paying interest on US dollars ($N \times S_0$). Importantly, the "basis" component (of −15 bps) will be included along with the semiannual Canadian dollar reference floating rate.

Suppose that on the first settlement date the semiannual reference floating rate in Canadian dollars is 1.95% and the basis is –15 bps. Therefore, the Canadian dollar rate on the swap is 1.80% (= 1.95% – 15 bps), and we assume the US dollar rate is 2.50% (the semiannual reference floating rate). For the PE firm, the first of a sequence of periodic cash flows resulting from the swap amounts to:

CAD50 million × 1.80% × 180/360 = CAD450,000 (A)

PE Firm ⇄ Swap Dealer

CAD50million × 0.8000 USD/CAD × 2.50% × 180/360 = USD500,000 (B)

The interest rate payment on the PE firm's loan is CAD50 million × (1.95% + 0.65%) × (180/360) = CAD650,000. Considering the CAD450,000 received on the swap (A), the PE firm's net payment is CAD200,000.

At USD/CAD 0.8000, this net payment of CAD200,000 corresponds to a payment of USD160,000, which when added to the USD500,000 paid on the swap (B) totals USD660,000. Importantly, note that had the Canadian PE firm taken out the US loan instead, it would have paid periodically USD700,000 (= USD40 million × [2.50% + 1.0%] × [180/360]).

Flows at maturity.

At the maturity of the swap (and after a successful exit from the LBO via a US IPO), the Canadian PE firm swaps back US dollars in exchange for Canadian dollars (UDS × $1/S_0$).

CAD50 million (= USD40million × 1/0.8000)

PE Firm ⇄ Swap Dealer

USD40 million

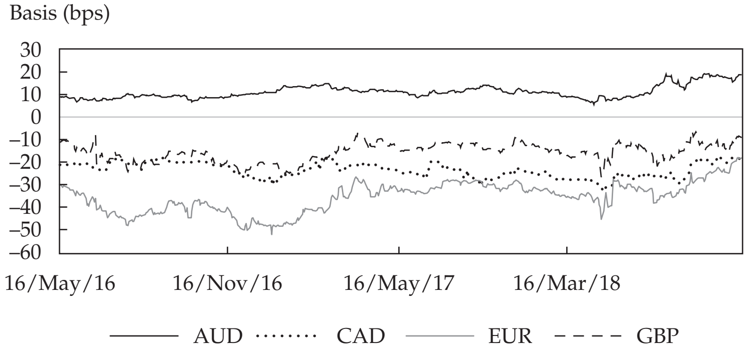
In this specific example, it is worth noting that the exchange rate was assumed not to change.

A common use of currency swaps by investors is in transactions meant to earn extra yield by investing in a foreign bond market and swapping the proceeds into the domestic currency. Given that the investment is hedged against the risk of exchange rate fluctuations, this corresponds to a synthetic domestic yield, but the repackaging allows the investor to earn a higher yield compared with the yield from direct purchase of the domestic asset, because of the level of the basis on the cross-currency swap. For example, during periods when demand for US dollars is strong relative to demand for Japanese yen (JPY), the US–Japan interest rate differential implied by the currency markets may be significantly wider than the actual interest rate differential. During such a period, a US investor might choose among the following two options: (1) Invest in short-term US Treasury bonds, or (2) use a cross-currency swap to lend and equivalent amount of US dollars and buy yen; buy short-term Japanese government debt; each period pay yen and receive US dollars on the swap; and at maturity swap an equivalent amount of yen back into US dollars. When the basis is largely negative, due to relatively weak (strong) demand for yen (US dollars) from swap market participants, the borrowing costs in yen (US dollars) are low (high), making the return from lending US dollars via a cross-currency swap particularly attractive. By choosing Option 2, the investor can earn more than he could from the investment in short-term US Treasury debt.

The rates on the cross-currency basis swaps will depend on the demand for US dollar funding, because when the US dollar reference floating rate is elevated, the counterparty receiving US dollars at initiation of the swap will be willing to receive a lower interest rate on the non-dollar currency periodic payments. Exhibit 1 shows the levels of the basis for one-year cross-currency swaps from May 2016 to April 2018 in the Australian dollar (AUD), the Canadian dollar (CAD), the euro (EUR), and the

British pound (GBP) versus USD Libor (quoted as six-month USD Libor versus six-month AUD bank bills, six-month CAD Libor, six-month Euribor, and six-month GBP Libor, respectively). Cross-currency basis spreads vary over time and are driven by credit and liquidity factors, and supply and demand for cross-currency financing. As noted previously, relatively strong demand for US dollar financing against the foreign currency would require the US dollar "borrower" in the swap to accept a lower rate on the periodic foreign currency cash flows it receives—for example, the foreign periodic reference rate less the basis. As shown in Exhibit 1, during the period covered this was the case for US dollar borrowers receiving periodic swap payments in all currencies shown except the Australian dollar.

Exhibit 1 Historical Levels for One-Year Cross-Currency Swap Spreads (Basis) vs. Major Currencies (Six-Month Settlement)



2.2.2 *Currency Forwards and Futures*

Currency forwards and futures are actively used to manage currency risk. These two financial instruments are used to hedge against undesired moves in the exchange rate by buying or selling a specified amount of foreign currency, at a defined time in the future and at an agreed-on price at contract initiation. Futures contracts are standardized and best meet dealers' and investors' needs to manage their portfolios' currency risk. Corporations often use customized forward contracts to manage the risk of cash flows in foreign currencies because they can be customized according to their needs.

For example, consider the general partner of a US-based venture capital (VC) firm that is calling down capital commitments for investment in "fintech" startups in Silicon Valley. It will receive in 30 days a payment of CAD50 million from a limited partner residing in Vancouver, British Columbia, and will immediately transfer the funds to its US dollar account. If the Canadian dollar were to depreciate versus the US dollar before the payment date, the US VC firm will receive fewer US dollars in exchange for the CAD50 million. To eliminate the foreign exchange risk associated with receiving this capital commitment, the firm can fix the price of the US dollars now via a forward contract in which it promises to sell CAD50 million for an agreed-on number of US dollars, based on the forward exchange rate, in 30 days.

EXAMPLE 8

Hedging Currency Risk with Futures

Consider the same US-based VC firm that is calling down capital commitments and will receive CAD50 million in 30 days. The general partner now decides to sell futures contracts to lock in the current USD/CAD rate. The hedge ratio is assumed to be equal to 1. The firm hedges its risk by selling Canadian dollar futures contracts with the closest expiry to the future Canadian dollar inflow.

Given a price for the Canadian dollar futures contract of USD/CAD 0.7838 (number of US dollars for 1 Canadian dollar) and a contract size of CAD100,000, determine how many Canadian dollar futures contracts the VC firm must sell to hedge its risk.

Solution:

To hedge the risk of the Canadian dollar depreciating against the US dollar, the VC firm must sell 500 futures contracts:

$$\frac{\text{CAD50,000,000}}{\text{CAD100,000}} = 500 \text{ contracts}$$

When the futures contracts expire, the VC firm will receive (pay) any depreciation (appreciation) in the Canadian dollar versus the US dollar compared with the futures contract price of USD0.7838/CAD.[7] If the changes in futures and spot prices are equal during the life of the futures contract, the hedge will be fully effective. A basis risk arises when the differential given by Futures price_t – Spot price_t is either positive or negative. In the absence of arbitrage, between the time when a hedging position is initiated and the time when it is liquidated, this spread may either widen or narrow to zero.

2.3 Managing Equity Risk

Investors can achieve or modify their equity risk exposures using equity swaps and equity forwards and futures. The asset underlying these financial instruments could be an equity index, a single stock, or a basket of stocks.

2.3.1 *Equity Swaps*

An equity swap is a derivative contract in which two parties agree to exchange a series of cash flows whereby one party pays a variable series that will be determined by a single stock, a basket of stocks, or an equity index and the other party pays either (1) a variable series determined by a different equity or rate or (2) a fixed series. An equity swap is used to convert the returns from an equity investment into another series of returns, which either can be derived from another equity series or can be a fixed rate. There are three main types of equity swaps:

- receive-equity return, pay-fixed;
- receive-equity return, pay-floating; and
- receive-equity return, pay-another equity return.

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7 Remember that, assuming covered interest rate parity holds, the forward rate $\left(F_{f/d}\right)$—expressed as units of foreign currency (f) for 1 unit of domestic currency (d)—is calculated from the exchange spot rate $\left(S_{f/d}\right)$ and the differential between the foreign (i_f) and domestic (i_d) interest rates. The forward rate is calculated on the basis of the following formula: $F_{f/d} = S_{f/d} \times \left[\left(1 + i_f \times ACT/360\right)/\left(1 + i_d \times ACT/360\right)\right]$.

Because they are an OTC derivative instrument, each counterparty in the equity swap bears credit risk exposure to the other. For this reason, equity swaps are usually collateralized in order to reduce the credit risk exposure. At the same time, as equity swaps are created in the OTC market, they can be customized as desired by the counterparties.

A total return swap is a slightly modified equity swap; it also includes in the performance any dividends paid by the underlying stocks or index during the period until the swap maturity. The swap has a fixed tenor and may provide for one single payment at the end of the swap's life, although more typically a series of periodic payments would be arranged instead. In another variation, at the time of each periodic payment, the notional amount could be reset or remain unchanged.

Equity swaps provide synthetic exposure to physical stocks. They are preferred by some investors over ownership of shares when access to a specific market is limited, when taxes are levied for owning physical stocks (e.g., stamp duty) but are not levied on swaps, the custodian fees are high, or the cost of monitoring the stock position is elevated (e.g., because of corporate actions). However, it is important to note that equity swaps require putting up collateral, are relatively illiquid contracts, and do not confer voting rights.

Example 9 shows how an equity swap might be used by an institutional investor with a portfolio indexed to the performance of the S&P 500 Index. He believes the stock market will decline over the next six months and would like to temporarily hedge part of the market exposure of his portfolio. He can do this by entering into a six-month equity swap with one payment at termination, exchanging the total return on the S&P 500 for a floating rate. We will consider two scenarios: In the first scenario, in six months the underlying portfolio is up 5%; in the second, it is down 5%.

EXAMPLE 9

Six-Month Equity Swap

An institutional investor holds a $100 million portfolio of US stocks indexed to the S&P 500. He expects the index will fall in the next six months and wants to reduce his market exposure by 30%. He enters into an equity swap with notional principal of $30 million whereby he agrees to pay the return on the index and to receive the floating reference interest rate, assumed to be 2.25%, minus 25 bps—so, 2.00% per annum.

Scenario 1:

In the first scenario, the stock market has increased by 5%. Thus, at swap settlement the institutional investor has an obligation to pay 5% × $30 million, or $1.5 million, and would receive 2% × 180/360 × $30 million, or $300,000. The two parties would net the payments and provide for a single payment of $1.2 million, which the institutional investor would pay. Because the portfolio has gained $5 million in this scenario, the profit and loss (P&L) on the combined position (including the original portfolio and the swap) is positive and equal to $3.8 million.

Scenario 1 Equity Portfolio Rises 5%	
US equity portfolio: $100 million × 5% =	+$5,000,000
P&L on the stock portfolio:	+$5,000,000
Swap settlement:	

Scenario 1 Equity Portfolio Rises 5%

Pay: $30 million × 5% =	–$1,500,000
Receive: $30 million × 2% × 180/360 =	+$300,000
Net payment on the swap:	–$1,200,000
P&L on the net position (70% of original exposure and 30% hedged): $5,000,000 – $1,200,000 =	+$3,800,000

Scenario 2:

In the second scenario, the stock market has decreased by 5%. So, it is slightly more complicated because the equity return that the institutional investor must pay is *negative*, which means he will receive money. He would receive $1.5 million because the S&P 500 had a negative performance in addition to receiving the $300,000. Because the portfolio has lost $5 million in this case, the P&L on the combined position is –$3.2 million. When the swap ends, the institutional investor returns to the same position in which he started, with the equity portfolio fully invested, and it is thereafter subject to full market risk once again.

Scenario 2 Equity Portfolio Declines 5%

US equity portfolio: $100 million × –5% =	–$5,000,000
P&L on the stock portfolio:	–$5,000,000
Swap settlement: *Receive (Pay negative return): $30 million × 5% =*	+$1,500,000
Receive: $30 million × 2% × 180/360 =	+$300,000
Net payment on the swap:	+$1,800,000
P&L on the net position (70% of original exposure and 30% hedged): –$5,000,000 + $1,800,000 =	–$3,200,000

To test the reasonableness of the result, a portfolio comprising 70% equities and 30% money market instruments assumed to earn 2% (1% over the six months) would achieve a return of 3.8% (= 0.7 × 5% + 0.3 × [2%/2]) or $3.8 million on $100 million in the bullish scenario (Scenario 1). In the bearish scenario (Scenario 2), the return would be –3.2% (= 0.7 × –5% + 0.3 × [2%/2]) or –$3.2 million on the initial $100 million portfolio. The total return swap effectively removes the risk associated with 30% of the equity portfolio allocation and converts it into money market equivalent returns.

Consider now a private high-net-worth investor who holds a large, concentrated position in a particular company's stock that pays dividends on a regular basis. She expects that in the next six months the total return from the stock, including the dividends received, will be negative, so she wants to temporarily neutralize her long exposure. At the same time, she does not wish to lose ownership and her voting rights by selling the stock on an exchange.

This investor can enter into a total return swap requiring her to transfer the total performance of the stock (i.e., total return) to the counterparty of the swap, at prespecified dates for an agreed-on fee. Under the terms of the swap, she will pay to the counterparty the share price appreciation plus the dividends received over the life of the contract. If the stock price decreases, she will receive the share price depreciation but net of the dividends. At the same prespecified dates, the investor will receive in exchange from the counterparty an agreed-on floating-rate interest payment based on the swap notional.

Equity swaps that have a single stock as underlying can be cash settled or physically settled. If the swap is cash settled, on the termination date of the contract the equity swap receiver will receive (pay) the equity appreciation (depreciation) in cash. If the swap is physically settled, on the termination date the equity swap receiver will receive the quantity of single stock specified in the contract and pay the notional amount. Let us assume for example that a portfolio manager is the receiver in a six-month equity swap with notional principal of €4.5 million and no interim cash flows that requires physical settlement, at maturity, of 300,000 shares of the Italian insurer Generali. At maturity of the swap, the portfolio manager will receive 300,000 shares of Generali and will pay €4.5 million, which corresponds to a purchase price per share of €15 (= €4.5 million/300,000). He will also pay the interest on the swap based on the agreed-on rate. Now let us also assume that at the swap's maturity the price of Generali is €16. This price implies a gain of €300,000 (= [€16 – €15] × 300,000) for the portfolio manager, assuming he sells the shares received in the swap at €16. If the same swap had cash settlement, instead of physical settlement, at maturity the portfolio manager would have received €300,000—given by €16 (the swap settlement price) less €15 (the agreed price on the swap) and multiplied by 300,000—against the payment of the interest on the swap.

2.3.2 *Equity Forwards and Futures*

Equity index futures are an indispensable tool for many investment managers: They are a low-cost instrument to implement tactical allocation decisions, achieve portfolio diversification, and attain international exposure. They are standardized contracts listed on an exchange, and when the underlying is a stock index, only cash settlement is available at contract expiration.

Single stock futures are also available to investors to acquire the desired exposure to a specific stock. This exposure is also achievable with equity forwards, which are OTC contracts that are used when the counterparties need a customized agreement. The underlying of a single stock futures contract is one specified stock, and the investor can receive or pay its performance. At expiration, the contract could require cash settlement or physical settlement using the stock.

In Example 9, rather than using an equity swap, the institutional investor could temporarily remove part of the market risk by selling S&P 500 Index futures. In the practical implementation of a stock index futures trade, we need to remember that the actual futures contract price is the quoted futures price times a designated multiplier. In determining the hedge ratio, the stock index futures price should be quoted on the same order of magnitude as the stock index.

For example, assume that a one-month futures contract on the S&P 500 is quoted at 2,700. Given the multiplier of \$250, the actual futures price is equal to \$675,000 (= 2,700 × \$250). We also assume that the portfolio to be hedged carries average market risk, meaning a beta of 1.0.[8] To hedge 30% of the \$100 million portfolio, the portfolio manager would want to sell 44 S&P 500 futures contracts, determined as follows:

$$\frac{\$30\text{ million}}{2{,}700(\$250)} = 44.444 \approx 44\text{ contracts}$$

Suppose the institutional investor sold the 44 futures at 2,700 and at expiration the S&P 500 *rises* by 0.5%. The cash settlement of the contract is at 2,713.5. Because the futures position is short and the index rose, there is a "loss" of 13.5 index points—each point being worth \$250—on 44 contracts, for a total cash outflow, paid by the institutional investor, of \$148,500:

−13.5 points per contract × \$250 per point × 44 contracts = −\$148,500 (a loss).

If the S&P 500 Index rose by 0.5%, the 30% of the portfolio that has been hedged would also be expected to rise by the same amount, but there is a small difference due to rounding the number of futures contracts used for the hedge:

\$30,000,000 × 0.5% = \$150,000.

If instead the S&P 500 *fell* by 0.5%, the numbers would be the same, but the signs would change. The institutional investor would receive the "gain" because he had a short stock index futures position when the index fell, which would offset the loss on the hedged portion of his stock portfolio. In sum, the equity market risk is hedged away.

In the previous example, the beta of the portfolio was the same as the beta of the equity index futures. This situation usually does not occur, and in most hedging strategies, it is necessary to determine the exact "hedge ratio" in terms of the number of futures contracts. Consider that the investment manager wishes to change the beta of the equity portfolio, β_S, to a target beta of β_T. Because the value of the futures contract begins each day at zero, the dollar beta of the combination of stocks and futures, assuming the target beta is achieved, is $\beta_T S$, where S is the market value of the stock portfolio.[9] The number of futures contracts we shall use is N_f, which can be determined by setting the target dollar beta equal to the dollar beta of the stock portfolio ($\beta_S S$) and the dollar beta of N_f futures ($N_f \beta_f F$), where β_f is the beta of the futures and F is the value per futures contract:

$$\beta_T S = \beta_S S + N_f \beta_f F$$

We then solve for N_f and obtain

$$N_f = \left(\frac{\beta_T - \beta_S}{\beta_f}\right)\left(\frac{S}{F}\right) \tag{10}$$

Note that if the investor wants to increase the portfolio's beta, β_T will exceed β_S and the sign of N_f will be positive, which means that she must buy futures. If she wants to decrease the beta, β_T will be less than β_S, the sign of N_f will be negative, and she must sell futures. This relationship should make sense: Selling futures will offset some of the risk of holding the stock, whereas buying futures will add risk.

8 If the portfolio carried above-market risk—say, with a beta of 1.10—the number of contracts needed to hedge would increase by this factor. Similarly, a lower-risk portfolio would require proportionately fewer contracts.

9 Recall that the market value of the portfolio will still be the same as the market value of the stock, because the value of the futures is zero. The futures value becomes zero whenever it is marked to market, which takes place at the end of each day. In other words, the target beta does not appear to be applied to the value of the futures in the preceding analysis because the value of the futures is zero.

In the special case in which the goal is to eliminate market risk, β_T would be set to zero and the formula would reduce to

$$N_f = -\left(\frac{\beta_S}{\beta_f}\right)\left(\frac{S}{F}\right)$$

In this case, the sign of N_f will always be negative, which makes sense, because in order to hedge away all the market risk, futures must be sold.

EXAMPLE 10

Increasing the Beta of a Portfolio with Futures

Paulo Bianchi is the manager of a fund that invests in UK defensive stocks, such as consumer staples producers and utilities. His firm's market outlook for the next quarter has become more positive, so Bianchi decides to increase the beta on the £40 million portfolio he manages from its current level of β_S = 0.85 to β_T = 1.10 for the next three months. He will execute this increase in equity market risk exposure using futures on the FTSE 100 Index. The futures contract price is currently £7,300, the contract's multiplier is £10 per index point (so each futures contract is worth £73,000), and its beta, β_f, is 1.00.

At the end of the three-month period, the UK stock market has increased by 2%. The stock portfolio has increased in value to £40,680,000, calculated as £40,000,000 × [1 + (0.02 × 0.85)]. The FTSE 100 futures contract has risen to £74,460.

1 Determine the appropriate number of FTSE 100 Index futures Bianchi should buy to increase the portfolio's beta to 1.10.
2 Demonstrate how the effective beta of the portfolio of stocks and the FTSE 100 Index futures matched Bianchi's target beta of 1.10.

Solution to 1:

Using Equation 10 and the preceding data, the appropriate number of futures contracts to buy to increase the portfolio's beta to 1.10 would be 137.

$$N_f = \left(\frac{\beta_T - \beta_S}{\beta_f}\right)\left(\frac{S}{F}\right) = \left(\frac{1.10 - 0.85}{1.00}\right)\left(\frac{£40{,}000{,}000}{£73{,}000}\right) = 136.99 \text{ (rounded to 137)}$$

Solution to 2:

The profit on the futures contracts is 137 × (£74,460 – £73,000) = £200,020. Adding the profit from the futures to the value of the stock portfolio gives a total market value of £40,680,000 + £200,020 = £40,880,020. The rate of return for the combined position is

$$\frac{£40{,}880{,}020}{£40{,}000{,}000} - 1 = 0.0220, \text{ or } 2.2\%$$

Because the market went up by 2% and the overall gain was 2.2%, the effective beta of the portfolio was

$$\frac{0.0220}{0.020} = 1.10$$

Thus, the effective beta matched the target beta of 1.10.

2.3.3 *Cash Equitization*

Cash securitization (also known as "cash equitization" or "cash overlay") is a strategy designed to boost returns by finding ways to "equitize" unintended cash holdings. By purchasing futures contracts, fund managers attempt to replicate the performance of the underlying market in which the cash would have been invested. Given the liquidity of the futures market, doing so would be relatively easy. An alternative solution could be to purchase calls and sell puts on the underlying asset with the same exercise price and expiry date.

In this case, we have a cash holding, implying $\beta_S = 0$, so the number of futures (with beta of β_f) that would need to be purchased in a cash equitization transaction is given by

$$N_f = \left(\frac{\beta_T}{\beta_f}\right)\left(\frac{S}{F}\right) \tag{11}$$

EXAMPLE 11

Cash Equitization

Akari Fujiwara manages a large equity fund denominated in Japanese yen that is indexed to the Nikkei 225 stock index. She determines that the current level of excess cash that has built up in the portfolio amounts to JPY140 million. She decides to purchase futures contracts to replicate the return on her fund's target index. Nikkei 225 index futures currently trade at a price of JPY23,000 per contract, the contract multiplier is JPY1,000 per index point (so each futures contract is worth JPY23 million), and the beta, β_f, is 1.00.

Determine the appropriate number of futures Fujiwara must buy to equitize her portfolio's excess cash position.

Solution:

Using Equation 11, which assumes $\beta_S = 0$, the answer is found as follows:

$$N_f = \left(\frac{\beta_T}{\beta_f}\right)\left(\frac{S}{F}\right) = \left(\frac{1.00}{1.00}\right)\left(\frac{\text{JPY140,000,000}}{\text{JPY23,000,000}}\right) = 6.087 \text{ (rounded to 6)}$$

The appropriate number of futures to buy to equitize the portfolio's excess cash position, based on the data provided, would be six contracts.

3 DERIVATIVES ON VOLATILITY

With the introduction of volatility futures and variance swaps, many investors now consider volatility an asset class in itself. In particular, long volatility exposure can be an effective hedge against a sell-off in a long equity portfolio, notably during periods of extreme market movements. Empirical studies have identified a negative correlation between volatility and stock index returns that becomes pronounced during stock market downturns. Importantly, variance swaps, which will be discussed in this section, have a valuable convexity feature—as realized volatility increases (decreases), the positive (negative) swap payoffs increase (decrease)—that makes them particularly attractive for hedging long equity portfolios. For example, some investors use strategies that systematically allocate to volatility futures or variance swaps to hedge the "tail" risk of their portfolios. Naturally, the counterparties are selling a kind of insurance;

they expect such return tails will not materialize. The effectiveness of such hedges should be compared against more traditional "long volatility" hedging methods, such as implementing a rolling series of out-of-the-money put options or futures. The roll aspect affects portfolio returns, so the term structure should be carefully considered. For example, if futures prices are in backwardation (contango), then overall returns to an investor with a long position in the futures would be enhanced (diminished) owing to positive (negative) roll return. The results are necessarily reversed for the holder of the short futures position. In sum, all these derivatives strategies should be assessed on the basis of their ability to reduce portfolio risk and improve returns. In contrast, a common investment strategy implemented by opportunistic investors involves being systematically short volatility, thereby attempting to capture the risk premium embedded in option prices. This strategy is most profitable under stable market conditions, but it can lead to large losses if market volatility rises unexpectedly.

3.1 Volatility Futures and Options

The CBOE Volatility Index, known as the VIX or the "fear index," is a measure of investors' expectations of volatility in the S&P 500 over the next 30 days. It is calculated and published by the Chicago Board Options Exchange (CBOE) and is based on the prices of S&P 500 Index options. The CBOE began publishing real-time VIX data in 1993, and in 2004, VIX futures were introduced. Investors cannot invest directly in the VIX but instead must use VIX futures contracts that offer investors a pure play on the level of expected stock market volatility, regardless of the direction of the S&P 500. Volatility futures allow investors to implement their views depending on their expectations about the timing and magnitude of a change in implied volatility. For example, in order for a long VIX futures position to protect an equity portfolio during a downturn, the stock market's implied volatility, as derived from S&P 500 Index options, must increase by more than the consensus expectation of implied volatility prior to the sell-off.

A family of volatility indexes has also been introduced for European equity markets, and they are designed to reflect market expectations of near-term to long-term volatility. The most well known of these is the VSTOXX index, based on real-time option prices on the EURO STOXX 50 index. The family of volatility indexes also includes the VDAX-NEW Index, based on DAX stock index options.

Next, we discuss various shapes of the VIX futures term structure. The CBOE Futures Exchange (CFE) lists nine standard (monthly) VIX index futures contracts and six weekly expirations in VIX futures. Each weekly and monthly contract settles 30 calendar days prior to the subsequent standard S&P 500 Index option's expiration. The weekly futures have lower volumes and open interest than the monthly futures contracts have. Exhibit 2 presents the first six monthly VIX futures contracts at three different points in time; these are not consecutive days but, rather, are at intervals of about two months apart.

Exhibit 2 VIX Futures Contracts

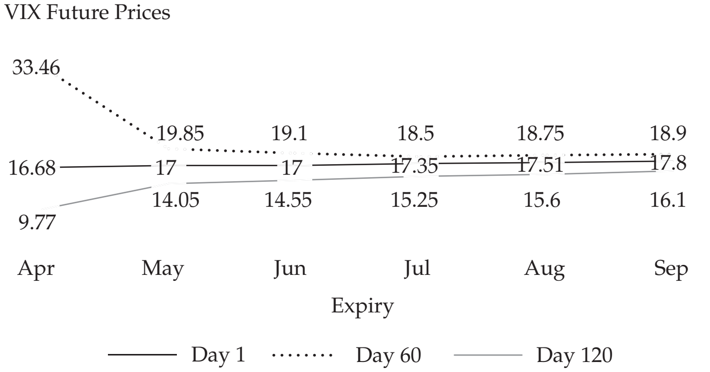
CBOE VIX Futures Expiry	Day 1	Day 60	Day 120
April	16.68	33.46	9.77
May	17.00	19.85	14.05
June	17.00	19.10	14.55
July	17.35	18.05	15.25

Exhibit 2 (Continued)

CBOE VIX Futures Expiry	Day 1	Day 60	Day 120
August	17.51	18.75	15.60
September	17.80	18.90	16.10

Exhibit 3 shows the shape of the VIX futures term structure corresponding to the data in Exhibit 2. The vertical axis shows the futures prices, and the horizontal scale indicates the month of expiration.

Exhibit 3 Shapes of the VIX Futures Term Structure



The shape of the VIX futures curve is always changing, reflecting the current volatility environment, investors' expectations regarding the future level of volatility, and the buying and selling activity in VIX futures contracts by market participants. Depending on the mix of these factors, the VIX futures term structure can change from being positively sloped to flat or inverted in just a few months' time.

Day 1 illustrates what happens when volatility is expected to remain stable over the near to long term: The term structure of VIX futures is flat. Day 60 shows the VIX futures in backwardation. This situation typically is a signal that investors expect more volatility in the short term and thus require higher prices for shorter-term contracts than for longer-term ones. In contrast, Day 120 is an example of the VIX futures being in contango. The curve is upward sloped, and it is steep for VIX buyers, with nearly 4.3 volatility points between the April and May expiries. Higher longer-term VIX futures prices are interpreted as an expectation that the VIX will rise because of increasing long-term volatility.

The VIX futures converge to the spot VIX as expiration approaches, so the two must be equal at expiration. When the VIX futures curve is in contango (backwardation) and assuming volatility expectations remain unchanged, the VIX futures price will get "pulled" closer to the VIX spot price, and they will decrease (increase) in price as they approach expiration. Traders calculate the daily roll as the difference between the front-month VIX futures price and the VIX spot price, divided by the number of business days until the VIX futures contract settles. Assuming that the basis declines linearly until settlement, when the term structure is in contango (backwardation), the trader who is long in back-month VIX futures would realize roll-down losses (profits).

Importantly, VIX futures may not reflect the index, especially when the VIX experiences large spikes, because longer-maturity futures contracts are less sensitive to short-term VIX movements. Furthermore, establishing long positions in VIX futures can be very expensive over time. When the short end of the VIX futures curve is much steeper than the long end of the curve, the carrying costs created from the contract roll down are elevated.

This phenomenon is particularly evident for investors who cannot invest directly in futures but must invest in volatility funds that attempt to track the VIX. These funds have attracted interest and substantial money flows because they are easily accessed in the form of exchange-traded products (ETPs) and, in particular, exchange-traded notes (ETNs) that provide exposure to short- and medium-term VIX futures. Some of these products also provide leveraged exposure. When using these investment products to hedge against a rise in the VIX, the VIX futures term structure should be taken into in consideration because volatility ETPs typically hold a mix of VIX futures that is adjusted daily to keep the average time to expiration of the portfolio constant. The daily rebalancing requires shorter-term futures to be sold and longer-dated futures to be purchased. When the VIX futures are in contango, the cost of rolling over hedges (i.e., negative carry) increases, thereby reducing profits and causing the ETP to underperform relative to the movement in the VIX. In contrast, "inverse" VIX ETPs offer investors the opportunity to profit from decreases in S&P 500 volatility. However, the purchase of these funds implies a directional positioning on volatility, and investors must accept the risk of large losses when volatility increases sharply.

In 2006, VIX options were introduced, providing an asymmetrical exposure to potential increases or decreases in anticipated volatility. VIX options are European style, and their prices depend on the prices of VIX futures with similar expirations because the market makers of VIX options typically hedge the risk of their option positions using VIX futures. To understand the use of VIX calls and puts, it is very important to recognize that the increases in the VIX (and VIX futures) are negatively correlated with the prices of equity assets. In particular, a trader or investor would purchase VIX call options when he expects that volatility will increase owing to a significant sell-off in the equity market. In contrast, VIX put options would be bought to profit from an expectation that volatility will decrease because of stable equity market conditions. Options on the VSTOXX index also exist, but they have lower volumes and open interest than those on the VIX.

3.2 Variance Swaps

Variance swaps are instruments used by investors for taking directional bets on implied versus realized volatility for speculative or hedging purposes. The term "variance swap" refers to the fact that these instruments have a payoff analogous to that of a swap. In a variance swap, the buyer of the contract will pay the difference between the fixed *variance strike* agreed on in the contract and the *realized variance* (annualized) on the underlying over the period specified and applied to a variance notional. In variance swaps, there is no exchange of cash at the contract inception or during the life of the swap. The payoff at expiration of a long variance position will be positive (negative) when realized variance is greater (less) than the swap's variance strike. If the payment amount is positive (negative), the swap seller (buyer) pays the swap buyer (seller). The payoff at settlement is found as follows:

$$\text{Settlement amount}_T = (\text{Variance notional})(\text{Realized variance} - \text{Variance strike}) \quad \textbf{(12)}$$

The realized variance is calculated as follows, where $R_i = \ln(P_{i+1}/P_i)$ and N is the number of days observed:

$$\text{Realized variance} = 252 \times \left[\sum_{i=1}^{N-1} R_i^2 \Big/ (N-1)\right] \quad \textbf{(13)}$$

Since most market participants are accustomed to thinking in terms of volatility, variance swap traders typically agree on the following two things: (1) a variance swap trade size expressed in **vega notional**, N_{Vega} (not in variance notional), and (2) the strike (X), which represents the expected future variance of the underlying, expressed as volatility (not variance). This approach is intuitive because the vega notional represents the average profit and loss of the variance swap for a 1% change in volatility from the strike. For example, when the vega notional is \$50,000, the profit and loss for one volatility point of difference between the realized volatility and the strike will be close to \$50,000.

We must bear in mind that this is an approximation because the variance swap payoff is convex and the profit and loss is not linear for changes in the realized volatility. Specifically, to calculate the exact payoff, the variance strike is the strike squared and the **variance notional**, $N_{variance}$, is defined and calculated as

$$\text{Variance notional} = \frac{\text{Vega notional}}{2 \times \text{Strike price}} \tag{14}$$

Thus, given the realized volatility (σ), we have the following equivalence:

$$\text{Settlement amount}_T = N_{Vega}\left(\frac{\sigma^2 - X^2}{2 \times \text{Strike price}}\right) = N_{variance}\left(\sigma^2 - X^2\right) \tag{15}$$

The strike on a variance swap is calculated on the basis of the implied volatility skew for a specific expiration, derived from calls and puts quoted in the market. As discussed previously, volatility skew is a plot of the differences in implied volatilities of a basket of options with the same maturity and underlying asset but with different strikes (and thus moneyness). As a rule of thumb, the strike of a variance swap typically corresponds to the implied volatility of the put that has 90% moneyness (calculated as the option's strike divided by the current level of the underlying).

The mark-to-market valuation of a variance swap at time t (VarSwap_t) will depend on realized volatility from the swap's initiation to t, RealizedVol(0,t), and implied volatility at t, ImpliedVol(t,T), over the remaining life of the swap ($T - t$). $PV_t(T)$ is the present value at time t of \$1 received at maturity T. The value of a variance swap at time t is given by the following formula:[10]

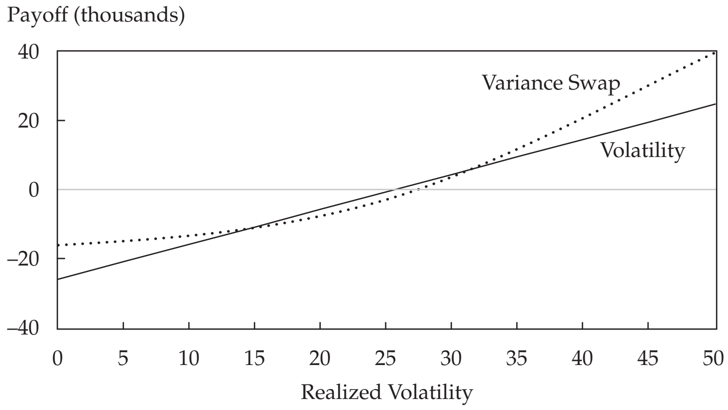
$$\begin{aligned}\text{VarSwap}_t &= \text{Variance notional} \times PV_t(T) \times \\ &\left\{\frac{t}{T} \times \left[\text{RealizedVol}(0,t)\right]^2 + \frac{T-t}{T} \times \left[\text{ImpliedVol}(t,T)\right]^2 - \text{Strike}^2\right\}\end{aligned} \tag{16}$$

Importantly, the sensitivity of a variance swap to changes in implied volatility diminishes over time.

A feature of variance swaps that makes them particularly interesting to investors is that their payoffs are convex in volatility, as seen Exhibit 4. This convexity occurs because being long a variance swap is equivalent to be long a basket of options and short the underlying asset (typically by selling a futures contract). A long position in a variance swap is thus long gamma and has a convex payoff. This characteristic allows volatility sellers to sell variance swaps at a higher price than at-the-money options because the swap's convex payoff profile is attractive to investors who desire a long volatility position as a tail risk hedge.

10 Note that the terms in the braces—RealizedVol, ImpliedVol, and Strike—are all expressed in volatility units. They are squared so that they are expressed in variance units for determining the value of a variance swap.

Exhibit 4 The Payoff of a Variance Swap Is Convex in Volatility



EXAMPLE 12

Variance Swap Valuation and Settlement

Olivia Santos trades strategies that systematically sell volatility on the S&P 500 Index. She sells \$50,000 vega notional of a one-year variance swap on the S&P 500 at a strike of 20% (quoted as annual volatility).

Now six months have passed, and the S&P 500 has experienced a realized volatility of 16% (annualized). On the same day, the fair strike of a new six-month variance swap on the S&P 500 is 19%.

Determine the following:

1. The current value of the variance swap sold by Santos (note that the annual interest rate is 2.5%)
2. The settlement amount at expiration of the swap if the one-year realized volatility is 18%

Solution to 1:

Santos sold \$50,000 vega notional of a one-year variance swap on the S&P 500 with a strike (in volatility terms) of 20%. The value of the variance swap sold by Santos is found using Equation 16:

$$\text{VarSwap}_t = \text{Variance notional} \times PV_t(T) \times \left\{\frac{t}{T} \times \left[\text{RealizedVol}(0,t)\right]^2 + \frac{T-t}{T} \times \left[\text{ImpliedVol}(t,T)\right]^2 - \text{Strike}^2\right\}$$

Values for the inputs are as follows:

Volatility strike on existing swap = 20.

Variance strike on existing swap = 20^2 = 400.

From Equation 14, Variance notional $= \frac{\text{Vega notional}}{2 \times \text{Strike}} = \frac{\$50{,}000}{2 \times 20} = 1{,}250$.

$\text{RealizedVol}(0,t)^2 = 16^2 = 256$.
$\text{ImpliedVol}(t,T)^2 = 19^2 = 361$.
t = 6 months.
T = 12 months.
$PV_t(T) = 1/[1 + (2.5\% \times 6/12)] = 0.987654$ (= Present Value Interest Factor for six months, where the annual rate is 2.5%).

The current value of the swap is

$$\text{VarSwap}_t = 1{,}250 \times (0.987654) \times [(6/12) \times 256 + (6/12) \times 361 - 400]$$
$$= -\$112{,}962.9263.$$

Given that Santos is short the variance swap, the mark-to-market value is positive for her, and it equals $112,963.

Solution to 2:

The settlement amount is calculated using Equation 12 as follows:

$$\text{Settlement}_T = \text{Variance notional} \times (\text{Realized variance} - \text{Variance strike}) = 1{,}250 \times (18^2 - 20^2)$$
$$= -\$95{,}000$$

If the payment amount is positive (negative), the swap seller (buyer) pays the swap buyer (seller). So, in this case, Santos would receive $95,000 from the swap buyer.

4 USES OF DERIVATIVES IN PORTFOLIO MANAGEMENT

4.1 Equity Swaps

Bernhard Steinbacher has a client with a holding of 100,000 shares in Tundra Corporation, currently trading for €14 per share. The client has owned the shares for many years and thus has a very low tax basis on this stock. Steinbacher wants to safeguard the value of the position since the client does not want to sell the shares. He cannot find exchange-traded options on the stock. Steinbacher wants to present a way in which the client could protect the investment portfolio from a decline in Tundra's stock price.

Discuss a swap strategy that Steinbacher might recommend to his client.

Solution:

A possible solution is to enter into an equity swap trading the Tundra stock return for the floating reference interest rate. Given Tundra's current share price of €14, the position is worth €1.4 million. Steinbacher can agree to exchange the *total return* on the shares (which includes the price performance and the dividends received) for the reference rate return on this sum of money. Now he needs to determine the time over which the protection is needed and must match the swap tenor to this period. After consulting with his client, Steinbacher decides on six months. The floating reference rate is 0.34%, expressed as an annual rate.

Scenario A: Over the six months, Tundra pays a €0.10 dividend and the share price rises 1%.

The total return on the stock is $\frac{(14 \times 1.01) - 14 + 0.10}{14} = 1.71\%$. For a six-month period, the reference rate return would be half the annual rate, or 0.17%. Tundra's total return *exceeds* the six-month reference rate return: (1.71% – 0.17%) × €1.4 million = €21,620, which is a positive amount, so Steinbacher's client would need to *pay* the swap counterparty.

Scenario B: Over the six months, Tundra pays a €0.10 dividend and the share price falls 1%.

The total return on the stock is $\frac{(14 \times 0.99) - 14 + 0.10}{14} = -0.29\%$. Tundra's total return is less than the six-month reference rate return: (–0.29% – 0.17%) × €1.4 million = –€6,380, which is a negative amount, so Steinbacher's client would *receive* the negative return and the reference rate return from the swap counterparty (meaning the client will receive a positive cash inflow of €6,380).

4.2 Cash Equitization

Georgia McMillian manages a fund invested in UK stocks that is indexed to the FTSE 100 Index. The fund has £250 million of total assets under management, including £20 million of cash reserves invested at the three-month British pound floating rate of 0.63% (annualized). McMillian does not have an expectation on the direction of UK stocks over the next quarter. However, she is keen to minimize tracking error risk, so she implements a cash equitization strategy attempting to replicate the performance of the FTSE 100 on the cash reserves. Futures on the FTSE 100 settling in three months currently trade at a price of £7,900, the contract's value is £10 per index point (so each futures contract is worth £79,000), and its beta, β_f, is 1.0.

McMillian engages in a synthetic index strategy to gain exposure on a notional amount of £20 million to the FTSE 100 by purchasing equity index futures. The number of futures she must purchase is given by the following:

$$N_f = \left(\frac{\beta_T}{\beta_f}\right)\left(\frac{S}{F}\right) = \left(\frac{1.0}{1.0}\right)\left(\frac{20{,}000{,}000}{79{,}000}\right) = 253.16 \approx 253$$

where the beta of the futures contract, β_f, and the target beta, β_T, are both equal to 1.0.

Scenario: Three months later, the FTSE 100 Index has increased by 5%.

Three months later, the FTSE 100 has increased by 5%, and the original value of £230 million invested in UK stocks has increased to £241.5 million. The price of the FTSE 100 Index futures contract has increased to £8,282.5. Interest on the cash invested at the three-month floating rate amounts to £31,500 (£20,000,000 × 0.63% × 90/360). McMillian bought the futures at £7,900, and the cash settlement of the contract at is £8,282.5. So, there is a "gain" of 382.5 index points, each point being worth £10, on 253 contracts for a total cash inflow of £967,725 (382.5 points per contract × £10 per point × 253 contracts). Adding to the portfolio the profit from the futures and the cash reserves plus the interest earned on the cash gives a total market value for McMillian's portfolio of £262,499,225 (= £241,500,000 + £20,000,000 + £967,725 + £31,500). The rate of return for the combined position is:

$$\frac{£262{,}499{,}225}{£250{,}000{,}000} - 1 = 0.05, \text{ or } 5\%$$

Importantly, without implementing this strategy, McMillian's return would have been slightly over 4.6%, calculated as (£230 million/£250 million) × 5.0% + (£20 million/£250 million) × 0.63% × (90/360). So, she accomplished her goal of minimizing tracking error by following this strategy.

4.3 Asset Allocation Using Derivatives

4.3.1 *Changing Allocations between Asset Classes Using Futures*

Mario Rossi manages a €500 million portfolio that is allocated 70% to stocks and 30% to bonds. Over the next three-month horizon, he is bearish on eurozone stocks, except for German shares, and is bullish on Italian bonds. So, Rossi wants to reduce the overall allocation to stocks by 10%, to 60%, and achieve the same weight (30%) in Italian stocks (which have a beta of 1.1 with respect to the FTSE MIB Index) and German stocks (which have a beta of 0.9 with respect to the DAX index). He also wants to increase the overall allocation to Italian government bonds (BTPs) by 10%, to 40%. The bond portion of his portfolio has a modified duration of 6.45. In summary, as shown in Exhibit 5, Rossi needs to remove €100 million of exposure to Italian stocks, add €50 million of exposure to German stocks, and add €50 million of exposure to Italian bonds in his portfolio.

Exhibit 5 Summary of Rossi's Original and New Asset Allocation

Stock Index	Original (€350 Million, 70%)	New (€300 Million, 60%)	Transaction
FTSE MIB	€250 million (50%)	€150 million (30%)	Sell €100 million
DAX	€100 million (20%)	€150 million (30%)	Buy €50 million

Bonds	Original (€150 Million, 30%)	New (€200 Million, 40%)	Transaction
Italian BTPs	€150 million (30%)	€200 million (40%)	Buy €50 million

Rossi uses stock index futures and bond futures to achieve this objective. Once the notional values to be traded are known, Rossi determines how many futures contracts should be purchased or sold to achieve the desired asset allocation. The FTSE MIB Index futures contract has a price of €23,100 and a multiplier of €5, for a value of €115,500. The DAX index futures contract has a price of €13,000 and a multiplier of €25, for a value of €325,000. Both futures contracts have a beta of 1. The BTP futures contract has a price of 132.50 and a contract size of €100,000. The cheapest-to-deliver bond has a price of €121; a modified duration of 8.19; a BPV_{CTD} (from Equation 7) of €99.10, calculated as 8.19 × 0.0001 × [(121/100) × €100,000)]; and a conversion factor of 0.913292.

1 Determine how many stock index and bond futures contracts Rossi should use to implement the desired asset allocation and whether he should go long or short.

2 At the horizon date (three months later), the value of the Italian stock portfolio has fallen 5% whereas that of the German stock portfolio has increased 1%. The FTSE MIB futures price is €22,000, and the DAX futures price is €13,100.

Determine the change in market value of the equity portfolio assuming the futures transactions specified in Part 1 have been carried out (note that you can ignore transaction costs).

3 At the horizon date, the Italian bond yield curve has a parallel shift downward of 25 bps. Determine the change in market value of the bond portfolio assuming the transactions specified in Part 1 have been carried out (note that you can ignore transactions costs).

Solution to 1: The market value of the Italian stocks is 0.50(€500,000,000) = €250,000,000, and Rossi wants to reduce the exposure to this market by 0.20(€500,000,000) = €100,000,000. The market value of the German stocks is 0.20(€500,000,000) = €100,000,000, and he wants to increase the exposure to this market by 0.10(€500,000,000) = €50,000,000. He decides to sell enough futures contracts on the FTSE MIB to reduce the exposure to Italian stocks by €100 million and to purchase enough futures on the DAX index to increase the exposure to German stocks by €50 million.

The number of stock index futures, N_f, is

$$N_f = \left(\frac{\beta_T - \beta_S}{\beta_f}\right)\left(\frac{S}{F}\right)$$

where β_T is the target beta of zero, β_S is the stock beta of 1.1, β_f is the futures beta of 1.0, S is the market value of the stocks involved in the transaction, and F is the value of the futures contract.

To achieve the desired reduction in exposure to Italian stocks, the market value of the stocks involved in the transaction will be S = €100,000,000. The Italian stocks' beta (β_S) is 1.1, and the target beta is $\beta_T = 0$. The FTSE MIB Index futures have a contract value of €115,500 and a beta (β_f) of 1.0:

$$N_f = \left(\frac{\beta_T - \beta_S}{\beta_f}\right)\left(\frac{S}{F}\right) = \left(\frac{0.0 - 1.1}{1.0}\right)\left(\frac{€100{,}000{,}000}{€115{,}500}\right) = -952.38$$

Rossi sells 952 futures contracts (after rounding).

To achieve the desired exposure to German stocks (which have a beta of 0.9), the market value of the stocks involved in the transaction will be S = €50,000,000. In this case, $\beta_S = 0.0$ because Rossi is starting with a notional "cash" position from the reduction in Italian stock exposure, and the target beta is now $\beta_T = 0.9$. Given the value of the DAX index futures contract of €325,000 and a beta (β_f) of 1.0, we obtain

$$N_f = \left(\frac{\beta_T - \beta_S}{\beta_f}\right)\left(\frac{S}{F}\right) = \left(\frac{0.9 - 0.0}{1.0}\right)\left(\frac{€50{,}000{,}000}{€325{,}000}\right) = 138.46$$

Rossi buys 138 futures contracts (after rounding).

The market value of the Italian bonds is 0.30(€500,000,000) = €150,000,000, and Rossi wants to increase the exposure to this market by 0.10(€500,000,000) = €50,000,000. He decides to purchase enough Euro-BTP futures so that €50 million exposure in Italian bonds is added to the portfolio. The target basis point value exposure (BPV_T) is determined using Equation 4:

$$BPV_T = MDUR_T \times 0.01\% \times MV_P = 6.45 \times 0.0001 \times €50{,}000{,}000 = €32{,}250$$

The cheapest-to-deliver bond is the BTP 4¾ 09/01/28, which has a conversion factor of 0.913292 and BPV_{CTD} of €99.10. The number of Euro-BTP futures to buy to convert the €50 million in notional cash (BPV_P = 0) to the desired exposure in Italian bonds is found using Equation 9:

$$BPVHR = \left(\frac{BPV_T - BPV_P}{BPV_{CTD}}\right) \times CF = \left[(€32{,}250 - 0)/€99.10\right] \times 0.913292 = 297.21$$

Rossi buys 297 Euro-BTP futures contracts (after rounding).

Solution to 2: The value of the Italian stock portfolio decreases by €7,264,000. This outcome is the net effect of the following:

- The original Italian stock portfolio decreases by €12,500,000 (= €250 million × –5%).
- The short position in 952 FTSE MIB futures gains €5,236,000, calculated as

  –(22,000 – 23,100) × 952 × 5.

The value of the German stock portfolio increases by €1,345,000. This outcome is the net effect of the following:

- The original German stock portfolio increases by €1,000,000 (= €100 million × 1%).
- The long position in 138 DAX futures gains €345,000, calculated as (13,100 – 13,000) × 138 × 25.

The total value of the stock position has decreased by €5,919,000 or –1.691% (= –5,919,000/350,000,000).

Had Rossi sold the Italian stocks and then converted the proceeds into German stocks, the equity portfolio would have decreased by €6,000,000 or –1.71% (= –6,000,000/350,000,000). This outcome would have been the net effect of the following:

- A decrease in the new Italian stock portfolio of €7,500,000 (= €150 million × –5%)
- An increase in the new German stock portfolio of €1,500,000 (= €150 million × 1%)

Solution to 3: The Italian bond yield curve had a parallel shift downward of 25 bps. The value of the Italian bond portfolio increases by €3,224,426. This outcome is the net effect of the following:

- The €150 million portfolio's BPV_P, per Equation 5, is €96,750 (= 6.45 × 0.0001 × €150,000,000). Thus, for a 25 bp decrease in rates, the portfolio value increases by €2,418,750 (= €96,750 × 25).
- The long position in 297 BTP futures has a BPV_{CTD} of €99.10, and the CF is 0.913292. So, using Equation 6, BPV_F is €108.51 (= €99.10/0.913292). Thus, for a 25 bp decrease in rates, the futures position increases in value by €805,676, calculated as follows: BPV_F × Change in yield × Number of futures contracts = €108.51 × 25 × 297.

Had Rossi bought the Italian bonds, the new €200 million bond portfolio would have increased by €3,225,000. The portfolio has a BPV_P of 6.45 × 0.0001 × €200,000,000 = €129,000. Thus, for a 25 bp decrease in rates, the portfolio value increases by €3,225,000 (= €129,000 × 25).

4.3.2 *Rebalancing an Asset Allocation Using Futures*

Yolanda Grant manages a portfolio with a target allocation of 40% in stocks and 60% in bonds. Over the last month, the value of the portfolio has increased from €100 million to €106 million, and Grant wants to rebalance it back to the target allocation (40% stocks/60% bonds). As shown in Exhibit 6, the current portfolio has €46 million (43.4%) in European stocks (with beta of 1.2 with respect to the EURO STOXX 50 index) and €60 million (56.6%) in German bunds. The bonds have a modified duration of 9.5.

Exhibit 6 Summary of Grant's Current and Rebalanced Allocation

Stocks	Current	Rebalanced	Transaction
European stocks	€46 million (43.4%)	€42.4 million (40%)	Sell €3.6 million

Bonds	Current	Rebalanced	Transaction
German bunds	€60 million (56.6%)	€63.6 million (60%)	Buy €3.6 million

Grant will use stock index futures and bond futures to achieve this objective. Once the notional values to be traded are known, she determines how many futures contracts should be purchased or sold to achieve the desired asset allocation.

The EURO STOXX 50 index futures contract has a price of €3,500 and a multiplier of €10, for a value of €35,000. The Euro-Bund futures contract has a contract size of €100,000. The cheapest-to-deliver bond has a modified duration of 8.623 and a price of 98.14, so (per Equation 7) its BPV_{CTD} is €84.63, calculated as 8.623 × 0.0001 × [(98.14/100) × €100,000)]. Its conversion factor is 0.619489.

Determine how many stock index and bond futures contracts Grant should use to implement the desired asset allocation and whether she should go long or short.

Solution: The market value of the European stocks is €46,000,000, and Grant wants to reduce the exposure to this market to 40% or 0.40(€106,000,000) = €42,400,000. She decides to sell enough futures contracts on the EURO STOXX 50 to reduce the allocation to European stocks by 0.034(€106,000,000) = €3,604,000.

To achieve the desired reduction in exposure to European stocks, the market value of the stocks involved in the transaction (S) will be €3,604,000. The European stocks' beta (β_S) is 1.2, and the target beta is $\beta_T = 0$. The EURO STOXX 50 index futures have a contract value (F) of €35,000, with a beta (β_f) of 1.0, so

$$N_f = \left(\frac{\beta_T - \beta_S}{\beta_f}\right)\left(\frac{S}{F}\right) = \left(\frac{0.0 - 1.2}{1.0}\right)\left(\frac{€3{,}604{,}000}{€35{,}000}\right) = -123.57$$

Grant sells 124 futures contracts (after rounding).

The market value of the German bunds is €60,000,000, and Grant wants to increase the exposure to this market to 0.60(€106,000,000) = €63,600,000. She decides to purchase enough Euro-Bund futures so that €3,604,000 (= 0.034 × €106,000,000) of exposure to German bonds is added to the portfolio. The target basis point value (BPV_T) is given by Equation 4, as follows:

$$BPV_T = MDUR_T \times 0.01\% \times MV_P = 9.5 \times 0.0001 \times €3{,}604{,}000 = €3{,}424$$

The cheapest-to-deliver bond has a BPV_{CTD} of €84.63 and a conversion factor of 0.619489. The number of Euro-Bund futures to buy to convert the €3.6 million in notional cash (BPV_P = 0) to the desired exposure in German bonds is found using Equation 9:

$$BPVHR = \left(\frac{BPV_T - BPV_P}{BPV_{CTD}}\right) \times CF$$

$$= \left[(€3{,}424 - 0)/€84.63\right] \times 0.619489 = 25.06 \approx 25 \text{ contracts}$$

So, Grant should buy 25 Euro-Bund futures contracts.

4.3.3 *Changing Allocations between Asset Classes Using Swaps*

Tactical Money Management Inc. (TMM) is interested in changing the asset allocation on a \$200 million segment of its portfolio. This money is invested 75% in US stocks and 25% in US bonds. Within the stock allocation, the funds are invested 60% in large cap, 30% in mid-cap, and 10% percent in small cap. Within the bond sector, the funds are invested 80% in US government bonds and 20% in investment-grade corporate bonds.

Given that it is bullish on equities, especially large-cap stocks, over the next year, TMM would like to change the overall allocation to 90% stocks and 10% bonds. Specifically, TMM would like to split the stock allocation into 65% large cap, 25% mid-cap, and 10% small cap. It also wants to change the bond allocation to 75% US government and 25% investment-grade corporate. The current position, the desired new position, and the necessary transactions to get from the current position to the new position are shown in Exhibit 7.

Exhibit 7 Summary of TMM's Current and New Asset Allocation

Stock	Current (\$150 Million, 75%)	New (\$180 Million, 90%)	Transaction
Large cap	\$90 million (60%)	\$117 million (65%)	Buy \$27 million
Mid-cap	\$45 million (30%)	\$45 million (25%)	None
Small cap	\$15 million (10%)	\$18 million (10%)	Buy \$3 million

Bonds	Current (\$50 Million, 25%)	New (\$20 Million, 10%)	Transaction
Government	\$40 million (80%)	\$15 million (75%)	Sell \$25 million
Corporate	\$10 million (20%)	\$5 million (25%)	Sell \$5 million

TMM knows these changes would entail a considerable amount of trading in stocks and bonds. So, TMM decides to execute a series of swaps that would enable it to change its position temporarily but more easily and less expensively than by executing the physical transactions. TMM engages Dynamic Dealers Inc. to perform the swaps.

TMM decides to increase the allocation in the large-cap sector by investing in the S&P 500 Index and to increase that in the small-cap sector by investing in the S&P SmallCap 600 Index (SPSC). To reduce the allocation in the overall fixed-income sector, TMM decides to replicate the performance of the Bloomberg Barclays US Treasury Index (BBT) for the government bond sector and the BofA Merrill Lynch US Corporate Index (BAMLC) for the corporate bond sector.

Discuss how TMM can use a combination of equity and fixed-income swaps to synthetically implement its desired asset allocation.

Solution: To achieve the desired asset allocation, TMM takes the following exposures:

- A long position of $27 million in the S&P 500
- A long position of $3 million in the SPSC
- A short position of $25 million in the BBT
- A short position of $5 million in the BAMLC

The mid-cap exposure of $45 million does not change, so TMM does not need to incorporate a mid-cap index into the swap. TMM uses a combination of equity and fixed-income swaps to achieve its target allocation and structures the swap to have all payments occur on the same dates six months apart. TMM also decides that the swap should mature in one year. If it wishes to extend this period, TMM would need to renegotiate the swap at expiration. Likewise, TMM could decide to unwind the position before one year elapses, which it could do by executing a new swap with opposite payments for the remainder of the life of the original swap.

Every six months and at maturity, each of the equity swaps involves the settlement of the following cash flows:

- *Equity swap 1:* TMM receives the total return of the S&P 500 and makes a floating payment tied to the market reference rate (MRR) minus the agreed-on spread, both on a notional principal of $27 million.
- *Equity swap 2:* TMM receives the total return of the SPSC and makes a floating payment tied to the MRR minus the agreed-on spread, both on a notional principal of $3 million.

The fixed-income swaps will require the following cash flow settlements every six months and at maturity:

- *Fixed-income swap 1:* TMM pays the total return of the BBT and receives floating payments tied to the MRR minus the agreed-on spread, both on notional principal of $25 million.
- *Fixed-income swap 2:* TMM pays the total return of the BAMLC and receives floating payments tied to the MRR minus the agreed-on spread, both on a notional principal of $5 million.

It is important to recognize that this transaction will not perfectly replicate the performance of TMM's equity and fixed-income portfolios, unless they are indexed to the indexes selected as underlying of the swaps. In addition, TMM could encounter a cash flow problem if its fixed-income payments exceed its equity receipts and its portfolio does not generate enough cash to fund its net obligation. The stock and bond portfolio will generate cash only from dividends and interest. Capital gains will not be received in cash unless a portion of the portfolio is sold. But avoiding selling a portion of the portfolio is the very reason why TMM wants to use swaps.

4.4 Using Derivatives to Infer Market Expectations

As mentioned at the beginning of this reading, an important use of derivatives by market participants is for inferring market expectations. These expectations can be for changes in interest rates; for changes in prices for the whole economy (i.e., inflation), individual stocks, or other assets; or even for changes in key factors, such as implied volatility. Exhibit 8 provides a brief list of some of the myriad applications by which information embedded in derivatives prices is used to infer current market expectations. It is important to emphasize that these inferences relate to *current expectations* of future events—they do not foretell what will actually happen—which can change with the arrival of new information.

Exhibit 8 Some Typical Applications of Derivatives for Inferring Market Expectations

Use Cases/Applications	Derivative Type
1. Inferring expectations for FOMC moves	Fed funds futures
2. Inferring expectations for inflation rates	CPI (inflation) swaps
3. Inferring expectations for market volatility	VIX futures

The first application in Exhibit 8, using fed funds futures to infer expectations of federal funds rate changes by the Federal Open Market Committee (FOMC), is likely the most common and well-publicized use of derivatives for inferring market expectations, so it is the focus of the following discussion.

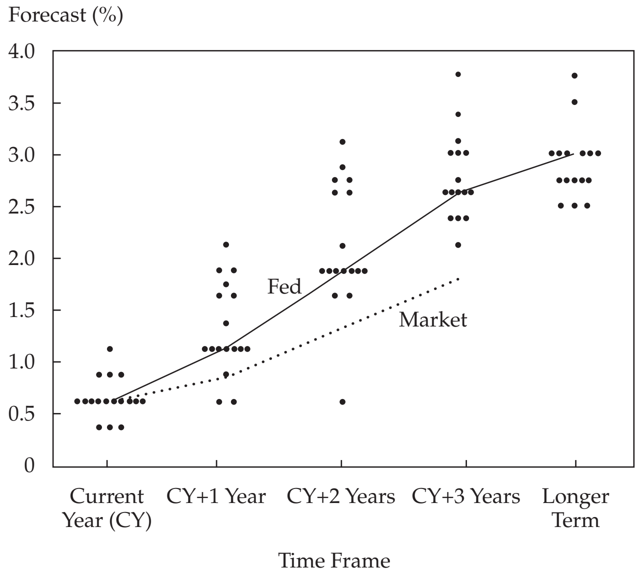
4.4.1 *Using Fed Funds Futures to Infer the Expected Average Federal Funds Rate*

Market participants are interested in knowing the probabilities of various interest rate level outcomes, deriving from central banks' future decisions, as implied by the pricing of financial instruments. This provides them with an indication about the extent to which markets are "pricing in" future monetary policy changes. Note that such implied probabilities represent the market's view and may diverge from the guidance provided by central banks in their regular communications about the likely future course of monetary policy actions. Furthermore, especially for the longer-term horizon, these inferred probabilities usually do not have strong predictive power. Most information providers and the business media report current implied probability data for selected interest rates and historical analysis charts that show how the implied probabilities of policy rate settings have changed over time.

A commonly followed metric is the probability of a change in the federal funds rate at upcoming FOMC meetings that is implied by the prices of fed funds futures contracts. When the US central bank began its rate hiking cycle in 2015, it declared an intention to maintain a 25 bp "target range" (lower and upper bounds) for the federal funds rate. The Fed regularly communicates its "forward guidance" along with the so-called dot plot, which shows where each FOMC meeting participant believes the federal funds rate should be at the end of the year, for the next few years, and in the longer run.

To derive probabilities of potential upcoming Fed interest rate actions, market participants look at the pricing of fed funds futures, which are tied to the **effective federal funds (FFE) rate**—the rate actually transacted between depository institutions—not the Fed's target federal funds rate. The underlying assumption is that the implied futures market rates are predicting the value of the monthly average effective federal funds rate. As shown in Exhibit 9, where the yellow dots represent forecasts of the federal funds rate by each FOMC member, implied market expectations (blue line) can diverge significantly from the Fed's forward guidance (black line, the median of the yellow dots).

Exhibit 9 Hypothetical Example of Market's Implied Forecast vs. FOMC Forecast of Federal Funds Rate



Fed funds futures are traded on the Chicago Board of Trade, and the contract price is quoted as 100 minus the market's expectation for the FFE rate, as follows:

Fed funds futures contract price = 100 – Expected FFE rate. **(16)**

At expiration, the contract is cash settled to the simple average (overnight) effective federal funds rate for the delivery month. The overnight rate is calculated and reported daily by the Federal Reserve Bank of New York.

To determine the probability of a change in the federal funds rate, the following formula is used, where the current federal funds rate is the midpoint of the current target range:

$$\frac{\text{Effective federal funds rate implied by futures contract} - \text{Current federal funds rate}}{\text{Federal funds rate assuming a rate hike} - \text{Current federal funds rate}} \quad (17)$$

4.4.2 *Inferring Market Expectations*

Andrew Okyung manages a portfolio of short-term floating-rate corporate debt, and he is interested in understanding current market expectations for any Fed rate actions at the upcoming FOMC meeting. He observes that the current price for the fed funds futures contract expiring after the next FOMC meeting is 97.90. The current federal funds rate target range is set between 1.75% and 2.00%.

Demonstrate how Okyung can use the information provided to determine the following:

1 The expected average FFE rate

2 The probability of a 25 bp interest rate hike at the next FOMC meeting

Solution to 1: The FFE rate implied by the futures contract price is 2.10% (= 100 – 97.90). Okyung understands that this is the rate that market participants expect to be the average federal funds rate for that month.

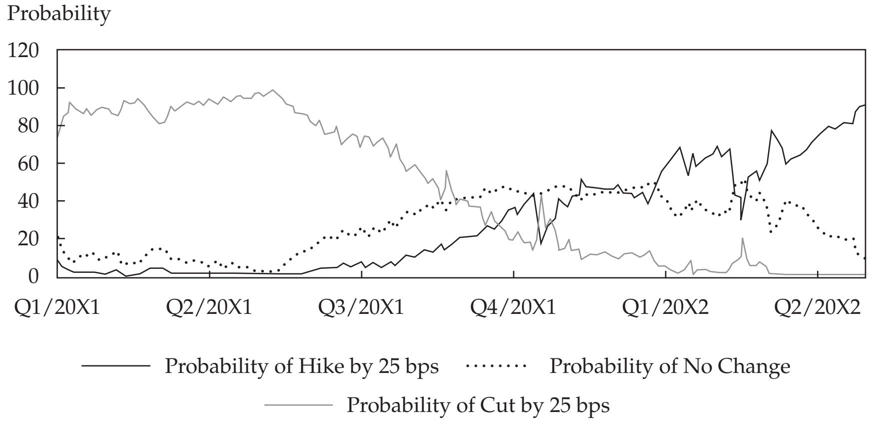
Solution to 2: Okyung knows that given that the FFE rate embedded in the fed funds futures price is 2.10%, there is a high probability that the FOMC will increase rates by 25 bps from its current target range of 1.75%–2.00% to the new target range of 2.00%–2.25%. Given the Fed's declared incremental move size of 25 bps, he calculates the probability of a rate hike as

$$\frac{2.100\% - 1.875\%}{2.125\% - 1.875\%} = 0.90, \text{ or } 90\%$$

where 1.875% is the midpoint of the current target range (1.75%–2.00%) and 2.125% is the midpoint of the new target range (2.00%–2.25%) assuming a rate hike.

Exhibit 10 displays, as a hypothetical example, the trends in implied probabilities (y-axis) derived from fed funds futures prices of an FOMC rate action—either a 25 bp rate hike, a 25 bp rate cut, or no change—at the next FOMC meeting date. Note that the probability of a rate hike or cut is represented as the probability of a move from the current target range at the specified meeting date, and of course, the probabilities of all three actions at a particular meeting date sum to 1.

Exhibit 10 Hypothetical Example of Trends of Probabilities for Federal Funds Rate Actions by the FOMC



Importantly, typical end-of-month (EOM) activity by large financial and banking institutions often induces "dips" in the FFE rate that create bias issues when using the rate as the basis for probability calculations of potential FOMC rate moves. For example, if such activity increased the price for the relevant fed funds futures contract to 98.05, then the FFE rate would decline to 1.95% (= 100 – 98.05). In this case, using the same equation as before, the probability of an FOMC rate hike decreases from 90% to just 30%:

$$\frac{1.950 - 1.875}{0.25} = 0.30, \text{ or } 30\%$$

To overcome this end-of-month bias, data providers have implemented various methods of "smoothing" the EOM dips. One prominent data provider uses a method that builds a forward rate structure based on where the market believes interest rates will settle in non-FOMC meeting months and then uses these forward rates to make appropriate adjustments. For each FOMC meeting month, it is assumed that an effective rate prevails until the meeting date, and then some rate prevails after the meeting, with the average effective rate over the month being implied by the futures price.

SUMMARY

This reading on swap, forward, and futures strategies shows a number of ways in which market participants might use these derivatives to enhance returns or to reduce risk to better meet portfolio objectives. Following are the key points.

- Interest rate, currency, and equity swaps, forwards, and futures can be used to modify risk and return by altering the characteristics of the cash flows of an investment portfolio.
- An interest rate swap is an OTC contract in which two parties agree to exchange cash flows on specified dates, one based on a floating interest rate and the other based on a fixed rate (swap rate), determined at swap initiation. Both rates are applied to the swap's notional value to determine the size of the payments, which are typically netted. Interest rate swaps enable a party with a fixed (floating) risk or obligation to effectively convert it into a floating (fixed) one.
- Investors can use short-dated interest rate futures and forward rate agreements or longer-dated fixed-income (bond) futures contracts to modify their portfolios' interest rate risk exposure.
- When hedging interest rate risk with bond futures, one must determine the basis point value of the portfolio to be hedged, the target basis point value, and the basis point value of the futures, which itself is determined by the basis point value of the cheapest-to-deliver bond and its conversion factor. The number of bond futures to buy or sell to reach the target basis point value is then determined by the basis point value hedge ratio: $BPVHR = \left(\frac{BPV_T - BPV_P}{BPV_{CTD}}\right) \times CF$.
- Cross-currency basis swaps help parties in the swap to hedge against the risk of exchange rate fluctuations and to achieve better rate outcomes. Firms that need foreign-denominated cash can obtain funding in their local currency (likely at a more favorable rate) and then swap the local currency for the required foreign currency using a cross-currency basis swap.
- Equity risk in a portfolio can be managed using equity swaps and total return swaps. There are three main types of equity swap: (1) receive-equity return, pay-fixed; (2) receive-equity return, pay-floating; and (3) receive-equity return, pay-another equity return. A total return swap is a modified equity swap; it also includes in the performance any dividends paid by the underlying stocks or index during the period until the swap maturity.
- Equity risk in a portfolio can also be managed using equity futures and forwards. Equity futures are standardized, exchange-listed contracts, and when the underlying is a stock index, only cash settlement is available at contract expiration. The number of equity futures contracts to buy or sell is determined by $N_f = \left(\frac{\beta_T - \beta_S}{\beta_f}\right)\left(\frac{S}{F}\right)$.
- Cash equitization is a strategy designed to boost returns by finding ways to "equitize" unintended cash holdings. It is typically done using stock index futures and interest rate futures.
- Derivatives on volatility include VIX futures and options and variance swaps. Importantly, VIX option prices are determined from VIX futures, and both instruments allow an investor to implement a view depending on her expectations about the timing and magnitude of a change in implied volatility.

- In a variance swap, the buyer of the contract will pay the difference between the fixed variance strike specified in the contract and the realized variance (annualized) on the underlying over the period specified and applied to a variance notional. Thus, variance swaps allow directional bets on implied versus realized volatility.
- Derivatives can be used to infer market participants' current expectations for changes over the short term in inflation (e.g., CPI swaps) and market volatility (e.g., VIX futures). Another common application is using fed funds futures prices to derive the probability of a central bank move in the federal funds rate target at the FOMC's next meeting.

PRACTICE PROBLEMS

1 A US bond portfolio manager wants to hedge a long position in a 10-year Treasury bond against a potential rise in domestic interest rates. He would *most likely:*

A sell fixed-income (bond) futures.

B enter a receive-fixed 10-year interest rate swap.

C sell a strip of 90-day Eurodollar futures contracts.

2 A European bond portfolio manager wants to increase the modified duration of his €30 million portfolio from 3 to 5. She would *most likely* enter a receive-fixed interest rate swap that has principal notional of €20 million and:

A a modified duration of 2.

B a modified duration of 3.

C a modified duration of 4.

3 The CIO of a Canadian private equity company wants to lock in the interest on a three-month "bridge" loan his firm will take out in six months to complete an LBO deal. He buys the relevant interest rate futures contracts at 98.05. In six-months' time, he initiates the loan at 2.70% and unwinds the hedge at 97.30. The effective interest rate on the loan is:

A 0.75%.

B 1.95%.

C 2.70%.

4 A US institutional investor in search of yield decides to buy Italian government bonds for her portfolio but wants to hedge against the risk of exchange rate fluctuations. She enters a cross-currency basis swap, with the same payment dates as the bonds, where at inception she delivers US dollars in exchange for euros for use in purchasing the Italian bonds. The notional principals on the swap are *most likely* exchanged:

A at inception only.

B at maturity only.

C both at inception and at maturity.

5 Continuing from the previous question, assume demand for US dollars is strong relative to demand for euros, so there is a positive basis for "lending" US dollars. By hedging the position in Italian government bonds with the currency basis swap, the US investor will *most likely* increase the periodic net interest payments received from the swap counterparty in:

A euros only.

B US dollars only.

C both euros and US dollars.

6 An equity portfolio manager is invested 100% in US large-cap stocks, but he wants to reduce the current allocation by 20%, to 80%, and allocate 20% to US small caps. He decides not to sell the stocks because of the high transaction costs. Rather, he will use S&P 500 Index futures and Russell 2000 Index futures for achieving the desired exposure in, respectively, US large caps and small caps. To achieve the new allocation, he will for an equivalent of 20% of the portfolio value:

A purchase Russell 2000 futures only.

B purchase Russell 2000 futures and sell S&P 500 futures.

C sell Russell 2000 futures and purchase S&P 500 futures.

7 A volatility trader observes that the VIX term structure is upward sloping. In particular, the VIX is at 13.50, the front-month futures contract trades at 14.10, and the second-month futures contract trades at 15.40. Assuming the shape of the VIX term structure will remain constant over the next three-month period, the trader decides to implement a trade that would profit from the VIX carry roll down. She will *most likely* purchase the:

A VIX and sell the VIX second-month futures.

B VIX and sell the VIX front-month futures.

C VIX front-month futures and sell the VIX second-month futures.

8 The CEO of a corporation owns 100 million shares of his company's stock, which is currently priced at €30 a share. Given the huge exposure of his personal wealth to this one company, he has decided to sell 10% of his position and invest the funds in a floating interest rate instrument. A derivatives dealer suggests that he do so using an equity swap.

Explain how to structure such a swap.

9 A $30 million investment account of a bank trust fund is allocated one-third to stocks and two-thirds to bonds. The portfolio manager wants to change the overall allocation to 50% stock and 50% bonds and the allocation within the stock fund from 70% domestic stock and 30% foreign stock to 60% domestic and 40% foreign. The bond allocation will remain entirely invested in domestic corporate issues.

Explain how swaps can be used to implement this adjustment. The market reference rate is assumed to be flat for all swaps, and you do not need to refer to specific stock and bond indexes.

10 Sarah Ko, a private wealth adviser in Singapore, is developing a short-term interest rate forecast for her private wealth clients who have holdings in the US fixed-income markets. Ko needs to understand current market expectations for possible upcoming central bank (i.e., US Federal Reserve Board) rate actions. The current price for the fed funds futures contract expiring after the next FOMC meeting is 97.175. The current federal funds rate target range is set between 2.50% and 2.75%.

Explain how Ko can use this information to understand potential movements in the current federal funds rate.

SOLUTIONS:

1 A is correct. The portfolio manager would *most likely* use a longer-dated fixed-income (bond) futures contract to hedge his interest rate risk exposure. The choice of the hedging instrument, in fact, will depend on the maturity of the bond being hedged. Interest rate futures, like 90-day Eurodollar futures, have a limited number of maturities and can be used to hedge short-term bonds. The mark-to-market value of a receive-fixed 10-year interest rate swap will become negative if interest rates rises, and thus the swap cannot be used as a hedge in this case.

2 B is correct. The portfolio manager's goal is to use the receive-fixed, pay-floating swap such that the €30 million of bonds, with modified duration of 3, and the €20 million swap will combine to make up a portfolio with a market value of €30 million and modified duration of 5. This relationship can be expressed as follows:

$$€30,000,000(3) + (N_S \times MDUR_S) = €30,000,000(5).$$

Given the swap's notional (N_S) of €20,000,000, its required modified duration can be obtained as:

$$MDUR_S = [(5 - 3)€30,000,000]/€20,000,000 = 3.$$

3 B is correct. The CIO buys the relevant interest rate future contracts at 98.05, locking in a forward rate of 1.95% (= 100 – 98.05). After six months, the CIO initiates the bridge loan at a rate of 2.70%, but he unwinds the hedge at the lower futures price of 97.30, thus gaining 75 bps (= 98.05 – 97.30). The effective interest rate on the loan is 1.95% (= 2.70% – 0.75%).

4 C is correct. In a cross-currency basis swap, the goals of the transaction are to achieve favorable funding and exchange rates and to swap the foreign currency amounts back to the currency of choice—in this case, the US dollar—at maturity. There is one exchange rate specified in the swap that is used to determine the notional principals in the two currencies, exchanged at inception and at maturity.

5 B is correct. By hedging the position in Italian government bonds with the cross-currency basis swap, the US investor will most likely increase the periodic net interest she receives in US dollars. The reason is that the periodic net interest payments made by the swap counterparty to the investor will include the positive basis resulting from the relatively strong demand for US dollars versus euros.

6 B is correct. To reduce the current allocation by 20%, to 80%, in US large-cap stocks, the portfolio manager will sell S&P 500 futures. At the same time, to allocate this 20% to US small caps, he will purchase Russell 2000 futures for the same notional amount.

7 C is correct. VIX futures converge to the spot VIX as expiration approaches, and the two must be equal at expiration. When the VIX futures curve is in contango and assuming volatility remains stable, the VIX futures will get "pulled" closer to the spot VIX, and they will decrease in price as they approach expiration. Traders calculate the difference between the front-month VIX futures price and the VIX as 0.60, and the spread between the front-month and the second-month futures is 1.30. Assuming that the spread declines linearly until settlement, the trader would realize roll-down gains as the spread decreases from 1.30 to 0.60 as the front-month futures approaches its expiration. At

expiration, VIX futures are equal to the VIX, and the spread with the old second-month (and now the front-month) futures contract will be 0.60. Finally, since one cannot directly invest in the VIX, trades focusing on the VIX term structure must be implemented using either VIX futures or VIX options, so Answers A and B are not feasible.

8 The swap is structured such that the executive pays the return on 10 million shares of the company's stock, which is 10% of his holdings, and he receives the return based on a floating interest rate, such as the market reference rate, on a notional principal of €300 million (= €30/share × 10 million shares).

9 Currently the allocation is $10 million in stocks and $20 million in bonds. Within the stock category, the current allocation is $7 million domestic and $3 million foreign. The desired allocation is $15 million in stocks and $15 million in bonds. Thus, the allocation must change by moving $5 million into stocks and out of bonds. The desired stock allocation is $9 million domestic and $6 million foreign. The desired bond allocation is $15 million, all domestic corporate.

To make the changes with swaps, the manager must enter into swaps against the market reference rate, which is assumed to be flat for all swaps in this example. Using the swaps, the bank trust fund portfolio manager needs to (1) receive the returns on $2 million based on a domestic equity index and on $3 million based on a foreign equity index and (2) pay the return on $5 million based on a domestic corporate bond index. The market reference rate outflows from the swaps in (1) and the inflows from the swap in (2) will cancel out through summation.

10 First, Ko knows that the FFE rate implied by the futures contract price of 97.175 is 2.825% (= 100 – 97.175). This is the rate that market participants expect to be the average federal funds rate for that month.

Second, Ko should determine the probability of a rate change. She knows the 2.825% FFE rate implied by the futures signals a fairly high chance that the FOMC will increase rates by 25 bps from its current target range of 2.50%–2.75% to the new target range of 2.75%–3.00%. She calculates the probability of a rate hike as follows:

$$\frac{2.825\% - 2.625\%}{2.875\% - 2.625\%} = 0.80, \text{ or } 80\%$$

Ko can now incorporate this probability of a Fed rate hike into her forecast of short-term US interest rates.

READING

17

Currency Management: An Introduction

by William A. Barker, PhD, CFA

William A. Barker, PhD, CFA (Canada).

LEARNING OUTCOMES

Mastery	The candidate should be able to:
☐	**a.** analyze the effects of currency movements on portfolio risk and return;
☐	**b.** discuss strategic choices in currency management;
☐	**c.** formulate an appropriate currency management program given financial market conditions and portfolio objectives and constraints;
☐	**d.** compare active currency trading strategies based on economic fundamentals, technical analysis, carry-trade, and volatility trading;
☐	**e.** describe how changes in factors underlying active trading strategies affect tactical trading decisions;
☐	**f.** describe how forward contracts and FX (foreign exchange) swaps are used to adjust hedge ratios;
☐	**g.** describe trading strategies used to reduce hedging costs and modify the risk–return characteristics of a foreign-currency portfolio;
☐	**h.** describe the use of cross-hedges, macro-hedges, and minimum-variance-hedge ratios in portfolios exposed to multiple foreign currencies;
☐	**i.** discuss challenges for managing emerging market currency exposures.

1 INTRODUCTION

Globalization has been one of the most persistent themes in recent history, and this theme applies equally to the world of finance. New investment products, deregulation, worldwide financial system integration, and better communication and information networks have opened new global investment opportunities. At the same time, investors have increasingly shed their "home bias" and sought investment alternatives beyond their own borders.

The benefits of this trend for portfolio managers have been clear, both in terms of the broader availability of higher-expected-return investments as well as portfolio diversification opportunities. Nonetheless, investments denominated in foreign currencies also bring a unique set of challenges: measuring and managing foreign exchange risk. Buying foreign-currency denominated assets means bringing currency risk into the portfolio. Exchange rates are volatile and, at least in the short to medium term, can have a marked impact on investment returns and risks—*currency matters*. The key to the superior performance of global portfolios is the effective management of this currency risk.

This reading explores basic concepts and tools of currency management. Section 2 reviews some of the basic concepts of foreign exchange (FX) markets. The material in subsequent sections presumes an understanding of these concepts. Section 3 examines some of the basic mathematics involved in measuring the effects of foreign-currency investments on portfolio return and risk. Section 4 discusses the *strategic* decisions portfolio managers face in setting the target currency exposures of the portfolio. The currency exposures that the portfolio can accept range from a fully hedged position to active management of currency risk. Section 5 discusses some of the *tactical* considerations involving active currency management if the investment policy statement (IPS) extends some latitude for active currency management. A requisite to any active currency management is having a market view; so this section includes various methodologies by which a manager can form directional views on future exchange rate movements and volatility. Section 6 covers a variety of trading tools available to implement both hedging and active currency management strategies. Although the generic types of FX derivatives tools are relatively limited—spot, forward, option, and swap contracts—the number of variations within each and the number of combinations in which they can be used is vast. Section 7 examines some of the issues involved in managing the currency exposures of emerging market currencies—that is, those that are less liquid than the major currencies. Section 8 presents a summary.

2 REVIEW OF FOREIGN EXCHANGE CONCEPTS

We begin with a review of the basic trading tools of the foreign exchange market: spot, forward, FX swap, and currency option transactions. The concepts introduced in this section will be used extensively in our discussion of currency management techniques in subsequent sections.

Most people think only of spot transactions when they think of the foreign exchange market, but in fact the spot market accounts for less than 40% of the average daily turnover in currencies.[1] Although cross-border *business* may be transacted in the spot market (making and receiving foreign currency payments), the *risk management* of these flows takes place in FX derivatives markets (i.e., using forwards, FX swaps, and currency options). So does the hedging of foreign currency assets and liabilities. It is unusual for market participants to engage in any foreign currency transactions without also managing the currency risk they create. Spot transactions typically generate derivative transactions. As a result, understanding these FX derivatives markets, and their relation to the spot market, is critical for understanding the currency risk management issues examined in this reading.

1 2013 Triennial Survey, Bank for International Settlements (2013).

2.1 Spot Markets

In professional FX markets, exchange rate quotes are described in terms of the three-letter currency codes used to identify individual currencies. Exhibit 1 shows a list of some of the more common currency codes.

Exhibit 1 Currency Codes

USD	US dollar
EUR	Euro
GBP	British pound
JPY	Japanese yen
MXN	Mexican peso
CHF	Swiss franc
CAD	Canadian dollar
SEK	Swedish krona
AUD	Australian dollar
KRW	Korean won
NZD	New Zealand dollar
BRL	Brazilian real
RUB	Russian ruble
CNY	Chinese yuan
INR	Indian rupee
ZAR	South African rand

An exchange rate is the number of units of one currency (called the *price currency*) that one unit of another currency (called the *base currency*) will buy. For example, in the notation we will use a USD/EUR rate of 1.3650 which means that one euro buys $1.3650; equivalently, the price of one euro is 1.3650 US dollars. Thus, the euro here is the base currency and the US dollar is the price currency. The exact notation used to represent exchange rates can vary widely between sources, and occasionally the same exchange rate notation will be used by different sources to mean completely different things. The reader should be aware that the notation used here may not be the same as that encountered elsewhere. To avoid confusion, this reading will identify exchange rates using the convention of "P/B," which refers to the price of one unit of the base currency "B" expressed in terms of the price currency "P."

How the professional FX market quotes exchange rates—which is the base currency, and which is the price currency, in any currency pair—is not arbitrary but follows conventions that are broadly agreed on throughout the market. Generally, there is a hierarchy as to which currency will be quoted as the base currency in any given P/B currency pair:

1 Currency pairs involving the EUR will use the EUR as the base currency (for example, GBP/EUR).

2 Currency pairs involving the GBP, other than those involving the EUR, will use the GBP as the base currency (for example, CHF/GBP).

3 Currency pairs involving either the AUD or NZD, other than those involving either the EUR or GBP, will use these currencies as the base currency (for example, USD/AUD and NZD/AUD). The market convention between these two currencies is for a NZD/AUD quote.
4 All other currency quotes involving the USD will use USD as the base currency (for example, MXN/USD).

Readers are encouraged to familiarize themselves with the quoting conventions used in the professional FX market because they are the currency quotes that will be experienced in practice. Exhibit 2 lists some of the most commonly traded currency pairs in global FX markets and their market-standard quoting conventions. These market-standard conventions will be used for the balance of this reading.

Exhibit 2 Select Market-Standard Currency Pair Quotes

Quote convention	Market name
USD/EUR	Euro-dollar
GBP/EUR	Euro-sterling
USD/GBP	Sterling-dollar
JPY/USD	Dollar-yen
USD/AUD	Aussie-dollar
CHF/USD	Dollar-Swiss
CAD/USD	Dollar-Canada
JPY/EUR	Euro-yen
CHF/EUR	Euro-Swiss
JPY/GBP	Sterling-yen

Another convention used in professional FX markets is that most spot currency quotes are priced out to four decimal places: for example, a typical USD/EUR quote would be 1.3500 and not 1.35. The price point at the fourth decimal place is commonly referred to as a "pip." Professional FX traders also refer to what is called the "big figure" or the "handle," which is the integer to the left side of the decimal place as well as the first two decimal places of the quote. For example, for a USD/EUR quote of 1.3568, 1.35 is the handle and there are 68 pips.

There are exceptions to this four decimal place rule. First, forward quotes—discussed later—will often be quoted out to five and sometimes six decimal places. Second, because of the relative magnitude of some currency values, some currency quotes will only be quoted out to two decimal places. For example, because it takes many Japanese yen to buy one US dollar, the typical spot quote for JPY/USD is priced out to only two decimal places (for example, 86.35 and not 86.3500).[2]

The spot exchange rate is usually for settlement on the second business day after the trade date, referred to as $T + 2$ settlement.[3] In foreign exchange markets—as in other financial markets—market participants confront a two-sided price in the form of a bid price and an offer price (also called an ask price) being quoted by potential counterparties. The **bid price** is the price, defined in terms of the price currency, at

2 Many electronic dealing platforms in the FX market are moving to five decimal place pricing for spot quotes, using what are referred to as "deci-pips." In this case, for example, a USD/EUR spot quote might be shown as 1.37645. Spot quotes for JPY/USD on these systems will be given out to three decimal places.
3 The exception among the major currencies is CAD/USD, for which standard spot settlement is $T + 1$.

which the counterparty providing a two-sided price quote is willing to buy one unit of the **base** currency. Similarly, **offer price** is the price, in terms of the price currency, at which that counterparty is willing to sell one unit of the base currency. For example, given a price request from a client, a dealer might quote a two-sided price on the spot USD/EUR exchange rate of 1.3648/1.3652. This quote means that the dealer is willing to pay USD1.3648 to buy one euro (bid) and that the dealer will sell one euro (offer) for USD1.3652. The market width, usually referred to as dealer's spread or the bid–offer spread, is the difference between the bid and the offer. When transacting on a dealer's bid-offer two-sided price quote, a client is said to either "hit the bid" (selling the base currency) or "pay the offer" (buying the base currency).

An easy check to see whether the bid or offer should be used for a specific transaction is that the party *asking* the dealer for a price should be on the more expensive side of the market. For example, if one wants to buy 1 EUR, 1.3652 is more USD per EUR than 1.3648. Hence, paying the offer involves paying more EUR. Similarly, when selling 1 EUR, hitting the bid at 1.3648 means less USD received than 1.3652.

2.2 Forward Markets

Forward contracts are agreements to exchange one currency for another on a future date at an exchange rate agreed on today.[4] In contrast to spot rates, forward contracts are any exchange rate transactions that occur with settlement longer than the usual $T + 2$ settlement for spot delivery.

In professional FX markets, forward exchange rates are typically quoted in terms of "points." The points on a forward rate quote are simply the difference between the forward exchange rate quote and the spot exchange rate quote; that is, the forward premium or discount, with the points scaled so that they can be related to the last decimal place in the spot quote. Forward points are adjustments to the spot price of the base currency, using our standard price/base (P/B) currency notation.

This means that forward rate quotes in professional FX markets are typically shown as the bid–offer on the spot rate and the number of forward points at each maturity.[5] For illustration purposes, assume that the bid–offer for the spot and forward points for the USD/EUR exchange rate are as shown in Exhibit 3.

Exhibit 3 Sample Spot and Forward Quotes (Bid–Offer)

Maturity	Spot Rate or Forward Points
Spot (USD/EUR)	1.3549/1.3651
One month	–5.6/–5.1
Three months	–15.9/–15.3
Six months	–37.0/–36.3
Twelve months	–94.3/–91.8

To convert any of these quoted forward points into a forward rate, one would divide the number of points by 10,000 (to scale down to the fourth decimal place, the last decimal place in the USD/EUR spot quote) and then add the result to the spot

4 These are sometimes called outright forwards to distinguish them from FX swaps, which are discussed later.
5 Maturity is defined in terms of the time between spot settlement, usually $T + 2$, and the settlement of the forward contract.

exchange rate quote.[6] But one must be careful about which side of the market (bid or offer) is being quoted. For example, suppose a market participant was *selling* the EUR forward against the USD. Given the USD/EUR quoting convention, the EUR is the base currency. This means the market participant must use the *bid* rates (i.e., the market participant will "hit the bid") given the USD/EUR quoting convention. Using the data in Exhibit 3, the three-month forward *bid* rate in this case would be based on the bid for both the spot and the forward points, and hence would be:

$$1.3549 + \left(\frac{-15.9}{10{,}000}\right) = 1.35331$$

This result means that the market participant would be selling EUR three months forward at a price of USD1.35331 per EUR. Note that the quoted points are already scaled to each maturity—they are not annualized—so there is no need to adjust them.

Although there is no cash flow on a forward contract until settlement date, it is often useful to do a mark-to-market valuation on a forward position before then to (1) judge the effectiveness of a hedge based on forward contracts (i.e., by comparing the change in the mark-to-market of the underlying asset with the change in the mark-to-market of the forward), and (2) to measure the profitability of speculative currency positions at points before contract maturity.

As with other financial instruments, the mark-to-market value of forward contracts reflects the profit (or loss) that would be realized from closing out the position at current market prices. To close out a forward position, it must be offset with an equal and opposite forward position using the spot exchange rate and forward points available in the market when the offsetting position is created. When a forward contract is initiated, the forward rate is such that no cash changes hands (i.e., the mark-to-market value of the contract at initiation is zero). From that moment onward, however, the mark-to-market value of the forward contract will change as the spot exchange rate changes as well as when interest rates change in either of the two currencies.

Consider an example. Suppose that a market participant bought GBP10,000,000 for delivery against the AUD in six months at an "all-in" forward rate of 1.6100 AUD/GBP. (The all-in forward rate is simply the sum of the spot rate and the forward points, appropriately scaled to size.) Three months later, the market participant wants to close out this forward contract. To do that would require selling GBP10,000,000 three months forward using the AUD/GBP spot exchange rate and forward points in effect at that time. Assume the bid–offer for spot and forward points three months prior to the settlement date are as follows:

Spot rate (AUD/GBP)	1.6210/1.6215
Three-month points	130/140

To sell GBP (the base currency in the AUD/GBP quote) means calculating the *bid* side of the market. Hence, the appropriate all-in three-month forward rate to use is

$$1.6210 + 130/10{,}000 = 1.6340$$

Thus, the market participant originally bought GBP10,000,000 at an AUD/GBP rate of 1.6100 and subsequently sold them at a rate of 1.6340. These GBP amounts will net to zero at settlement date (GBP10 million both bought and sold), but the AUD amounts will not net to zero because the forward rate has changed. The AUD cash flow at settlement date will be equal to

$$(1.6340 - 1.6100) \times 10{,}000{,}000 = \text{AUD}240{,}000$$

6 Because the JPY/USD exchange rate is only quoted to two decimal places, forward points for the dollar/yen currency pair are divided by 100.

This amount is a cash *inflow* because the market participant was long the GBP with the original forward position and the GBP subsequently appreciated (the AUD/GBP rate increased).

This cash flow is paid at settlement day, which is still three months away. To calculate the mark-to-market value on the dealer's position, this cash flow must be discounted to the present. The present value of this amount is found by discounting the settlement day cash flow by the three-month discount rate. Because it is an AUD amount, the three-month AUD discount rate is used. If Libor is used and the three-month AUD Libor is 4.80% (annualized), the present value of this future AUD cash flow is then

$$\frac{\text{AUD}240{,}000}{1 + 0.048\left[\frac{90}{360}\right]} = \text{AUD}237{,}154$$

This is the mark-to-market value of the original long GBP10 million six-month forward contract when it is closed out three months prior to settlement.

To summarize, the process for marking-to-market a forward position is relatively straightforward:

1 Create an equal and offsetting forward position to the original forward position. (In the example earlier, the market participant is long GBP10 million forward, so the offsetting forward contract would be to sell GBP10 million.)

2 Determine the appropriate all-in forward rate for this new, offsetting forward position. If the base currency of the exchange rate quote is being sold (bought), then use the bid (offer) side of the market.

3 Calculate the cash flow at settlement day. This calculation will be based on the original contract size times the difference between the original forward rate and the rate calculated in Step 2. If the currency the market participant was originally long (short) subsequently appreciated (depreciated), then there will be a cash *inflow*. Otherwise, there will be a cash outflow. (In the earlier example, the market participant was long the GBP and it subsequently appreciated; this appreciation led to a cash inflow at the settlement day.)

4 Calculate the present value of this cash flow at the future settlement date. The currency of the cash flow and the discount rate must match. (In the example earlier, the cash flow at the settlement date is in AUD, so an AUD Libor rate is used to calculate the present value.)

Finally, we note that in the example, the mark-to-market value is given in AUD. It would be possible to translate this AUD amount into any other currency value using the current spot rate for the relevant currency pair. In the example above, this would be done by redenominating the mark-to-market in USD, by selling 240,000 AUD 90-days forward against the USD at the prevailing USD/AUD 90-day forward bid rate. This will produce a USD cash flow in 90 days. This USD amount can then be present-valued at the 90-day US rate to get the USD mark-to-market value of the AUD/GBP forward position. The day-count convention used here is an "actual/360" basis.

2.3 FX Swap Markets

An FX swap transaction consists of offsetting and simultaneous spot and forward transactions, in which the base currency is being bought (sold) spot and sold (bought) forward. These two transactions are often referred to as the "legs" of the swap. The two legs of the swap can either be of equal size (a "matched" swap) or one can be larger than the other (a "mismatched" swap). FX swaps are distinct from currency swaps. Similar to currency swaps, FX swaps involve an exchange of principal amounts in different currencies at swap initiation that is reversed at swap maturity. Unlike currency swaps, FX swaps have no interim interest payments and are nearly always of much shorter term than currency swaps.

FX swaps are important for managing currency risk because they are used to "roll" forward contracts forward as they mature. For example, consider the case of a trader who *bought* GBP1,000,000 one month forward against the CHF in order to set up a currency hedge. One month later, the forward contract will expire. To maintain this long position in the GBP against the CHF, two days prior to contract maturity, given $T + 2$ settlement, the trader must (1) sell GBP1,000,000 against the CHF spot, to settle the maturing forward contract; and (2) buy GBP1,000,000 against the CHF forward. That is, the trader is engaging in an FX swap (a matched swap in this case because the GBP currency amounts are equal).

If a trader wanted to adjust the size of the currency hedge (i.e., the size of the outstanding forward position), the forward leg of the FX swap can be of a different size than the spot transaction when the hedge is rolled. Continuing the previous example, if the trader wanted to increase the size of the long-GBP position by GBP500,000 as the outstanding forward contract expires, the transactions required would be to (1) sell GBP1,000,000 against the CHF spot, to settle the maturing forward contract; and (2) buy GBP1,500,000 against the CHF forward. This would be a mismatched swap.

The pricing of swaps will differ slightly depending on whether they are matched or mismatched swaps. If the amount of the base currency involved for the spot and forward legs of the swap are equal (a matched swap), then these are exactly offsetting transactions; one is a buy, the other a sell, and both are for the same amount. Because of this equality, a common *spot* exchange rate is typically applied to both legs of the swap transaction; it is standard practice to use the mid-market spot exchange rate for a matched swap transaction. However, the *forward* points will still be based on either the bid or offer, depending on whether the market participant is buying or selling the base currency forward. In the earlier example, the trader is *buying* the GBP (the base currency) forward and would hence pay the *offer* side of the market for forward points.

If the FX swap is mismatched, then pricing will need to reflect the difference in trade sizes between the two legs of the transaction. Continuing the example in which the trader increased the size of the long-GBP position by GBP500,000, this mismatched swap is equivalent to (1) a matched swap for a size of GBP1,000,000, and (2) an outright forward contract buying GBP500,000. Pricing for the mismatched swap must reflect this net GBP purchase amount. Because the matched swap would already price the forward points on the offer side of the market, typically this mismatched size adjustment would be reflected in the *spot* rate quoted as the base for the FX swap. Because a net amount of GBP is being *bought*, the spot quote would now be on the *offer* side of the CHF/GBP spot rate quote. (In addition, the trader would still pay the offer side of the market for the forward points.)

We will return to these topics later in the reading when discussing in more depth the use of forward contracts and FX swaps to adjust hedge ratios. (A **hedge ratio** is the ratio of the nominal value of the derivatives contract used as a hedge to the market value of the hedged asset.)

2.4 Currency Options

The final product type within FX markets is currency options. The market for currency options is, in many ways, similar to option markets for other asset classes, such as bonds and equities. As in other markets, the most common options in FX markets are call and put options, which are widely used for both risk management and speculative purposes. However, in addition to these vanilla options, the FX market is also characterized by active trading in exotic options. ("Exotic" options have a variety of features that make them exceptionally flexible risk management tools, compared with vanilla options.)

The risk management uses of both vanilla and exotic currency options will be examined in subsequent sections. Although daily turnover in FX options market is small in *relative* terms compared with the overall daily flow in global spot currency markets, because the overall currency market is so large, the *absolute* size of the FX options market is still very considerable.

CURRENCY RISK AND PORTFOLIO RETURN AND RISK

3

In this section, we examine the effect of currency movements on asset returns and portfolio risk. We then turn to how these effects help determine construction of a foreign asset portfolio.

3.1 Return Decomposition

In this section, we examine how international exposure affects a portfolio's return. A **domestic asset** is an asset that trades in the investor's **domestic currency** (or **home currency**). From a portfolio manager's perspective, the domestic currency is the one in which portfolio valuation and returns are reported. *Domestic* refers to a relation between the currency denomination of the asset and the investor; it is not an inherent property of either the asset or the currency. An example of a domestic asset is a USD-denominated bond portfolio from the perspective of a US-domiciled investor. The return on a domestic asset is not affected by exchange rate movements of the domestic currency.

Foreign assets are assets denominated in currencies other than the investor's home currency. An example of a foreign asset is a USD-denominated bond portfolio from the perspective of a eurozone-domiciled investor (and for whom the euro is the home currency). The return on a foreign asset will be affected by exchange rate movements in the home currency against the **foreign currency**. Continuing with our example, the return to the eurozone-domiciled investor will be affected by the USD return on the USD-denominated bond as well as movements in the exchange rate between the home currency and the foreign currency, the EUR and USD respectively.

The return of the foreign asset measured in foreign-currency terms is known as the **foreign-currency return**. Extending the example, if the value of the USD-denominated bond increased by 10%, measured in USD, that increase is the foreign-currency return to the eurozone-domiciled investor. The **domestic-currency return** on a foreign asset will reflect both the foreign-currency return on that asset as well as percentage movements in the spot exchange rate between the home and foreign currencies. The domestic-currency return is multiplicative with respect to these two factors:

$$R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1 \quad (1)$$

where R_{DC} is the domestic-currency return (in percent), R_{FC} is the foreign-currency return, and R_{FX} is the percentage change of the foreign currency against the domestic currency.

Returning to the example, the domestic-currency return for the eurozone-domiciled investor on the USD-denominated bond will reflect both the bond's USD-denominated return as well as movements in the exchange rate between the USD and the EUR.

Suppose that the foreign-currency return on the USD-denominated bond is 10% and the USD appreciates by 5% against the EUR. In this case, the domestic-currency return to the eurozone investor will be:

$$(1 + 10\%)(1 + 5\%) - 1 = (1.10)(1.05) - 1 = 0.155 = 15.5\%$$

Although the concept is seemingly straightforward, the reader should be aware that Equation 1 hides a subtlety that must be recognized. The term R_{FX} is defined as the percentage change in the foreign currency against the domestic currency. However, this change is *not* always the same thing as the percentage change in the spot rate using market standard P/B quotes (for example, as shown in Exhibit 2). Specifically, it is not always the case that $R_{FX} = \%\Delta S_{P/B}$, where the term on the right side of the equal sign is defined in standard FX market convention (note that %Δ is percentage change).

In other words, R_{FX} is calculated as the change in the directly quoted exchange rate, where the domestic currency is defined as the investor's home currency. Because market quotes are not always in direct terms, analysts will need to convert to direct quotes before calculating percentage changes.

With this nuance in mind, what holds for the domestic-currency return of a single foreign asset also holds for the returns on a multi-currency portfolio of foreign assets, except now the portfolio weights must be considered. More generally, the domestic-currency return on a portfolio of multiple foreign assets will be equal to

$$R_{DC} = \sum_{i=1}^{n} \omega_i \left(1 + R_{FC,i}\right)\left(1 + R_{FX,i}\right) - 1 \tag{2}$$

where $R_{FC,i}$ is the foreign-currency return on the i-th foreign asset, $R_{FX,i}$ is the appreciation of the i-th foreign currency against the domestic currency, and ω_i are the portfolio weights of the foreign-currency assets (defined as the percentage of the aggregate domestic-currency value of the portfolio) and $\sum_{i=1}^{n} \omega_i = 1$. (Note that if short selling is allowed in the portfolio, some of the ω_i can be less than zero.) Again, it is important that the exchange rate notation in this expression (used to calculate $R_{FX,i}$) must be consistently defined with the domestic currency as the price currency.

Assume the following information for a portfolio held by an investor in India. Performance is measured in terms of the Indian rupee (INR) and the weights of the two assets in the portfolio, at the beginning of the period, are 80% for the GBP-denominated asset and 20% for the EUR-denominated asset, respectively. (Note that the portfolio weights are measured in terms of a common currency, the INR, which is the investor's domestic currency in this case.)

	One Year Ago	**Today***
INR/GBP spot rate	84.12	85.78
INR/EUR spot rate	65.36	67.81
GBP-denominated asset value, in GBP millions	43.80	50.70
EUR-denominated asset value, in EUR millions	14.08	12.17
GBP-denominated asset value, in INR millions	3,684.46	
EUR-denominated asset value, in INR millions	920.27	
GBP-denominated assets, portfolio weight (INR)	80%	
EUR-denominated assets, portfolio weight (INR)	20%	

* Today's asset values are prior to rebalancing.

The domestic-currency return (R_{DC}) is calculated as follows:

$$R_{DC} = 0.80(1 + R_{FC,GBP})(1 + R_{FX,GBP}) + 0.20(1 + R_{FC,EUR})(1 + R_{FX,EUR}) - 1$$

Note that given the exchange rate quoting convention, the INR is the price currency in the P/B quote for both currency pairs. Adding the data from the table leads to:

$$R_{DC} = 0.80\left(\frac{50.70}{43.80}\right)\left(\frac{85.78}{84.12}\right) + 0.20\left(\frac{12.17}{14.08}\right)\left(\frac{67.81}{65.36}\right) - 1$$

This solves to 0.124 or 12.4%.

To get the *expected* future return on a foreign-currency asset portfolio, based on Equation 2, the portfolio manager would need a market opinion for the expected price movement in each of the foreign assets ($R_{A,i}$) and exchange rates ($R_{FX,i}$) in the portfolio. There are typically correlations between all of these variables—correlations between the foreign asset price movements across countries, correlations between movements among various currency pairs, and correlations between exchange rate movements and foreign-currency asset returns. The portfolio manager would need to account for these correlations when forming expectations about future asset price and exchange rate movements.

3.2 Volatility Decomposition

Now we will turn to examining the effect of currency movements on the volatility of domestic-currency returns. Equation 1 can be rearranged as

$$R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1 = R_{FC} + R_{FX} + R_{FC}R_{FX}$$

When R_{FC} and R_{FX} are small, then the cross-term ($R_{FC}R_{FX}$) is small, and as a result this equation can be approximated as

$$R_{DC} \approx R_{FC} + R_{FX} \quad (3)$$

We return to the example in which the foreign-currency return on the USD-denominated bond was 10% and the USD appreciated by 5% against the EUR. In this example, the domestic-currency return for the Eurozone investor's holding in the USD-denominated bond was approximately equal to 10% + 5% = 15% (which is close to the exact value of 15.5%). We can combine the approximation of Equation 3 with the statistical rule that:

$$\sigma^2\left(\omega_x X + \omega_y Y\right) = \omega_x^2\sigma^2\left(X\right) + \omega_y^2\sigma^2\left(Y\right) + 2\omega_x\omega_y\sigma\left(X\right)\sigma\left(Y\right)\rho\left(X,Y\right) \quad (4)$$

where X and Y are random variables, ω are weights attached to X and Y, σ^2 is variance of a random variable, σ is the corresponding standard deviation, and ρ represents the correlation between two random variables. Applying this result to the domestic-currency return approximation of Equation 3 leads to:

$$\sigma^2(R_{DC}) \approx \sigma^2(R_{FC}) + \sigma^2(R_{FX}) + 2\sigma(R_{FC})\sigma(R_{FX})\rho(R_{FC},R_{FX}) \quad (5)$$

This equation is for the variance of the domestic-currency returns (R_{DC}), but risk is more typically defined in terms of standard deviation because mean and standard deviation are measured in the same units (percent, in this case). Hence, the total risk for domestic-currency returns—that is, $\sigma(R_{DC})$—is the square root of the results calculated in Equation 5.

Note as well that because Equation 5 is based on the addition of all three terms on the right side of the equal sign, exchange rate exposure will generally cause the variance of domestic-currency returns, $\sigma^2(R_{DC})$, to increase to more than that of the foreign-currency returns, $\sigma^2(R_{FC})$, considered on their own. That is, if there was no exchange rate risk, then it would be the case that $\sigma^2(R_{DC}) = \sigma^2(R_{FC})$. Using this as our base-case scenario, adding exchange rate risk exposure to the portfolio usually adds to domestic-currency return variance (the effect is indeterminate if exchange rate movements are negatively correlated with foreign asset returns).

These results on the variance of domestic-currency return can be generalized to a portfolio of foreign-currency assets. If we define the random variables X and Y in Equation 4 in terms of the domestic-currency return (R_{DC}) of two different foreign-currency investments, and the ω_i as portfolio weights that sum to one, then the result is the variance of the domestic-currency returns for the overall foreign asset portfolio:

$$\sigma^2(\omega_1 R_1 + \omega_2 R_2) \approx \omega_1^2\sigma^2(R_1) + \omega_2^2\sigma^2(R_2) + 2\omega_1\omega_2\sigma(R_1)\sigma(R_2)\rho(R_1, R_2) \quad (6)$$

where R_i is the domestic-currency return of the i-th foreign-currency asset. But as shown in Equation 3, the domestic-currency return of a foreign-currency asset (R_{DC}) is itself based on the sum of two random variables: R_{FC} and R_{FX}. This means that we would have to embed the variance expression shown in Equation 5 in *each* of the $\sigma^2(R_i)$ shown in Equation 6 to get the complete solution for the domestic-currency return variance of the overall portfolio. (We would also have to calculate the correlations between *all* of the R_i.) These requirements would lead to a very cumbersome mathematical expression for even a portfolio of only two foreign-currency assets; the expression would be far more complicated for a portfolio with many foreign currencies involved.

Thus, rather than attempt to give the complete mathematical formula for the variance of domestic-currency returns for a multi-currency portfolio, we will instead focus on the key intuition behind this expression. Namely, that the domestic-currency risk exposure of the overall portfolio—that is, $\sigma(R_{DC})$—will depend not only on the variances of *each* of the foreign-currency returns (R_{FC}) and exchange rate movements (R_{FX}) but also on how each of these *interacts* with the others. Generally speaking, negative correlations among these variables will help reduce the overall portfolio's risk through diversification effects.

Note as well that the overall portfolio's risk exposure will depend on the portfolio weights (ω_i) used. If short-selling is allowed in the portfolio, some of these ω_i can be negative as long as the total portfolio weights sum to one. So, for two foreign assets with a strong positive return correlation, short selling one can create considerable diversification benefits for the portfolio. (This approach is equivalent to trading movements in the price spread between these two assets.)

As before with the difference between realized and expected domestic-currency portfolio returns (R_{DC}), there is a difference between realized and expected domestic-currency portfolio risk, $\sigma(R_{DC})$. For Equation 6 to apply to the expected future volatility of the domestic-currency return of a multi-currency foreign asset portfolio, we would need to replace the observed, historical values of the variances and covariances in Equation 6 with their expected future values. This can be challenging, not only because it potentially involves a large number of variables but also because historical price patterns are not always a good guide to future price behavior. Variance and correlation measures are sensitive to the time period used to estimate them and can also vary over time. These variance and correlation measures can either drift randomly with time, or they can be subject to abrupt movements in times of market stress. It should also be clear that these observed, historical volatility and correlation measures need not be the same as the forward-looking *implied* volatility (and correlation) derived from option prices. Although sometimes various survey or consensus forecasts can be used, these too can be sensitive to sample size and composition and are not always available on a timely basis or with a consistent starting point. As with any forecast, they are also not necessarily an accurate guide to future developments; judgment must be used.

Hence, to calculate the expected future risk of the foreign asset portfolio, the portfolio manager would need a market opinion—however derived—on the variance of each of the foreign-currency asset returns (R_{FC}) over the investment horizon as well the variance of future exchange rate movements (R_{FX}) for each currency pair. The portfolio manager would also need a market opinion of how each of these future variables would interact with each other (i.e., their expected correlations). Historical price patterns can serve as a guide, and with computers and large databases, this modeling problem is daunting but not intractable. But the portfolio manager must always be mindful that historical risk patterns may not repeat going forward.

EXAMPLE 1

Portfolio Risk and Return Calculations

The following table shows current and future expected asset prices, measured in their domestic currencies, for both eurozone and Canadian assets (these can be considered "total return" indexes). The table also has the corresponding data for the CAD/EUR spot rate.

	Eurozone		Canada	
	Today	**Expected**	**Today**	**Expected**
Asset price	100.69	101.50	101.00	99.80
CAD/EUR	1.2925	1.3100		

1 What is the expected domestic-currency return for a eurozone investor holding the Canadian asset?

2 What is the expected domestic-currency return for a Canadian investor holding the eurozone asset?

3 From the perspective of the Canadian investor, assume that $\sigma(R_{FC})$ = 3% (the expected risk for the foreign-currency asset is 3%) and the $\sigma(R_{FX})$ = 2% (the expected risk of exchange rate movements is 2%). Furthermore, the expected correlation between movements in foreign-currency asset returns and movements in the CAD/EUR rate is +0.5. What is the expected risk of the domestic-currency return [$\sigma(R_{DC})$]?

Solution to 1:

For the eurozone investor, the R_{FC} = (99.80/101.00) – 1 = –1.19%. Note that, given we are considering the eurozone to be "domestic" for this investor and given the way the R_{FX} expression is defined, we will need to convert the CAD/EUR exchange rate quote so that the EUR is the *price* currency. This leads to R_{FX} = [(1/1.3100)/(1/1.2925)] – 1 = –1.34%. Hence, for the eurozone investor, R_{DC} = (1 – 1.19%)(1 – 1.34%) – 1 = –2.51%.

Solution to 2:

For the Canadian investor, the R_{FC} = (101.50/100.69) – 1 = +0.80%. Given that in the CAD/EUR quote the CAD is the price currency, for this investor the R_{FX} = (1.3100/1.2925) – 1 = +1.35%. Hence, for the Canadian investor the R_{DC} = (1 + 0.80%)(1 + 1.35%) – 1 = 2.16%.

Solution to 3:

Because this is a single foreign-currency asset we are considering (not a portfolio of such assets), we can use Equation 5:

$$\sigma^2(R_{DC}) \approx \sigma^2(R_{FC}) + \sigma^2(R_{FX}) + 2\sigma(R_{FC})\sigma(R_{FX})\rho(R_{FC},R_{FX})$$

Inserting the relevant data leads to

$$\sigma^2(R_{DC}) \approx (3\%)^2 + (2\%)^2 + 2(3\%)(2\%)(0.50) = 0.0019$$

Taking the square root of this leads to $\sigma(R_{DC}) \approx 4.36\%$. (Note that the units in these expressions are all in percent, so in this case 3% is equivalent to 0.03 for calculation purposes.)

4 CURRENCY MANAGEMENT: STRATEGIC DECISIONS

There are a variety of approaches to currency management, ranging from trying to avoid all currency risk in a portfolio to actively seeking foreign exchange risk in order to manage it and enhance portfolio returns.

There is no firm consensus—either among academics or practitioners—about the most effective way to manage currency risk. Some investment managers try to hedge all currency risk, some leave their portfolios unhedged, and others see currency risk as a potential source of incremental return to the portfolio and will actively trade foreign exchange. These widely varying management practices reflect a variety of factors including investment objectives, investment constraints, and beliefs about currency markets.

Concerning beliefs, one camp of thought holds that in the long run currency effects cancel out to zero as exchange rates revert to historical means or their fundamental values. Moreover, an efficient currency market is a zero-sum game (currency "A" cannot appreciate against currency "B" without currency "B" depreciating against currency "A"), so there should not be any long-run gains overall to speculating in currencies, especially after netting out management and transaction costs. Therefore, both currency hedging and actively trading currencies represent a cost to a portfolio with little prospect of consistently positive active returns.

At the other extreme, another camp of thought notes that currency movements can have a dramatic impact on short-run returns and return volatility and holds that there are pricing inefficiencies in currency markets. They note that much of the flow in currency markets is related to international trade or capital flows in which FX trading is being done on a need-to-do basis and these currency trades are just a spinoff of the other transactions. Moreover, some market participants are either not in the market on a purely profit-oriented basis (e.g., central banks, government agencies) or are believed to be "uninformed traders" (primarily retail accounts). Conversely, speculative capital seeking to arbitrage inefficiencies is finite. In short, marketplace diversity is believed to present the potential for "harvesting alpha" through active currency trading.

This ongoing debate does not make foreign-currency risk in portfolios go away; it still needs to managed, or at least, recognized. Ultimately, each portfolio manager or investment oversight committee will have to reach their own decisions about how to manage risk and whether to seek return enhancement through actively trading currency exposures.

Fortunately, there are a well-developed set of financial products and portfolio management techniques that help investors manage currency risk no matter what their individual objectives, views, and constraints. Indeed, the potential combinations of trading tools and strategies are almost infinite, and can shape currency exposures to custom-fit individual circumstance and market opinion. In this section, we explore various points on a spectrum reflecting currency exposure choices (a risk spectrum) and the guidance that portfolio managers use in making strategic decisions about where to locate their portfolios on this continuum. First, however, the implication of investment objectives and constraints as set forth in the investment policy statement must be recognized.

4.1 The Investment Policy Statement

The Investment Policy Statement (IPS) mandates the degree of discretionary currency management that will be allowed in the portfolio, how it will be benchmarked, and the limits on the type of trading polices and tools (e.g., such as leverage) than can be used.

The starting point for organizing the investment plan for any portfolio is the IPS, which is a statement that outlines the broad objectives and constraints of the beneficial owners of the assets. Most IPS specify many of the following points:

- the general objectives of the investment portfolio;
- the risk tolerance of the portfolio and its capacity for bearing risk;
- the time horizon over which the portfolio is to be invested;
- the ongoing income/liquidity needs (if any) of the portfolio; and
- the benchmark against which the portfolio will measure overall investment returns.

The IPS sets the guiding parameters within which more specific portfolio management policies are set, including the target asset mix; whether and to what extent leverage, short positions, and derivatives can be used; and how actively the portfolio will be allowed to trade its various risk exposures.

For most portfolios, currency management can be considered a sub-set of these more specific portfolio management policies within the IPS. The currency risk management policy will usually address such issues as the

- target proportion of currency exposure to be passively hedged;
- latitude for active currency management around this target;
- frequency of hedge rebalancing;
- currency hedge performance benchmark to be used; and
- hedging tools permitted (types of forward and option contracts, etc.).

Currency management should be conducted within these IPS-mandated parameters.

4.2 The Portfolio Optimization Problem

Having described the IPS as the guiding framework for currency management, we now examine the strategic choices that have to be made in deciding the benchmark currency exposures for the portfolio, and the degree of discretion that will be allowed around this benchmark. This process starts with a decision on the optimal foreign-currency asset and FX exposures.

Optimization of a multi-currency portfolio of foreign assets involves selecting portfolio weights that locate the portfolio on the efficient frontier of the trade-off between risk and expected return defined in terms of the investor's domestic currency. As a simplification of this process, consider the portfolio manager examining the expected return and risk of the multi-currency portfolio of foreign assets by using different combinations of portfolio weights (ω_i) that were shown in Equations 2 and 6, respectively, which are repeated here:

$$R_{DC} = \sum_{i=1}^{n} \omega_i \left(1 + R_{FC,i}\right)\left(1 + R_{FX,i}\right) - 1$$

$$\sigma^2\left(\omega_1 R_1 + \omega_2 R_2\right) \approx \omega_1^2 \sigma^2\left(R_1\right) + \omega_2^2 \sigma^2\left(R_2\right) + 2\omega_1 \sigma\left(R_1\right) \omega_2 \sigma\left(R_2\right) \rho\left(R_1, R_2\right)$$

Recall that the R_i in the equation for variance are the R_{DC} for each of the foreign-currency assets. Likewise, recall that the R_{FX} term is defined such that the investor's "domestic" currency is the price currency in the P/B exchange rate quote. In other words, this calculation may require using the algebraic reciprocal of the standard market quote convention. These two equations together show the domestic-currency return and risk for a multi-currency portfolio of foreign assets.

When deciding on an optimal investment position, these equations would be based on the *expected* returns and risks for each of the foreign-currency assets; and hence, including the *expected* returns and risks for each of the foreign-currency exposures. As we have seen earlier, the number of market parameters for which the portfolio manager would need to have a market opinion grows geometrically with the complexity (number of foreign-currency exposures) in the portfolio. That is, to calculate the expected efficient frontier, the portfolio manager must have a market opinion for *each* of the $R_{FC,i}$, $R_{FX,i}$, $\sigma(R_{FC,i})$, $\sigma(R_{FX,i})$, and $\rho(R_{FC,i}\ R_{FX,i})$, as well as for each of the $\rho(R_{FC,i}\ R_{FC,j})$ and $\rho(R_{FX,i}\ R_{FX,j})$. This would be a daunting task for even the most well-informed portfolio manager.

In a perfect world with complete (and costless) information, it would likely be optimal to *jointly* optimize all of the portfolio's exposures—over all currencies and all foreign-currency assets—simultaneously. In the real world, however, this can be a much more difficult task. Confronted with these difficulties, many portfolio managers handle asset allocation with currency risk as a two-step process: (1) portfolio optimization over fully hedged returns; and (2) selection of active currency exposure, if any. Derivative strategies can allow the various risk exposures in a portfolio to be "unbundled" from each other and managed separately. The same applies for currency risks. Because the use of derivatives allows the price risk ($R_{FC,i}$) and exchange rate risk ($R_{FX,j}$) of foreign-currency assets to be unbundled and managed separately, a starting point for the selection process of portfolio weights would be to assume a complete currency hedge. That is, the portfolio manager will choose the exposures to the foreign-currency assets first, and then decide on the appropriate currency exposures afterward (i.e., decide whether to relax the full currency hedge). These decisions are made to simplify the portfolio construction process.

If the currency exposures of foreign assets could be perfectly and costlessly hedged, the hedge would completely neutralize the effect of currency movements on the portfolio's domestic-currency return (R_{DC}).[7] In Equation 2, this would set R_{FX} = 0, meaning that the domestic-currency return is then equal to the foreign-currency return ($R_{DC} = R_{FC}$). In Equation 5, this would set $\sigma^2(R_{DC}) = \sigma^2(R_{FC})$, meaning that the domestic-currency return risk is equal to the foreign-currency return risk.

Removing the currency effects leads to a simpler, two-step process for portfolio optimization. First the portfolio manager could pick the set of portfolio weights (ω_i) for the foreign-currency assets that optimize the expected foreign-currency asset risk–return trade-off (assuming there is no currency risk). Then the portfolio manager could choose the desired currency exposures for the portfolio and decide whether and by how far to relax the constraint to a full currency hedge for each currency pair.

4.3 Choice of Currency Exposures

A natural starting point for the strategic decisions is the "currency-neutral" portfolio resulting from the two-step process described earlier. The question then becomes, How far along the risk spectrum between being fully hedged and actively trading currencies should the portfolio be positioned?

7 A "costless" hedge in this sense would not only mean zero transaction costs, but also no "roll yield."

4.3.1 *Diversification Considerations*

The time horizon of the IPS is important. Many investment practitioners believe that in the long run, adding unhedged foreign-currency exposure to a portfolio does not affect expected long-run portfolio returns; hence in the long run, it would not matter if the portfolio was hedged. (Indeed, portfolio management costs would be reduced without a hedging process.) This belief is based on the view that in the long run, currencies "mean revert" to either some fair value equilibrium level or a historical average; that is, that the *expected* $\%\Delta S = 0$ for a sufficiently long time period. This view typically draws on the expectation that purchasing power parity (PPP) and the other international parity conditions that link movements in exchange rates, interest rates, and inflation rates will eventually hold over the long run.

Supporting this view, some studies argue that in the long-run currencies will in fact mean revert, and hence that currency risk is lower in the long run than in the short run (an early example is Froot 1993). Although much depends on how long run is defined, an investor (IPS) with a very long investment horizon and few immediate liquidity needs—which could potentially require the liquidation of foreign-currency assets at disadvantageous exchange rates—might choose to forgo currency hedging and its associated costs. Logically, this would require a portfolio benchmark index that is also unhedged against currency risk.

Although the international parity conditions may hold in the long run, it can be a *very* long time—possibly decades. Indeed, currencies can continue to drift away from the fair value mean reversion level for much longer than the time period used to judge portfolio performance. Such time periods are also typically longer than the patience of the portfolio manager's oversight committee when portfolio performance is lagging the benchmark. If this very long-run view perspective is not the case, then the IPS will likely impose some form of currency hedging.

Diversification considerations will also depend on the *asset composition* of the foreign-currency asset portfolio. The reason is because the foreign-currency asset returns (R_{FC}) of different asset classes have different correlation patterns with foreign-currency returns (R_{FX}). If there is a negative correlation between these two sets of returns, having at least some currency exposure may help portfolio diversification and moderate the domestic-currency return risk, $\sigma(R_{DC})$. (Refer to Equation 5 in Section 3.3.)

It is often asserted that the correlation between foreign-currency returns and foreign-currency asset returns tends to be greater for fixed-income portfolios than for equity portfolios. This assertion makes intuitive sense: both bonds and currencies react strongly to movements in interest rates, whereas equities respond more to expected earnings. As a result, the implication is that currency exposures provide little diversification benefit to fixed-income portfolios and that the currency risk should be hedged. In contrast, a better argument can be made for carrying currency exposures in global equity portfolios.

To some degree, various studies have corroborated this relative advantage to currency hedging for fixed income portfolios. But the evidence seems somewhat mixed and depends on which markets are involved. One study found that the hedging advantage for fixed-income portfolios is not always large or consistent (Darnell 2004). Other studies (Campbell 2010; Martini 2010) found that the optimal hedge ratio for foreign-currency equity portfolios depended critically on the investor's domestic currency. (Recall that the hedge ratio is defined as the ratio of the nominal value of the hedge to the market value of the underlying.) For some currencies, there was no risk-reduction advantage to hedging foreign equities (the optimal hedge ratio was close to 0%), whereas for other currencies, the optimal hedge ratio for foreign equities was close to 100%.

Other studies indicate that the optimal hedge ratio also seems to depend on *market conditions* and longer-term trends in currency pairs. For example, Campbell, Serfaty-de Medeiros, and Viceira (2007) found that there were no diversification benefits from currency exposures in foreign-currency bond portfolios, and hence to minimize the risk to domestic-currency returns these positions should be fully hedged. The authors also found, however, that during the time of their study (their data spanned 1975 to 2005), the US dollar seemed to be an exception in terms of its correlations with foreign-currency asset returns. Their study found that the US dollar tended to appreciate against foreign currencies when global bond prices fell (for example, in times of global financial stress there is a tendency for investors to shift investments into the perceived safety of reserve currencies). This finding would suggest that keeping some exposure to the US dollar in a global bond portfolio would be beneficial. For non-US investors, this would mean under-hedging the currency exposure to the USD (i.e., a hedge ratio less than 100%), whereas for US investors it would mean over-hedging their foreign-currency exposures back into the USD. Note that some currencies—the USD, JPY, and CHF in particular—seem to act as a safe haven and appreciate in times of market stress. Keeping some of these currency exposures in the portfolio—having hedge ratios that are not set at 100%--can help hedge losses on riskier assets, especially for foreign currency equity portfolios (which are more risk exposed than bond portfolios).

Given this diversity of opinions and empirical findings, it is not surprising to see actual hedge ratios vary widely in practice among different investors. Nonetheless, it is still more likely to see currency hedging for fixed-income portfolios rather than equity portfolios, although actual hedge ratios will often vary between individual managers.

4.3.2 *Cost Considerations*

The costs of currency hedging also guide the strategic positioning of the portfolio. Currency hedges are not a "free good" and they come with a variety of expenses that must be borne by the overall portfolio. Optimal hedging decisions will need to balance the benefits of hedging against these costs.

Hedging costs come mainly in two forms: trading costs and opportunity costs. The most immediate costs of hedging involve trading expenses, and these come in several forms:

- Trading involves dealing on the bid–offer spread offered by banks. Their profit margin is based on these spreads, and the more the client trades and "pays away the spread," the more profit is generated by the dealer. Maintaining a 100% hedge and rebalancing frequently with every minor change in market conditions would be expensive. Although the bid–offer spreads on many FX-related products (especially the spot exchange rate) are quite narrow, "churning" the hedge portfolio would progressively add to hedging costs and detract from the hedge's benefits.
- Some hedges involve currency options; a long position in currency options requires the payment of up-front premiums. If the options expire out of the money (OTM), this cost is unrecoverable.
- Although forward contracts do not require the payment of up-front premiums, they do eventually mature and have to be "rolled" forward with an FX swap transaction to maintain the hedge. Rolling hedges will typically generate cash inflows or outflows. These cash flows will have to be monitored, and as necessary, cash will have to be raised to settle hedging transactions. In other words, even though the currency hedge may *reduce* the volatility of the domestic mark-to-market value of the foreign-currency asset portfolio, it will typically *increase* the volatility in the organization's cash accounts. Managing these cash flow

costs can accumulate to become a significant portion of the portfolio's value, and they become more expensive (for cash outflows) the higher interest rates go.

- One of the most important trading costs is the need to maintain an administrative infrastructure for trading. Front-, middle-, and back-office operations will have to be set up, staffed with trained personnel, and provided with specialized technology systems. Settlement of foreign exchange transactions in a variety of currencies means having to maintain cash accounts in these currencies to make and receive these foreign-currency payments. Together all of these various overhead costs can form a significant portion of the overall costs of currency trading.

A second form of costs associated with hedging are the opportunity cost of the hedge. To be 100% hedged is to forgo any possibility of favorable currency rate moves. If skillfully handled, accepting and managing currency risk—or any financial risk—can potentially add value to the portfolio, even net of management fees. (We discuss the methods by which this might be done in Section 5.)

These opportunity costs lead to another motivation for having a strategic hedge ratio of less than 100%: regret minimization. Although it is not possible to accurately predict foreign exchange movements in advance, it is certainly possible to judge after the fact the results of the decision to hedge or not. Missing out on an advantageous currency movement because of a currency hedge can cause *ex post* regret in the portfolio manager or client; so too can having a foreign-currency loss if the foreign-currency asset position was unhedged. Confronted with this *ex ante* dilemma of whether to hedge, many portfolio managers decide simply to "split the difference" and have a 50% hedge ratio (or some other rule-of-thumb number). Both survey evidence and anecdotal evidence show that there is a wide variety of hedge ratios actually used in practice by managers, and that these variations cannot be explained by more "fundamental" factors alone. Instead, many managers appear to incorporate some degree of regret minimization into hedging decisions (for example, see Michenaud and Solnik 2008).

All of these various hedging expenses—both trading and opportunity costs—will need to be managed. Hedging is a form of insurance against risk, and in purchasing any form of insurance the buyer matches their needs and budgets with the policy selected. For example, although it may be possible to buy an insurance policy with full, unlimited coverage, a zero deductible, and no co-pay arrangements, such a policy would likely be prohibitively expensive. Most insurance buyers decide that it is not necessary to insure against every outcome, no matter how minor. Some minor risks can be accepted and "self-insured" through the deductible; some major risks may be considered so unlikely that they are not seen as worth paying the extra premium. (For example, most ordinary people would likely not consider buying insurance against being kidnapped.)

These same principles apply to currency hedging. The portfolio manager (and IPS) would likely not try to hedge every minor, daily change in exchange rates or asset values, but only the larger adverse movements that can materially affect the overall domestic-currency returns (R_{DC}) of the foreign-currency asset portfolio. The portfolio manager will need to balance the benefits and costs of hedging in determining both strategic positioning of the portfolio as well as any latitude for active currency management. However, around whatever strategic positioning decision taken by the IPS in terms of the benchmark level of currency exposure, hedging cost considerations alone will often dictate a *range* of permissible exposures instead of a single point. (This discretionary range is similar to the deductible in an insurance policy.)

4.4 Locating the Portfolio Along the Currency Risk Spectrum

The strategic decisions encoded in the IPS with regard to the trade-off between the benefits and costs of hedging, as well as the potential for incremental return to the portfolio from active currency management, are the foundation for determining specific currency management strategies. These strategies are arrayed along a spectrum from very risk-averse passive hedging, to actively seeking out currency risk in order to manage it for profit. We examine each in turn.

4.4.1 *Passive Hedging*

In this approach, the goal is to keep the portfolio's currency exposures close, if not equal to, those of a benchmark portfolio used to evaluate performance. Note that the benchmark portfolio often has no foreign exchange exposure, particularly for fixed-income assets; the benchmark index is a "local currency" index based only on the foreign-currency asset return (R_{FC}). However, benchmark indexes that have some foreign exchange risk are also possible.

Passive hedging is a rules-based approach that removes almost all discretion from the portfolio manager, regardless of the manager's market opinion on future movements in exchange rates or other financial prices. In this case, the manager's job is to keep portfolio exposures as close to "neutral" as possible and to minimize tracking errors against the benchmark portfolio's performance. This approach reflects the belief that currency exposures that differ from the benchmark portfolio inject risk (return volatility) into the portfolio without any sufficiently compensatory return. Active currency management—taking positional views on future exchange rate movements—is viewed as being incapable of consistently adding incremental return to the portfolio.

But the hedge ratio has a tendency to "drift" with changes in market conditions, and even passive hedges need periodic rebalancing to realign them with investment objectives. Often the management guidance given to the portfolio manager will specify the rebalancing period—for example, monthly. There may also be allowance for intra-period rebalancing if there have been large exchange rate movements.

4.4.2 *Discretionary Hedging*

This approach is similar to passive hedging in that there is a "neutral" benchmark portfolio against which actual portfolio performance will be measured. However, in contrast to a strictly rules-based approach, the portfolio manager now has some limited discretion on how far to allow actual portfolio risk exposures to vary from the neutral position. Usually this discretion is defined in terms of percentage of foreign-currency market value (the portfolio's currency exposures are allowed to vary plus or minus x% from the benchmark). For example, a eurozone-domiciled investor may have a US Treasury bond portfolio with a mandate to keep the hedge ratio within 95% to 105%. Assuming no change in the foreign-currency return (R_{FC}), but allowing exchange rates (R_{FX}) to vary, this means the portfolio can tolerate exchange rate movements between the EUR and USD of up to 5% before the exchange rate exposures in the portfolio are considered excessive. The manager is allowed to manage currency exposures within these limits without being considered in violation of the IPS.

This discretion allows the portfolio manager at least some limited ability to express directional opinions about future currency movements—to accept risk in an attempt to earn reward—in order to add value to the portfolio performance. Of course, the portfolio manager's actual performance will be compared with that of the benchmark portfolio.

4.4.3 *Active Currency Management*

Further along the spectrum between extreme risk aversion and purely speculative trading is active currency management. In principle, this approach is really just an extension of discretionary hedging: the portfolio manager is allowed to express directional opinions on exchange rates, but is nonetheless kept within mandated risk limits. The performance of the manager—the choices of risk exposures assumed—is benchmarked against a "neutral" portfolio. But for all forms of active management (i.e., having the discretion to express directional market views), there is no allowance for unlimited speculation; there are risk management systems in place for even the most speculative investment vehicles, such as hedge funds. These controls are designed to prevent traders from taking unusually large currency exposures and risking the solvency of the firm or fund.

In many cases, the difference between discretionary hedging and active currency management is one of emphasis more than degree. The primary duty of the discretionary hedger is to protect the portfolio from currency risk. As a secondary goal, within limited bounds, there is some scope for directional opinion in an attempt to enhance overall portfolio returns. If the manager lacks any firm market conviction, the natural neutral position for the discretionary hedger is to be flat—that is, to have no meaningful currency exposures. In contrast, the active currency manager is supposed to take currency risks and manage them for profit. The primary goal is to add alpha to the portfolio through successful trading. Leaving actual portfolio exposures near zero for extended periods is typically not a viable option.

4.4.4 *Currency Overlay*

Active management of currency exposures can extend beyond limited managerial discretion within hedging boundaries. Sometimes accepting and managing currency risk for profit can be considered a portfolio objective. Active currency management is often associated with what are called **currency overlay programs**, although this term is used differently by different sources.

- In the most limited sense of the term, currency overlay simply means that the portfolio manager has outsourced managing currency exposures to a firm specializing in FX management. This could imply something as limited as merely having the external party implement a fully passive approach to currency hedges. If dealing with FX markets and managing currency hedges is beyond the professional competence of the investment manager, whose focus is on managing foreign equities or some other asset class, then hiring such external professional help is an option. Note that typically currency overlay programs involve external managers. However, some large, sophisticated institutional investors may have in-house currency overlay programs managed by a separate group of specialists within the firm.
- A broader view of currency overlay allows the externally hired currency overlay manager to take directional views on future currency movements (again, with the caveat that these be kept within predefined bounds). Sometimes a distinction is made between currency overlay and "foreign exchange as an asset class." In this classification, currency overlay is limited to the currency exposures already in the foreign asset portfolio. For example, if a eurozone-domiciled investor has GBP- and CHF-denominated assets, currency overlay risks are allowed only for these currencies.
- In contrast, the concept of foreign exchange as an asset class does not restrict the currency overlay manager, who is free to take FX exposures in any currency pair where there is value-added to be harvested, regardless of the underlying portfolio. In this sense, the currency overlay manager is very similar to an FX-based hedge fund. To implement this form of active currency management, the

currency overlay manager would have a *joint* opinion on a range of currencies, and have market views not only on the expected movements in the spot rates but also the likelihood of these movements (the variance of the expected future spot rate distribution) as well as the expected correlation between future spot rate movements. Basically, the entire portfolio of currencies is actively managed and optimized over all of the expected returns, risks, and correlations among all of the currencies in the portfolio.

We will focus on this latter form of currency overlay in this reading: active currency management conducted by external, FX-specialized sub-advisors to the portfolio.

It is quite possible to have the foreign-currency asset portfolio fully hedged (or allow some discretionary hedging internally) but then also to add an external currency overlay manager to the portfolio. This approach separates the hedging and alpha function mandates of the portfolio. Different organizations have different areas of expertise; it often makes sense to allocate managing the hedge (currency "beta") and managing the active FX exposures (currency "alpha") to those individuals with a comparative advantage in that function.

Adding this form of currency overlay to the portfolio (FX as an asset class) is similar in principle to adding any type of alternative asset class, such as private equity funds or farmland. In each case, the goal is the search for alpha. But to be most effective in adding value to the portfolio, the currency overlay program should add incremental returns (alpha) and/or greater diversification opportunities to improve the portfolio's risk–return profile. To do this, the currency alpha mandate should have minimum correlation with both the major asset classes and the other alpha sources in the portfolio.

Once this FX as an asset class approach is taken, it is not necessary to restrict the portfolio to a single overlay manager any more than it is necessary to restrict the portfolio to a single private equity fund. Different overlay managers follow different strategies (these are described in more detail in Section 5). Within the overall portfolio allocation to "currency as an alternative asset class", it may be beneficial to diversify across a range of active management styles, either by engaging several currency overlay managers with different styles or by applying a fund-of-funds approach, in which the hiring and management of individual currency overlay managers is delegated to a specialized external investment vehicle.

Whether managed internally or externally (via a fund of funds) it will be necessary to monitor, or benchmark, the performance of the currency overlay manager: Do they generate the returns expected from their stated trading strategy? Many major investment banks as well as specialized market-information firms provide a wide range of proprietary indexes that track the performance of the investible universe of currency overlay managers; sometimes they also offer sub-indexes that focus on specific trading strategies (for example, currency positioning based on macroeconomic fundamentals). However, the methodologies used to calculate these various indexes vary between suppliers. In addition, different indexes show different aspects of active currency management. Given these differences between indexes, there is no simple answer for which index is most suitable as a benchmark; much depends on the specifics of the active currency strategy.

EXAMPLE 2

Currency Overlay

Windhoek Capital Management is a South Africa-based investment manager that runs the Conservative Value Fund, which has a mandate to avoid all currency risk in the portfolio. The firm is considering engaging a currency overlay manager to help with managing the foreign exchange exposures of this investment vehicle. Windhoek does not consider itself to have the in-house expertise to manage FX risk.

Brixworth & St. Ives Asset Management is a UK-based investment manager, and runs the Aggressive Growth Fund. This fund is heavily weighted toward emerging market equities, but also has a mandate to seek out inefficiencies in the global foreign exchange market and exploit these for profit. Although Brixworth & St. Ives manages the currency hedges for all of its investment funds in-house, it is also considering engaging a currency overlay manager.

1 Using a currency overlay manager for the Conservative Value Fund is *most likely* to involve:

   A joining the alpha and hedging mandates.

   B a more active approach to managing currency risks.

   C using this manager to passively hedge their foreign exchange exposures.

2 Using a currency overlay manager for the Aggressive Growth Fund is *most likely* to involve:

   A separating the alpha and hedging mandates.

   B a less discretionary approach to managing currency hedges.

   C an IPS that limits active management to emerging market currencies.

3 Brixworth & St. Ives is *more likely* to engage multiple currency overlay managers if:

   A their returns are correlated with asset returns in the fund.

   B the currency managers' returns are correlated with each other.

   C the currency managers' use different active management strategies.

Solution to 1:

C is correct. The Conservative Value Fund wants to avoid all currency exposures in the portfolio and Windhoek believes that it lacks the currency management expertise to do this.

Solution to 2:

A is correct. Brixworth & St. Ives already does the FX hedging in house, so a currency overlay is more likely to be a pure alpha mandate. This should not change the way that Brixworth & St. Ives manages its hedges, and the fund's mandate to seek out inefficiencies in the global FX market is unlikely to lead to a restriction to actively manage only emerging market currencies.

Solution to 3:

C is correct. Different active management strategies may lead to a more diversified source of alpha generation, and hence reduced portfolio risk. Choices A and B are incorrect because a higher correlation with foreign-currency assets in the portfolio or among overlay manager returns is likely to lead to less diversification.

4.5 Formulating a Client-Appropriate Currency Management Program

We now try to bring all of these previous considerations together in describing how to formulate an appropriate currency management program given client objectives and constraints, as well as overall financial market conditions. Generally speaking, the *strategic* currency positioning of the portfolio, as encoded in the IPS, should be biased toward a more-fully hedged currency management program the more

- short term the investment objectives of the portfolio;
- risk averse the beneficial owners of the portfolio are (and impervious to *ex post* regret over missed opportunities);
- immediate the income and/or liquidity needs of the portfolio;
- fixed-income assets are held in a foreign-currency portfolio;
- cheaply a hedging program can be implemented;
- volatile (i.e., risky) financial markets are;[8] and
- skeptical the beneficial owners and/or management oversight committee are of the expected benefits of active currency management.

The relaxation of any of these conditions creates latitude to allow a more proactive currency risk posture in the portfolio, either through wider tolerance bands for discretionary hedging, or by introducing foreign currencies as a separate asset class (using currency overlay programs as an alternative asset class in the overall portfolio). In the latter case, the more currency overlay is expected to generate alpha that is uncorrelated with other asset or alpha-generation programs in the portfolio, the more it is likely to be allowed in terms of strategic portfolio positioning.

INVESTMENT POLICY STATEMENT

Kailua Kona Advisors runs a Hawaii-based hedge fund that focuses on developed market equities located outside of North America. Its investor base consists of local high-net-worth individuals who are all considered to have a long investment horizon, a high tolerance for risk, and no immediate income needs. In its prospectus to investors, Kailua Kona indicates that it actively manages both the fund's equity and foreign-currency exposures, and that the fund uses leverage through the use of loans as well as short-selling.

Exhibit 4 presents the hedge fund's currency management policy included in the IPS for this hedge fund.

8 As we will see, this also increases hedging costs when currency options are used.

Exhibit 4 Hedge Fund Currency Management Policy: An Example

Overall Portfolio Benchmark:	MSCI EAFE Index (local currency)
Currency Exposure Ranges:	Foreign-currency exposures, based on the USD market value of the equities actually held by the fund at the beginning of each month, will be hedged back into USD within the following tolerance ranges of plus or minus: ■ EUR: 20% ■ GBP: 15% ■ JPY: 10% ■ CHF: 10% ■ AUD: 10% ■ SEK: 10% Other currency exposures shall be left unhedged.
Rebalancing:	The currency hedges will be rebalanced at least monthly, to reflect changes in the USD-denominated market value of portfolio equity holdings.
Hedging Instruments:	■ Forward contracts up to 12 months maturity; ■ European put and call options can be bought or written, for maturities up to 12 months; and ■ Exotic options of up to 12 months maturity can be bought or sold.
Reporting:	Management will present quarterly reports to the board detailing net foreign-currency exposures and speculative trading results. Speculative trading results will be benchmarked against a 100% hedged currency exposure.

With this policy, Kailua Kona Advisors is indicating that it is willing to accept foreign-currency exposures within the portfolio but that these exposures must be kept within pre-defined limits. For example, suppose that at the beginning of the month the portfolio held EUR10 million of EUR-denominated assets. Also suppose that this EUR10 million exposure, combined with all the other foreign-currency exposures in the portfolio, matches Kailua Kona Advisors' desired portfolio weights by currency (as a US-based fund, these desired percentage portfolio allocations across all currencies will be based in USD).

The currency-hedging guidelines indicate that the hedge (for example, using a short position in a USD/EUR forward contract) should be between EUR8 million and EUR12 million, giving some discretion to the portfolio manager on the size of the net exposure to the EUR. At the beginning of the next month, the USD values of the foreign assets in the portfolio are measured again, and the process repeats. If there has been either a large move in the foreign-currency value of the EUR-denominated assets and/or a large move in the USD/EUR exchange rate, it is possible that Kailua Kona Advisors' portfolio exposure to EUR-denominated assets will be too far away from the desired percentage allocation.[9] Kailua Kona Advisors will then need to either buy or sell EUR-denominated assets. If movements in the EUR-denominated value of the assets or in the USD/EUR exchange rate are large enough, this asset rebalancing may have to be done before month's end. Either way, once the asset rebalancing is done, it establishes the new EUR-denominated asset value on which the currency hedge will be based (i.e., plus or minus 20% of this new EUR amount).

If the portfolio is not 100% hedged—for example, continuing the Kailua Kona illustration, if the portfolio manager only hedges EUR9 million of the exposure and has a residual exposure of being long EUR1 million—the success or failure of the manager's tactical decision will be compared with a "neutral" benchmark. In this case, the comparison would be against the performance of a 100% fully hedged portfolio—that is, with a EUR10 million hedge.

5 CURRENCY MANAGEMENT: TACTICAL DECISIONS

The previous section discussed the *strategic* decisions made by the IPS on locating the currency management practices of the portfolio along a risk spectrum ranging from a very conservative approach to currency risk to very active currency management. In this section, we consider the case in which the IPS has given the portfolio manager (or currency overlay manager) at least some limited discretion for actively managing currency risk within these mandated strategic bounds. This then leads to *tactical* decisions: which FX exposures to accept and manage within these discretionary limits. In other words, tactical decisions involve active currency management.

A market view is a prerequisite to any form of active management. At the heart of the trading decision in FX (and other) markets, lies a view on future market prices and conditions. This market opinion guides all decisions with respect to currency risk exposures, including whether currency hedges should be implemented and, if so, how they should be managed.

In what follows, we will explore some of the methods used to form directional views about the FX market. However, a word of caution that cannot be emphasized enough: *There is no simple formula, model, or approach that will allow market participants to precisely forecast exchange rates (or any other financial prices) or to be able to be confident that any trading decision will be profitable.*

5.1 Active Currency Management Based on Economic Fundamentals

This section sets out a broad framework for developing a view about future exchange rate movements based on underlying fundamentals. In contrast to other methods for developing a market view (which are discussed in subsequent sections), at the heart of this approach is the assumption that, in a flexible exchange rate system, exchange rates are determined by logical economic relationships and that these relationships can be modeled.

The simple economic framework is based on the assumption that in the long run, the real exchange rate will converge to its "fair value," but short- to medium-term factors will shape the convergence path to this equilibrium.[10]

9 The overall portfolio percentage allocations by currency will also depend on the price moves of all *other* foreign-currency assets and exchange rates as well, but we will simplify our example by ignoring this nuance.
10 This model was derived and explained by Rosenberg and Barker (2017).

Recall that the real exchange rate reflects the ratio of the real purchasing power between two countries; that is, the once nominal purchasing power in each country is adjusted by its respective price level as well as the spot exchange rate between the two countries. The long-run equilibrium level for the real exchange rate is determined by purchasing power parity or some other model of an exchange rate's fair value, and serves as the anchor for longer-term movements in exchange rates.

Over shorter time frames, movements in real exchange rates will also reflect movements in the real interest rate differential between countries. Recall that the real interest rate (r) is the nominal interest rate adjusted by the expected inflation rate, or $r = i - \pi^{\varepsilon}$, where i is the nominal interest rate and π^{ε} is the expected inflation rate over the same term as the nominal and real interest rates. Movements in risk premiums will also affect exchange rate movements over shorter-term horizons. The riskier a country's assets are perceived to be by investors, the more likely they are to move their investments out of that country, thereby depressing the exchange rate. Finally, the framework recognizes that there are two currencies involved in an exchange rate quote (the price and base currencies) and hence movements in exchange rates will reflect movements in the *differentials* between these various factors.

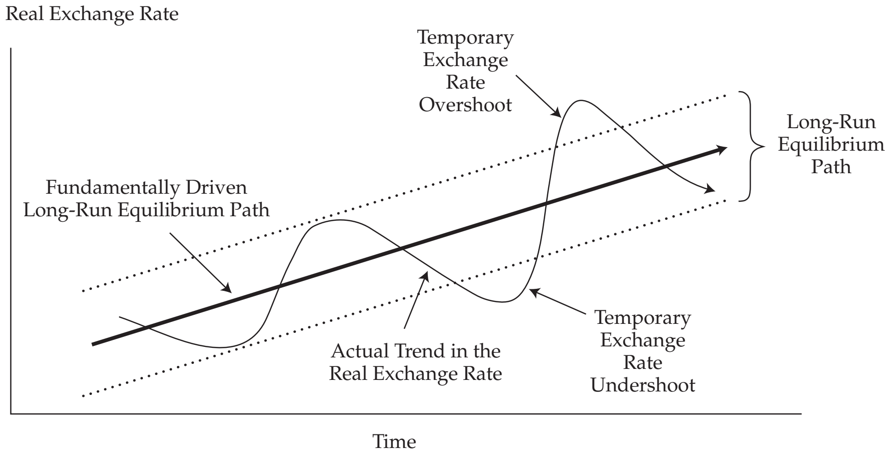
As a result, all else equal, the base currency's real exchange rate should appreciate if there is an upward movement in

- its long-run equilibrium real exchange rate;
- either its real or nominal interest rates, which should attract foreign capital;
- expected foreign inflation, which should cause the foreign currency to depreciate; and
- the foreign risk premium, which should make foreign assets less attractive compared with the base currency nation's domestic assets.

The real exchange rate should also increase if it is currently below its long-term equilibrium value. All of this makes intuitive sense.

In summary, the exchange rate forecast is a mix of long-term, medium-term, and short-term factors. The long-run equilibrium real exchange rate is the anchor for exchange rates and the point of long-run convergence for exchange rate movements. Movements in the short- to medium-term factors (nominal interest rates, expected inflation) affect the timing and path of convergence to this long-run equilibrium. A stylized depiction of the price dynamics generated by this interaction between short-, medium-, and longer-term pricing factors is shown in Exhibit 5.

Exhibit 5 Interaction of Long-term and Short-term Factors in Exchange Rates



Source: Based on Rosenberg (2002), page 32.

It needs to be stressed that it can be very demanding to model how each of these separate effects—nominal interest rate, expected inflation, and risk premium differentials—change over time and affect exchange rates. It can also be challenging to model movements in the long-term equilibrium real exchange rate. A broad variety of factors, such as fiscal and monetary policy, will affect all of these variables in our simple economic model.[11]

5.2 Active Currency Management Based on Technical Analysis

Another approach to forming a market view is based on technical analysis. This approach is based on quite different assumptions compared with modeling based on economic fundamentals. Whereas classical exchange rate economics tends to view market participants as rational, markets as efficient, and exchange rates as driven by underlying economic factors, technical analysis ignores economic analysis. Instead, technical analysis is based on three broad themes.[12]

First, market technicians believe that in a liquid, freely traded market the historical price data can be helpful in projecting future price movements.[13] The reason is because many traders have already used any useful data external to the market to generate their trading positions, so this information is already reflected in current prices. Therefore, it is not necessary to look outside of the market to form an opinion on future price movements. This means it is not necessary to examine interest rates, inflation rates, or risk premium differentials (the factors in our fundamentally based model) because exchange rates already incorporate these factors.

Second, market technicians believe that historical patterns in the price data have a tendency to repeat, and that this repetition provides profitable trade opportunities. These price patterns repeat because market prices reflect human behavior and human beings have a tendency to react in similar ways to similar situations, even if this

11 A broader discussion of exchange rate economics can be found in Rosenberg and Barker (2017).
12 Some material in this section is based on Sine and Strong (2012).
13 In many other asset classes, technical analysis is based on trade volume data as well as price data. But there are no reliable, timely, and high-frequency trade volume data that are publicly available for over-the-counter (OTC) FX markets.

repetitive behavior is not always fully rational. For example, when confronted with an upward price trend, many market participants eventually come to believe that it will extrapolate (an attitude of "irrational exuberance" or "this time it is different"). When the trend eventually breaks, a panicked position exit can cause a sharp overshoot of fair value to the downside. Broadly speaking, technical analysis can be seen as the study of market psychology and how market participant emotions—primarily greed and fear—can be read from the price data and used to predict future price moves.

Third, technical analysis does not attempt to determine where market prices *should* trade (fair value, as in fundamental analysis) but where they *will* trade. Because these price patterns reflect trader emotions, they need not reflect—at least immediately—any cool, rational assessment of the underlying economic or fundamental situation. Although market prices may eventually converge to fair value in the long run, the long run can be a very long time indeed. In the meanwhile, there are shorter-term trading opportunities available in trading the technical patterns in the price data.

Combined, these three principles of technical analysis define a discipline dedicated to identifying patterns in the historical price data, especially as it relates to identifying market trends and market turning points. (Technical analysis is less useful in a trendless market.) Technical analysis tries to identify when markets have become **overbought** or **oversold**, meaning that they have trended too far in one direction and are vulnerable to a trend reversal, or correction. Technical analysis also tries to identify what are called **support levels** and **resistance levels**, either within ongoing price trends or at their extremities (i.e., turning points). These support and resistance levels are price points on dealers' order boards where one would except to see clustering of bids and offers, respectively. At these exchange rate levels, the price action is expected to get "sticky" because it will take more order flow to pierce the wall of either bids or offers. But once these price points are breached, the price action can be expected to accelerate as **stops** are triggered. (Stops, in this sense, refer to stop-loss orders, in which traders leave resting bids or offers away from the current market price to be filled if the market reaches those levels. A stop-loss order is triggered when the price action has gone against a trader's position, and it gets the trader out of that position to limit further losses.)

Technical analysis uses visual cues for market patterns as well as more quantitative technical indicators. There is a wide variety of technical indexes based on market prices that are used in this context. Some technical indicators are as simple as using moving averages of past price points. The 200-day moving average of daily exchange rates is often seen as an important indicator of likely support and resistance. Sometimes two moving averages are used to establish when a price trend is building momentum. For example, when the 50-day moving average crosses the 200-day moving average, this is sometimes seen as a price "break out" point.

Other technical indicators are based on more complex mathematical formulae. There is an extremely wide variety of these more mathematical indicators, some of them very esoteric and hard to connect intuitively with the behavior of real world financial market participants.

In summary, many FX active managers routinely use technical analysis—either alone or in conjunction with other approaches—to form a market opinion or to time position entry and exit points. Even though many technical indicators lack the intellectual underpinnings provided by formal economic modeling, they nonetheless remain a prominent feature of FX markets.

5.3 Active Currency Management Based on the Carry Trade

The **carry trade** is a trading strategy of borrowing in low-yield currencies and investing in high-yield currencies. The term "carry" is related to what is known as the cost of carry—that is, of carrying or holding an investment. This investment has either an implicit or explicit cost (borrowing cost) but may also produce income. The net cost of carry is the difference between these two return rates.

If technical analysis is based on ignoring economic fundamentals, then the carry trade is based on exploiting a well-recognized violation of one of the international parity conditions often used to describe these economic fundamentals: uncovered interest rate parity. Recall that uncovered interest rate parity asserts that, *on a longer-term average*, the return on an unhedged foreign-currency asset investment will be the same as a domestic-currency investment. Assuming that the base currency in the P/B quote is the low-yield currency, stated algebraically uncovered interest rate parity asserts that

$$\%\Delta S_{H/L} \approx i_H - i_L$$

where $\%\Delta S_{H/L}$ is the percentage change in the $S_{H/L}$ spot exchange rate (the low-yield currency is the base currency), i_H is the interest rate on the high-yield currency and i_L is the interest rate on the low-yield currency. If uncovered interest rate parity holds, the yield spread *advantage* for the high-yielding currency (the right side of the equation) will, on average, be matched by the *depreciation* of the high-yield currency (the left side of the equation; the low-yield currency is the base currency and hence a positive value for $\%\Delta S_{H/L}$ means a depreciation of the high-yield currency). According to the uncovered interest rate parity theorem, it is this offset between (1) the yield advantage and (2) the currency depreciation that equates, on average, the unhedged currency returns.

But in reality, the historical data show that there are persistent deviations from uncovered interest rate parity in FX markets, at least in the short to medium term. Indeed, high-yield countries often see their currencies *appreciate*, not depreciate, for extended periods of time. The positive returns from a combination of a favorable yield differential plus an appreciating currency can remain in place long enough to present attractive investment opportunities.

This persistent violation of uncovered interest rate parity described by the carry trade is often referred to as the **forward rate bias**. An implication of uncovered interest rate parity is that the forward rate should be an unbiased predictor of future spot rates. The historical data, however, show that the forward rate is not the center of the distribution for future spot rates; in fact, it is a *biased* predictor (for example, see Kritzman 1999). Hence the name "forward rate bias." With the forward rate premium or discount defined as $F_{P/B} - S_{P/B}$ the "bias" in the forward rate bias is that the premium typically overstates the amount of appreciation of the base currency, and the discount overstates the amount of depreciation. Indeed, the forward discount or premium often gets even the *direction* of future spot rate movements wrong.

The carry trade strategy (borrowing in low-yield currencies, investing in high-yield currencies) is equivalent to a strategy based on trading the forward rate bias. Trading the forward rate bias involves buying currencies selling at a forward discount, and selling currencies trading at a forward premium. This makes intuitive sense: It is desirable to buy low and sell high.

To show the equivalence of the carry trade and trading the forward rate bias, recall that covered interest rate parity (which is enforced by arbitrage) is stated as

$$\frac{F_{P/B} - S_{P/B}}{S_{P/B}} = \frac{(i_P - i_B)\left(\frac{t}{360}\right)}{1 + i_B\left(\frac{t}{360}\right)}$$

This equation shows that when the base currency has a lower interest rate than the price currency (i.e., the right side of the equality is positive) the base currency will trade at a forward premium (the left side of the equality is positive). That is, being low-yield currency and trading at a forward premium is synonymous. Similarly, being a high-yield currency means trading at a forward discount. Borrowing in the low-yield currency and investing in the high-yield currency (the carry trade) is hence equivalent to selling currencies that have a forward premium and buying currencies that have a forward discount (trading the forward rate bias). We will return to these concepts in Section 6.1.2 when we discuss the roll yield in hedging with forward contracts. Exhibit 6 summarizes several key points about the carry trade.

Exhibit 6 The Carry Trade: A Summary

	Buy/Invest	Sell/Borrow
Implementing the carry trade	High-yield currency	Low-yield currency
Trading the forward rate bias	Forward discount currency	Forward premium currency

The gains that one can earn through the carry trade (or equivalently, through trading the forward rate bias) can be seen as the risk premiums earned for carrying an unhedged position—that is, for absorbing currency risk. (In efficient markets, there is no extra reward without extra risk.) Long periods of market stability can make these extra returns enticing to many investors, and the longer the yield differential persists between high-yield and low-yield currencies, the more carry trade positions will have a tendency to build up. But these high-yield currency advantages can be erased quickly, particularly if global financial markets are subject to sudden bouts of stress. This is especially true because the carry trade is a *leveraged* position: borrowing in the low-yielding currency and investing in the high-yielding currency. These occasional large losses mean that the return distribution for the carry trade has a pronounced negative skew.

This negative skew derives from the fact that the **funding currencies** of the carry trade (the low-yield currencies in which borrowing occurs) are typically the safe haven currencies, such as the USD, CHF, and JPY. In contrast, the **investment currencies** (the high-yielding currencies) are typically currencies perceived to be higher risk, such as several emerging market currencies. Any time global financial markets are under stress there is a flight to safety that causes rapid movements in exchange rates, and usually a panicked unwinding of carry trades. As a result, traders running carry trades often get caught in losing positions, with the leverage involved magnifying their losses. Because of the tendency for long periods of relatively small gains in the carry trade to be followed by brief periods of large losses, the carry trade is sometimes characterized as "picking up nickels in front of a steamroller." One guide to the riskiness of the carry trade is the volatility of spot rate movements for the currency pair; all else equal, lower volatility is better for a carry trade position.

We close this section by noting that although the carry trade can be based on borrowing in a single funding currency and investing in a single high-yield currency, it is more common for carry trades to use multiple funding and investment currencies. The number of funding currencies and investment currencies need not be equal: for example, there could be five of one and three of the other. Sometimes the portfolio weighting of exposures between the various funding and investment currencies are simply set equal to each other. But the weights can also be optimized to reflect the trader's market view of the expected movements in each of the exchange rates, as well as their individual risks ($\sigma[\%\Delta S]$) and the expected correlations between movements in the currency pairs. These trades can be dynamically rebalanced, with the relative weights among both funding and investment currencies shifting with market conditions.

5.4 Active Currency Management Based on Volatility Trading

Another type of active trading style is unique to option markets and is known as volatility trading (or simply "vol trading").[14] To explain this trading style, we will start with a quick review of some option basics.

The derivatives of the option pricing model show the sensitivity of the option's premium to changes in the factors that determine option value. These derivatives are often referred to as the "Greeks" of option pricing. There is a very large number of first, second, third, and cross-derivatives that can be taken of an option pricing formula, but the two most important Greeks that we will consider here are the following:

- **Delta:** The sensitivity of the option premium to a small change in the price of the underlying[15] of the option, typically a financial asset. This sensitivity is an indication of *price* risk.
- **Vega:** The sensitivity of the option premium to a small change in implied volatility. This sensitivity is an indication of *volatility* risk.

The most important concept to grasp in terms of volatility trading is that the use of options allows the trader, through a variety of trading strategies, to *unbundle* and isolate all of the various risk factors (the Greeks) and trade them separately. Once an initial option position is taken (either long or short), the trader has exposure to *all* of the various Greeks/risk factors. The unwanted risk exposures, however, can then be hedged away, leaving *only* the desired risk exposure to express that specific directional view.

Delta hedging is the act of hedging away the option position's exposure to delta, the price risk of the underlying (the FX spot rate, in this case). Because delta shows the sensitivity of the option price to changes in the spot exchange rate, it thus defines the option's hedge ratio: The size of the offsetting hedge position that will set the *net* delta of the combined position (option plus delta hedge) to zero. Typically implementing this delta hedge is done using either forward contracts or a spot transaction (spot, by definition, has a delta of one, and no exposure to any other of the Greeks; forward contracts are highly correlated with the spot rate). For example, if a trader was long a call option on USD/EUR with a nominal value of EUR1 million and a delta of +0.5, the delta hedge would involve a short forward position in USD/EUR of EUR0.5 million. That is, the size of the delta hedge is equal to the option's delta times the nominal size of the contract. This hedge size would set the net delta of the overall position (option

14 In principle, this trading style can be applied to all asset classes with options, not just FX trading. But FX options are the most liquid and widely traded options in the world, so it is in FX where most of volatility trading likely takes place in global financial markets.
15 The underlying asset of a derivative is typically referred to simply as the "underlying."

and forward) to zero.[16] Once the delta hedge has set the net delta of the position to zero, the trader then has exposure *only* to the other Greeks, and can use various trading strategies to position in these (long or short) depending on directional views.

Although one could theoretically trade *any* of the other Greeks, the most important one traded is vega; that is, the trader is expressing a view on the future movements in implied volatility, or in other words, is engaged in volatility trading. Implied volatility is not the same as realized, or observed, historical volatility, although it is heavily influenced by it. By engaging in volatility trading, the trader is expressing a view about the future volatility of exchange rates *but not their direction* (the delta hedge set the net delta of the position to zero).

One simple option strategy that implements a volatility trade is a **straddle**, which is a combination of both an at-the-money (ATM) put and an ATM call. A long straddle buys both of these options. Because their deltas are –0.5 and +0.5, respectively, the net delta of the position is zero; that is, the long straddle is delta neutral. This position is profitable in more volatile markets, when either the put or the call go sufficiently in the money to cover the upfront cost of the two option premiums paid. Similarly, a short straddle is a bet that the spot rate will stay relatively stable. In this case, the payout on any option exercise will be less than the twin premiums the seller has collected; the rest is net profit for the option seller. A similar option structure is a **strangle** position for which a long position is buying out-of-the-money (OTM) puts and calls with the same expiry date and the same degree of being out of the money (we elaborate more on this subject later). Because OTM options are being bought, the cost of the position is cheaper—but conversely, it also does not pay off until the spot rate passes the OTM strike levels. As a result, the risk–reward for a strangle is more moderate than that for a straddle.

The interesting thing to note is that by using delta-neutral trading strategies, volatility is turned into a product that can be actively traded like any other financial product or asset class, such as equities, commodities, fixed-income products, and so on. Volatility is not constant nor are its movements completely random. Instead volatility is determined by a wide variety of underlying factors—both fundamental and technical—that the trader can express an opinion on. Movements in volatility are cyclical, and typically subject to long periods of relative stability punctuated by sharp upward spikes in volatility as markets come under periodic bouts of stress (usually the result of some dramatic event, financial or otherwise). Speculative vol traders—for example, among currency overlay managers—often want to be net-short volatility. The reason is because most options expire out of the money, and the option writer then gets to keep the option premium without delivery of the underlying currency pair. The amount of the option premium can be considered the risk premium, or payment, earned by the option writer for absorbing volatility risk. It is a steady source of income under "normal" market conditions. Ideally, these traders would want to "flip" their position and be long volatility ahead of volatility spikes, but these episodes can be notoriously difficult to time. Most hedgers typically run options positions that are net-long volatility because they are buying protection from unanticipated price volatility. (Being long the option means being exposed to the time decay of the option's time value; that is similar to paying insurance premiums for the protection against exchange rate volatility.)

We can also note that just as there are *currency overlay* programs for actively trading the portfolio's currency exposures (as discussed in Section 4.4.4) there can also be *volatility overlay* programs for actively trading the portfolio's exposures to movements in currencies' implied volatility. Just as currency overlay programs manage the

16 Strictly speaking, the net delta would be *approximately* equal to zero because forward contracts do not have identical price properties to those of the spot exchange rate. But it is close enough for our purposes here, and we will ignore this small difference.

portfolio's exposure to currency delta (movements in spot exchange rates), volatility overlay programs manage the portfolio's exposure to currency vega. These volatility overlay programs can be focused on earning speculative profits, but can also be used to hedge the portfolio against risk (we will return to this concept in the discussion of macro hedges in Section 6.4.2.).

Enumerating all the potential strategies for trading foreign exchange volatility is beyond the scope of this reading. Instead, the reader should be aware that this dimension of trading FX volatility (not price) exists and sees a large amount of active trading. Moreover, the best traders are able to think and trade in both dimensions simultaneously. Movements in volatility are often correlated with directional movements in the price of the underlying. For example, when there is a flight to safety as carry trades unwind, there is typically a spike in volatility (and options prices) at the same time. Although pure vol trading is based on a zero-delta position, this need not always be the case; a trader can express a market opinion on volatility (vega exposure) and still have a directional exposure to the underlying spot exchange rate as well (delta exposure). That is, the overall trading position has net vega and delta exposures that reflect the *joint* market view.

We end this section by explaining how currency options are quoted in professional FX markets. (This information will be used in Section 6 when we discuss other option trading strategies.) Unlike exchanged-traded options, such as those used in equity markets, OTC options for currencies are not described in terms of specific strike levels (i.e., exchange rate levels). Instead, in the interdealer market, options are described in terms of their "delta." Deltas for puts can range from a minimum of –1 to a maximum of 0, with a delta of –0.5 being the point at which the put option is ATM; OTM puts have deltas between 0 and –0.5. For call options, delta ranges from 0 to +1, with 0.5 being the ATM point. In FX markets, these delta values are quoted both in *absolute* terms (i.e., in positive rather than negative values) and as percentages, with standard FX option quotes usually in terms of 25-delta and 10-delta options (i.e., a delta of 0.25 and 0.10, respectively; the 10-delta option is deeper OTM and hence cheaper than the 25-delta option). The FX options market is the most liquid around these standard delta quoting points (ATM, 25-delta, 10-delta), but of course, as a flexible OTC market, options of any delta/strike price can be traded. The 25-delta put option (for example) will still go in the money if the spot price dips below a *specific* exchange rate level; this *implied* strike price is *backed out* of an option pricing model once all the other pricing factors, including the current spot rate and the 25-delta of the option, are put into the option pricing model. (The specific option pricing model used is agreed on by both parties to the trade.)

These standard delta price points are often used to define option trading strategies. For example, a 25-delta strangle would be based on 25-delta put and call options. Similarly, a 10-delta strangle would be based on 10-delta options (and would cost less and have a more moderate payoff structure than a 25-delta strangle). Labeling option structures by their delta is common in FX markets.

EXAMPLE 3

Active Strategies

Annie McYelland works as an analyst at Scotland-based Kilmarnock Advisors, an investment firm that offers several investment vehicles for its clients. McYelland has been put in charge of formulating the firm's market views for some of the foreign currencies that these vehicles have exposures to. Her market views will be used to guide the hedging and discretionary positioning for some of the actively managed portfolios.

McYelland begins by examining yield spreads between various countries and the implied volatility extracted from the option pricing for several currency pairs. She collects the following data:

One-Year Yield Levels	
Switzerland	−0.103%
United States	0.162%
Poland	4.753%
Mexico	4.550%

One-Year Implied Volatility	
PLN/CHF	8.4%
MXN/CHF	15.6%
PLN/USD	20.3%
MXN/USD	16.2%

Note: PLN = Polish zloty; the Swiss yields are negative because of Swiss policy actions.

McYelland is also examining various economic indicators to shape her market views. After studying the economic prospects for both Japan and New Zealand, she expects that the inflation rate for New Zealand is about to accelerate over the next few years, whereas the inflation rate for Japan should remain relatively stable. Turning her attention to the economic situation in India, McYelland believes that the Indian authorities are about to tighten monetary policy, and that this change has not been fully priced into the market. She reconsiders her short-term view for the Indian rupee (i.e., the INR/USD spot rate) after conducting this analysis.

McYelland also examines the exchange rate volatility for several currency pairs to which the investment trusts are exposed. Based on her analysis of the situation, she believes that the exchange rate between Chilean peso and the US dollar (CLP/USD) is about to become much more volatile than usual, although she has no strong views about whether the CLP will appreciate or depreciate.

One of McYelland's colleagues, Catalina Ortega, is a market technician and offers to help McYelland time her various market position entry and exit points based on chart patterns. While examining the JPY/NZD price chart, Ortega notices that the 200-day moving average is at 62.0405 and the current spot rate is 62.0315.

1 Based on the data she collected, all else equal, McYelland's *best* option for implementing a carry trade position would be to fund in:

A USD and invest in PLN.

B CHF and invest in MXN.

C CHF and invest in PLN.

2 Based on McYelland's inflation forecasts, all else equal, she would be *more likely* to expect a(n):

A depreciation in the JPY/NZD.

B increase in capital flows from Japan to New Zealand.

C more accommodative monetary policy by the Reserve Bank of New Zealand.

3 Given her analysis for India, McYelland's short-term market view for the INR/USD spot rate is now *most likely* to be:

A biased toward appreciation.

B biased toward depreciation.

C unchanged because it is only a short-run view.

4 Using CLP/USD options, what would be the *cheapest* way for McYelland to implement her market view for the CLP?

A Buy a straddle

B Buy a 25-delta strangle

C Sell a 40-delta strangle

5 Based on Ortega's analysis, she would *most likely* expect:

A support near 62.0400.

B resistance near 62.0310.

C resistance near 62.0400.

Solution to 1:

C is correct. The yield spread between the funding and investment currencies is the widest and the implied volatility (risk) is the lowest. The other choices have a narrower yield spread and higher risk (implied volatility).

Solution to 2:

A is correct. All else equal, an increase in New Zealand's inflation rate will decrease its real interest rate and lead to the real interest rate differential favoring Japan over New Zealand. This would likely result in a depreciation of the JPY/NZD rate over time. The shift in the relative real returns should lead to reduced capital flows from Japan to New Zealand (so Choice B is incorrect) and the RBNZ—New Zealand's central bank—is more likely to tighten monetary policy than loosen it as inflation picks up (so Choice C is incorrect).

Solution to 3:

B is correct. Tighter monetary policy in India should lead to higher real interest rates (at least in the short run). This increase will cause the INR to appreciate against the USD, but because the USD is the base currency, this will be represented as depreciation in the INR/USD rate. Choice C is incorrect because a tightening of monetary policy that is not fully priced-in to market pricing is likely to move bond yields and hence the exchange rate in the short run (given the simple economic model in Section 5.1).

Solution to 4:

B is correct. Either a long straddle or a long strangle will profit from a marked increase in volatility in the spot rate, but a 25-delta strangle would be cheaper (because it is based on OTM options). Writing a strangle—particularly one that is close to being ATM, which is what a 40-delta structure is—is likely to be exercised in favor of the counterparty if McYelland's market view is correct.

Solution to 5:

C is correct. The 200-day moving average has not been crossed yet, and it is higher than the current spot rate. Hence this technical indicator suggests that resistance lies above the current spot rate level, likely in the 62.0400 area. Choice A is incorrect because the currency has not yet appreciated to 62.0400, so it cannot be considered a "support" level. Given that the currency pair has already traded through 62.0310 and is still at least 90 pips away from the 200-day moving average, it is more likely to suspect that resistance still lies above the current spot rate.

TOOLS OF CURRENCY MANAGEMENT

6

In this section, we focus on how the portfolio manager uses financial derivatives to implement both the *strategic* positioning of the portfolio along the risk spectrum (i.e., the performance benchmark) as well as the *tactical* decisions made in regard to variations around this "neutral" position. The manager's market view—whether based on carry, fundamental, currency volatility, or technical considerations—leads to this active management of risk positioning around the strategic benchmark point. Implementing both strategic and tactical viewpoints requires the use of trading tools, which we discuss in this section.

The balance of this reading will assume that the portfolio's strategic foreign-currency asset exposures and the maximum amount of currency risk desired have already been determined by the portfolio's IPS. We begin at the conservative end of the risk spectrum by describing a passive hedge for a single currency (with a 100% hedge ratio). After discussing the costs and limitations of this approach, we move out further along the risk spectrum by describing strategies in which the basic "building blocks" of financial derivatives can be combined to implement the manager's tactical positioning and construct much more customized risk–return profiles. Not surprisingly, the basic trading tools themselves—forwards, options, FX swaps—are used for both strategic and tactical risk management and by both hedgers and speculators alike (although for different ends). Note that the instruments covered as tools of currency management are not nearly an exhaustive list. For example, exchange-traded funds for currencies are a vehicle that can be useful in managing currency risk.

6.1 Forward Contracts

In this section, we consider the most basic form of hedging: a 100% hedge ratio for a single foreign-currency exposure. Futures or forward contracts on currencies can be used to obtain full currency hedges, although most institutional investors prefer to use forward contracts for the following reasons:

1 Futures contracts are standardized in terms of settlement dates and contract sizes. These may not correspond to the portfolio's investment parameters.

2 Futures contracts may not always be available in the currency pair that the portfolio manager wants to hedge. For example, the most liquid currency futures contracts trade on the Chicago Mercantile Exchange (CME). Although there are CME futures contracts for all major exchange rates (e.g., USD/EUR, USD/GBP) and many cross rates (e.g., CAD/EUR, JPY/CHF), there are not contracts available for all possible currency pairs. Trading these cross rates would need multiple futures contracts, adding to portfolio management costs. In addition, many of the "second tier" emerging market currencies may not have liquid futures contracts available against any currency, let alone the currency pair in which the portfolio manager is interested.

3 Futures contracts require up-front margin (initial margin). They also have intra-period cash flow implications, in that the exchange will require the investor to post additional variation margin when the spot exchange rate moves against the investor's position. These initial and ongoing margin requirements tie up the

investor's capital and require careful monitoring through time, adding to the portfolio management expense. Likewise, margin flows can go in the investor's favor, requiring monitoring and reinvestment.

In contrast, forward contracts do not suffer from any of these drawbacks. Major global investment dealers (such as Deutsche Bank, Royal Bank of Scotland, UBS, etc.) will quote prices on forward contracts for practically every possible currency pair, settlement date, and transaction amount. They typically do not require margin to be posted or maintained.

Moreover, the daily trade volume globally for OTC currency forward and swap contracts dwarfs that for exchange-traded currency futures contracts; that is, forward contracts are more liquid than futures for trading in large sizes. Reflecting this liquidity, forward contracts are the predominant hedging instrument in use globally. For the balance of this section, we will focus only on currency forward contracts. However, separate side boxes discuss exchange-traded currency futures contracts and currency-based exchange-traded funds (ETFs).

6.1.1 *Hedge Ratios with Forward Contracts*

In principle, setting up a full currency hedge is relatively straight forward: match the current market value of the foreign-currency exposure in the portfolio with an equal and offsetting position in a forward contract. In practice, of course, it is not that simple because the market value of the foreign-currency assets will change with market conditions. This means that the actual hedge ratio will typically *drift* away from the desired hedge ratio as market conditions change. A **static hedge** (i.e., unchanging hedge) will avoid transaction costs, but will also tend to accumulate unwanted currency exposures as the value of the foreign-currency assets change. This characteristic will cause a mismatch between the market value of the foreign-currency asset portfolio and the nominal size of the forward contract used for the currency hedge; this is pure currency risk. For this reason, the portfolio manager will typically need to implement a **dynamic hedge** by rebalancing the portfolio periodically. This hedge rebalancing will mean adjusting some combination of the size, number, and maturities of the forward currency contracts.

A simple example will illustrate this rebalancing process. Suppose that an investor domiciled in Switzerland has a EUR-denominated portfolio that, at the start of the period, is worth EUR1,000,000. Assume a monthly hedge-rebalancing cycle. To hedge this portfolio, the investor would sell EUR1,000,000 one month forward against the CHF. Assume that one month later, the EUR-denominated investment portfolio is then actually worth only EUR950,000. To roll the hedge forward for the next month, the investor will engage in a mismatched FX swap. (Recall that a "matched" swap means that both the spot and forward transactions—the near and far "legs" of the swap, respectively—are of equal size). For the near leg of the swap, EUR1 million will be bought at spot to settle the expiring forward contract. (The euro amounts will then net to zero, but a Swiss franc cash flow will be generated, either a loss or a gain for the investor, depending on how the CHF/EUR rate has changed over the month). For the far leg of the swap, the investor will sell EUR950,000 forward for one month.

Another way to view this rebalancing process is to consider the case in which the original short forward contract has a three-month maturity. In this case, rebalancing after one month would mean that the manager would have to *buy* 50,000 CHF/EUR two months forward. There is no cash flow at the time this second forward contract is entered, but the *net* amount of euro for delivery at contract settlement two months into the future is now the euro hedge amount desired (i.e., EUR950,000). There will be a net cash flow (denominated in CHF) calculated over these two forward contracts on the settlement date two months hence.

Although rebalancing a dynamic hedge will keep the actual hedge ratio close to the target hedge ratio, it will also lead to increased transaction costs compared with a static hedge. The manager will have to assess the cost–benefit trade-offs of how frequently to dynamically rebalance the hedge. These will depend on a variety of idiosyncratic factors (manager risk aversion, market view, IPS guidelines, etc.), and so there is no single “correct” answer—different managers will likely make different decisions.

However, we can observe that the higher the degree of risk aversion, the more frequently the hedge is likely to be rebalanced back to the “neutral” hedge ratio. Similarly, the greater the tolerance for active trading, and the stronger the commitment to a particular market view, the more likely it is that the actual hedge ratio will be allowed to vary from a “neutral” setting, possibly through entering into new forward contracts. (For example, if the P/B spot rate was seen to be oversold and likely to rebound higher, an actively traded portfolio might buy the base currency through forward contracts to lock in this perceived low price—and thus change the actual hedge ratio accordingly.) The sidebar on executing a hedge illustrates the concepts of rolling hedges, FX swaps and their pricing (bid–offer), and adjusting hedges for market views and changes in market values.

EXECUTING A HEDGE

Jiao Yang works at Hong Kong SAR-based Kwun Tong Investment Advisors; its reporting currency is the Hong Kong Dollar (HKD). She has been put in charge of managing the firm’s foreign-currency hedges. Forward contracts for two of these hedges are coming due for settlement, and Yang will need to use FX swaps to roll these hedges forward three months.

Hedge #1: Kwun Tong has a short position of JPY800,000,000 coming due on a JPY/HKD forward contract. The market value of the underlying foreign-currency assets has not changed over the life of the contract, and Yang does not have a firm opinion on the expected future movement in the JPY/HKD spot rate.

Hedge #2: Kwun Tong has a short position of EUR8,000,000 coming due on a HKD/EUR forward contract. The market value of the EUR-denominated assets has increased (measured in EUR). Yang expects the HKD/EUR spot rate to decrease.

The following spot exchange rates and three-month forward points are in effect when Yang transacts the FX swaps necessary to roll the hedges forward:

	Spot Rate	Three-Month Forward Points
JPY/HKD	10.80/10.82	–20/–14
HKD/EUR	10.0200/10.0210	125/135

Note: The JPY/HKD forward points will be scaled by 100; the HKD/EUR forward points will be scaled by 10,000

As a result, Yang undertakes the following transactions:

For **Hedge #1**, the foreign-currency value of the underlying assets has not changed, and she does not have a market view that would lead her to want to either over- or under-hedge the foreign-currency exposure. Therefore, to roll these hedges forward, she uses a matched swap. For matched swaps (see Section 2.3), the convention is to base pricing on the mid-market spot exchange rate. Thus, the spot leg of the swap would be to buy JPY800,000,000 at the mid-market rate of 10.81 JPY/HKD. The forward leg of the swap would require selling JPY800,000,000 forward three months. Selling JPY (the price currency in the JPY/HKD quote) is equivalent to buying HKD (the base currency). Therefore, she uses the offer-side forward points, and the all-in forward rate for the forward leg of the swap is as follows:

$$10.81 + \frac{-14}{100} = 10.67$$

For **Hedge #2**, the foreign-currency value of the underlying assets has increased; Yang recognizes that this implies that she should increase the size of the hedge greater than EUR8,000,000. She also believes that the HKD/EUR spot rate will decrease, and recognizes that this implies a hedge ratio of more than 100% (Kwun Tong Advisors has given her discretion to over- or under-hedge based on her market views). This too means that the size of the hedge should be increased more than EUR8,000,000, because Yang will want a larger short position in the EUR to take advantage of its expected depreciation. Hence, Yang uses a mismatched swap, buying EUR8,000,000 at spot rate against the HKD, to settle the maturing forward contract and then *selling* an amount *more* than EUR8,000,000 forward to increase the hedge size. Because the EUR is the base currency in the HKD/EUR quote, this means using the *bid* side for both the spot rate and the forward points when calculating the all-in forward rate:

$$10.0200 + \frac{125}{10,000} = 10.0325$$

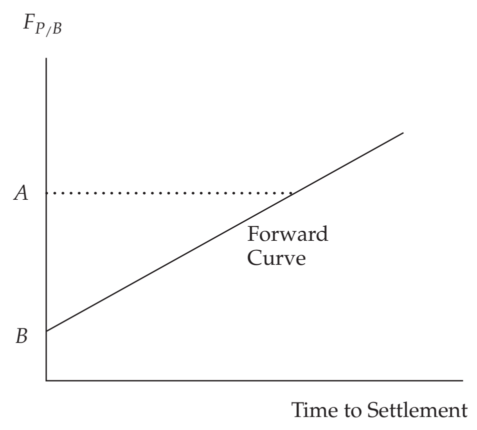
The spot leg of the swap—buying back EUR8,000,000 to settle the outstanding forward transaction—is also based on the bid rate of 10.0200. This is because Yang is selling an amount larger than EUR8,000,000 forward, and the all-in forward rate of the swap is already using the bid side of the market (as it would for a matched swap). Hence, to pick up the net increase in forward EUR sales, the dealer Yang is transacting with would price the swap so that Yang also has to use bid side of the *spot* quote for the spot transaction used to settle the maturing forward contract.

6.1.2 *Roll Yield*

The roll yield (also called the roll return) on a hedge results from the fact that forward contracts are priced at the spot rate adjusted for the number of forward points at that maturity (see the example shown in Exhibit 3). This forward point adjustment can either benefit or detract from portfolio returns (positive and negative roll yield, respectively) depending on whether the forward points are at a premium or discount, and what side of the market (buying or selling) the portfolio manager is on.

The concept of roll yield is illustrated with the simplified example shown in Exhibit 7.

Exhibit 7 The Forward Curve and Roll Yield



The magnitude of roll yield is given by $|(F_{P/B} - S_{P/B})/S_{P/B}|$ where "||" indicates absolute value. The sign depends on whether the investor needs to buy or to sell the base currency forward in order to maintain the hedge. A *positive* roll yield results from buying the base currency at a forward discount or selling it at a forward premium (the intuition here is that it is profitable to "buy low and sell high"). Otherwise, the roll yield is negative (i.e., a positive cost). Examining the case of negative roll yield, assume that to implement the hedge requires buying the base currency in the P/B quote, and that the base currency is trading at a forward premium (as shown in Exhibit 7). By using a long position in a forward contract to implement this hedge, it means paying the forward price of A. All else equal, as time passes the price of the forward contract will "roll down the curve" toward Price B as the forward contract's settlement date approaches. (Note that in reality the curve is not always linear.) At the settlement date of the forward contract, it is necessary to roll the hedging position forward to extend the currency hedge. This rolling forward will involve selling the base currency at the then-current spot exchange rate to settle the forward contract, and then going long another far-dated forward contract (i.e., an FX swap transaction). Note that the portfolio manager originally bought the base currency at Price A and then subsequently sold it at a lower Price B—and that buying high and selling low will be a cost to the portfolio. Or put differently, all else equal, the roll yield would be negative in this case. Note that the "all else equal" caveat refers to the fact that the all-in price of the forward contract consists of the spot rate and forward points, and both are likely to change over the life of the forward contract. It is possible that at the settlement date the spot rate would have moved higher than A, in which case the roll yield would be positive. But the larger the gap between A and B at contract initiation, the less likely this is to occur.

The concept of roll yield is very similar to the concept of forward rate bias (and the carry trade) introduced in Section 5. Indeed, a negative roll yield typically indicates that the hedger was trading *against* the forward rate bias by buying a currency at a forward premium (as in Exhibit 7) or selling a currency at a forward discount. This is the exact opposite of trading the forward rate bias, which is to buy at a discount and sell at a premium. Given the equivalence between the forward rate bias and the carry trade, by trading against the forward rate bias the hedger with a negative roll yield is also essentially entering into *negative* carry trade, in effect borrowing at high rates and investing at low rates. On average, this will not be a winning strategy. Given the equivalence between implementing a carry trade, trading the forward rate bias, and earning positive roll yield, we can now complete Exhibit 6 introduced in Section 5.3 on the carry trade:

Exhibit 8 The Carry Trade and Roll Yield

	Buy/Invest	Sell/Borrow	
Implementing the carry trade	High-yield currency	Low-yield currency	Earning a positive roll yield
Trading the forward rate bias	Forward discount currency	Forward premium currency	

Note as well that this concept of roll yield applies to forward and futures contracts used to trade *any* asset class, not just currencies: It applies equally well to forwards and futures on equities, fixed-income securities, commodities, and indeed, any financial product. For example, consider the case of a commodity processor that hedges the costs of its production process by going long corn futures contracts. If the futures curve for corn futures contracts is in contango (upward sloping, as in Exhibit 7), then this hedging position will also face the potential for negative roll yield.

To be fair, it is also possible for the level of, and movement in, forward points to be in the portfolio manager's favor. Extending our previous example, consider the case of a portfolio manager that has to *sell* the base currency to implement the currency hedge. In this case, the manager would be selling the base currency forward at Price A in Exhibit 7 and, all else equal and through entering an FX swap at settlement date, buying the currency back at the lower Price B—essentially, short selling a financial product with a declining price. In this case, the roll yield is positive.

Because the level of and movements in forward points can either enhance or reduce currency-hedged returns, it explains an observed tendency in foreign exchange markets for the amount of currency hedging to generally vary with movements in forward points. As forward points move against the hedger, the amount of hedging activity typically declines as the cost/benefit ratio of the currency hedge deteriorates. The opposite occurs when movements in forward points reduce hedging costs. Essentially the tendency to hedge will vary depending on whether implementing the hedge happens to be trading in the same direction of the forward rate bias strategy or against it. It is easier to sell a currency forward if there is a "cushion" when it is selling at a forward premium. Likewise, it is more attractive to buy a currency when it is trading at a forward discount. This swings the forward rate bias (and carry trade advantage) in favor of the hedge.

Combined with the manager's market view of future spot rate movements, what this concept implies is that, when setting the hedge ratio, the portfolio manager must balance the effect of expected future exchange rate movements on portfolio returns against the expected effect of the roll yield (i.e., the expected cost of the hedge).

A simple example can illustrate this effect. Consider a portfolio manager that needs to sell forward the base currency of a currency pair (P/B) to implement a currency hedge. Clearly, the manager would prefer to sell this currency at as high a price as possible. Assume that given the forward points for this currency pair and the time horizon for the hedge, the expected roll yield (cost of the hedge) is –3%. Suppose the portfolio manager had a market view that the base currency would depreciate by 4%. In this case, the hedge makes sense: It is better to pay 3% for the hedge to avoid an expected 4% loss.

Now, suppose that with a movement in forward points the new forward discount on the base currency is 6% away from the current spot rate. If the manager's market view is unchanged (an expected depreciation of the base currency of 4%), then now the use of the hedge is less clear: Does it make sense to pay 6% for the hedge to avoid an expected 4% loss? A *risk-neutral* manager would not hedge under these circumstances because the net expected value of the hedge is negative. But a *risk-averse* manager might still implement the hedge regardless of the negative net expected value. The reason is because it is possible that the market forecast is wrong and that the *actual* depreciation of the base currency (and realized loss to the portfolio) may be higher than the 6% cost of the hedge. The risk-averse manager must then weigh the *certainty* of a hedge that costs 6% against the *risk* that actual unhedged currency losses might be much higher than that.

Clearly, the cost/benefit analysis has shifted against hedging in this case, but many risk-averse investors would still undertake the hedge anyway. The risk-averse manager would likely only take an unhedged currency position if the difference between the expected cost of the hedge and the expected return on an unhedged position was so great as to make the risk acceptable. Balancing these two considerations would depend on the type of market view the manager held and the degree of conviction in it, as well as the manager's degree of risk aversion. The decision taken will vary among investors, so no definitive answer can be given as to what would be the appropriate hedging choice (different portfolio managers will make different choices given the same opportunity set). But hedging costs will vary with market conditions and the higher the expected cost of the hedge (negative roll yield) the more the cost/benefit calculation moves against using a fully hedged position. Or put another way, if setting up the hedge involves selling the low-yield currency and buying the high-yield currency in the P/B pair (i.e., an implicit carry position), then the more likely the portfolio will be fully hedged or even over-hedged. The opposite is also true: Trading against the forward rate bias is likely to lead to lower hedge ratios, all else equal.

EXAMPLE 4

The Hedging Decision

The reporting currency of Hong Kong SAR-based Kwun Tong Investment Advisors is the Hong Kong dollar (HKD). The investment committee is examining whether it should implement a currency hedge for the firm's exposures to the GBP and the ZAR (the firm has long exposures to both of these foreign currencies). The hedge would use forward contracts. The following data relevant to assessing the expected cost of the hedge and the expected move in the spot exchange rate has been developed by the firm's market strategist.

	Current Spot Rate	Six-Month Forward Rate	Six-Month Forecast Spot Rate
HKD/GBP	12.4610	12.6550	12.3000
HKD/ZAR	0.9510	0.9275	0.9300

1 Recommend whether to hedge the firm's long GBP exposure. Justify your recommendation.

2 Discuss the trade-offs in hedging the firm's long ZAR exposure.

Solution to 1:

Kwun Tong is long the GBP against the HKD, and HKD/GBP is selling at a forward premium of +1.6% compared with the current spot rate. All else equal, this is the expected roll yield—which is in the firm's favor, in this case, because to implement the hedge Kwun Tong would be *selling* GBP, the base currency in the quote, at a price *higher* than the current spot rate. Moreover, the firm's market strategist expects the GBP to *depreciate* by 1.3% against the HKD. Both of these considerations argue for hedging this exposure.

Solution to 2:

Kwun Tong is long the ZAR against the HKD, and HKD/ZAR is selling at a forward discount of –2.5% compared with the current spot rate. Implementing the hedge would require the firm to *sell* the base currency in the quote, the ZAR, at a price *lower* than the current spot rate. This would imply that, all else equal, the roll yield would go against the firm; that is, the expected cost of the hedge would be 2.5%. But the firm's strategist also forecasts that the ZAR will depreciate against the HKD by 2.2%. This makes the decision to hedge less certain. A risk-neutral investor would not hedge because the expected cost of the hedge is more than the expected depreciation of the ZAR. But this is only a point forecast and comes with a degree of uncertainty—there is a risk that the HKD/ZAR spot rate might depreciate by more than the 2.5% cost of the hedge. In this case, the decision to hedge the currency risk would depend on the trade-offs between

(1) the level of risk aversion of the firm; and (2) the conviction the firm held in the currency forecast—that is, the level of certainty that the ZAR would not depreciate by more than 2.5%.

6.2 Currency Options

One of the costs of forward contracts is the opportunity cost. Once fully hedged, the portfolio manager forgoes any upside potential for future currency moves in the portfolio's favor. Currency options remove this opportunity cost because they provide the manager the right, but not the obligation, to buy or sell foreign exchange at a future date at a rate agreed on today. The manager will only exercise the option at the expiry date if it is favorable to do so.[17]

Consider the case of a portfolio manager who is long the base currency in the P/B quote and needs to sell this currency to implement the hedge. One approach is to simply buy an at-the-money put option on the P/B currency pair. Matching a long position in the underlying with a put option is known as a **protective put** strategy. Suppose the current spot rate is 1.3650 and the strike price on the put option bought is 1.3650. If the P/B rate subsequently goes down (P appreciates and B depreciates) by the expiry date, the manager can exercise the option, implement the hedge, and guarantee a selling price of 1.3650. But if the P/B rate increases (P depreciates and B appreciates), the manager can simply let the option expire and collect the currency gains.

Unfortunately, like forward contracts, currency options are not "free goods" and, like any form of insurance, there is always a price to be paid for it. Buying an option means paying an upfront premium. This premium is determined, first, by its **intrinsic value**, which is the difference between the spot exchange rate and the strike price of the option (i.e., whether the option is in the money, at the money, or out of the money, respectively). ATM options are more expensive than OTM options, and frequently these relatively expensive options expire without being exercised.

The second determinant of an option's premium is its **time value**, which in turn is heavily influenced by the volatility in exchange rates. Regardless of exchange rate volatility, however, options are always moving toward expiry. In general, the time value of the option is always declining. This is the time decay of the option's value (theta, one of the "Greeks" of option prices, describes this effect) and is similar in concept to that of negative roll yield on forward contracts described earlier. Time decay always works against the owner of an option.

As with forward contracts, a portfolio manager will have to make judgments about the cost/benefit trade-offs of options-based strategies. Although options do allow the portfolio upside potential from favorable currency movements, options can also be a very expensive form of insurance. The manager will have to balance any market view of potential currency gains against hedging costs and the degree of risk aversion. There is no "right" answer; different managers will make different decisions about the cost/benefit trade-offs when given the same opportunity set.

17 Almost all options in the FX market are European-style options, which only allow for exercise at the expiry date.

EXAMPLE 5

Hedging Problems

Brixworth & St. Ives Asset Management is a UK-based firm managing a dynamic hedging program for the currency exposures in its Aggressive Growth Fund. One of the fund's foreign-currency asset holdings is denominated in the Mexican peso (MXN), and one month ago Brixworth & St. Ives fully hedged this exposure using a two-month MXN/GBP forward contract. The following table provides the relevant information.

	One Month Ago	Today
Value of assets (in MXN)	10,000,000	9,500,000
MXN/GBP spot rate (bid–offer)	20.0500/20.0580	19.5985/20.0065
One-month forward points (bid–offer)	625/640	650/665
Two-month forward points (bid–offer)	875/900	900/950

The Aggressive Growth Fund also has an unhedged foreign-currency asset exposure denominated in the South African rand (ZAR). The current mid-market spot rate in the ZAR/GBP currency pair is 5.1050.

1 One month ago, Brixworth & St. Ives *most likely* sold:
   - A MXN9,500,000 forward at an all-in forward rate of MXN/GBP 19.6635.
   - B MXN10,000,000 forward at an all-in forward rate of MXN/GBP 20.1375.
   - C MXN10,000,000 forward at an all-in forward rate of MXN/GBP 20.1480.

2 To rebalance the hedge today, the firm would *most likely* need to:
   - A buy MXN500,000 spot.
   - B buy MXN500,000 forward.
   - C sell MXN500,000 forward.

3 Given the data in the table, the roll yield on this hedge at the forward contracts' maturity date is *most likely* to be:
   - A zero.
   - B negative.
   - C positive.

4 Assuming that all ZAR/GBP options considered have the same notional amount and maturity, the *most* expensive hedge that Brixworth & St. Ives could use to hedge its ZAR exposure is a long position in a(n):
   - A ATM call.
   - B 25-delta call.
   - C put with a strike of 5.1050.

Solution to 1:

C is correct. Brixworth & St. Ives is long the MXN and hence must sell the MXN forward against the GBP. Selling MXN against the GBP means buying GBP, the base currency in the MXN/GBP quote. Therefore, the offer side of the market must be used. This means the all-in rate used one month ago would have been 20.0580 + 900/10,000, which equals 20.1480. Choice A is incorrect because it uses today's asset value and the bid side of the spot and one-month forward quotes and Choice B is incorrect because it uses the wrong side of the market (the bid side).

Solution to 2:

B is correct. The foreign investment went down in value in MXN terms. Therefore Brixworth & St. Ives must reduce the size of the hedge. Previously it had sold MXN10,000,000 forward against the GBP, and this amount must be reduced to MXN9,500,000 by buying MXN500,000 forward. Choice A is incorrect because hedging is done with forward contracts not spot deals. Choice C is incorrect because selling MXN forward would increase the size of the hedge, not decrease it.

Solution to 3:

B is correct. To implement the hedge, Brixworth & St. Ives must sell MXN against the GBP, or equivalently, buy GBP (the base currency in the P/B quote) against the MXN. The base currency is selling forward at a premium, and—all else equal—its price would "roll down the curve" as contract maturity approached. Having to settle the forward contract means then selling the GBP spot at a lower price. Buying high and selling low will define a negative roll yield. Moreover, the GBP has depreciated against the MXN, because the MXN/GBP spot rate declined between one month ago and now, which will also add to the negative roll yield.

Solution to 4:

A is correct. The Aggressive Growth Fund is long the ZAR through its foreign-currency assets, and to hedge this exposure it must sell the ZAR against the GBP, or equivalently, buy GBP—the base currency in the P/B quote—against the ZAR. Hedging a required purchase means a long position in a call option (not a put, which is used to hedge a required sale of the base currency in the P/B quote). An ATM call option is more expensive than a 25-delta call option.

6.3 Strategies to Reduce Hedging Costs and Modify a Portfolio's Risk Profile

In the previous sections, we showed that completely hedging currency risk is possible—but can also be expensive. It can be even more expensive when trying to avoid all downside risk while keeping the full upside potential for favorable currency movements (i.e., a protective put strategy with ATM options). Hedging can be seen as a form of insurance, but it is possible to overpay for insurance. Judgments have to be made to determine at what point the costs outweigh the benefits.

As with any form of insurance, there are always steps that can be taken to reduce hedging costs. For most typical insurance products, these cost-reduction measures include such things as higher deductibles, co-pay arrangements, and lower maximum payouts. The same sorts of measures exist in the FX derivatives market; we will explore these various alterative measures in this section. The key point to keep in mind is that all of these various cost-reduction measures invariably involve some combination of *less downside protection* and/or *less upside potential* for the hedge. In efficient markets, lower insurance premiums mean lower insurance.

These cost-reduction measures also start moving the portfolio away from a passively managed 100% hedge ratio toward discretionary hedging in which the manager is allowed to take directional positions. Once the possibility of accepting some downside risk, and some upside potential, is introduced into the portfolio, the manager is moving away from a rules-based approach to hedging toward a more active style of trading. The portfolio manager can then use the trading tools and strategies described in the following sections to express a market view and/or cut hedging costs.

The variety of trading strategies—involving various combinations of forwards, options, and swaps—that can be deployed to this end is almost infinite. We will not attempt to explore all of them in this reading, but rather to give a sense of the range of trading tools and strategies available for managing currency risk. We begin with Exhibit 9, which gives a high-level description of some of these various trading strategies that will then be explained in more detail in subsequent sections. Note that as this section progresses, we will be describing strategies at different points along the risk spectrum described in Section 4, moving in turn from passive hedge-based approaches to strategies used in more active currency management schemes.

Exhibit 9 Select Currency Management Strategies

Forward Contracts	Over-/under-hedging	Profit from market view
Option Contracts	OTM options	Cheaper than ATM
	Risk reversals	Write options to earn premiums
	Put/call spreads	Write options to earn premiums
	Seagull spreads	Write options to earn premiums
Exotic Options	Knock-in/out features	Reduced downside/upside exposure
	Digital options	Extreme payoff strategies

We will make one simplifying assumption for the following sections. Currency management strategies will differ fundamentally depending on whether the base currency of the P/B price quote must be bought or sold to decrease the foreign-currency exposure. To simplify the material and impose consistency on the discussions that follow, we will assume that the portfolio manager must sell the base currency in the P/B quote to reduce currency risk. In addition, unless otherwise noted, the notional amounts and expiration dates on all forward and options contracts are the same.[18]

6.3.1 *Over-/Under-Hedging Using Forward Contracts*

When the IPS gives the manager discretion either to over- or under-hedge the portfolio, relative to the "neutral" benchmark, there is the possibility to add incremental value based on the manager's market view. Profits from successful tactical positioning help reduce net hedging costs. For example, if the neutral benchmark hedge ratio is 100% for the base currency being hedged, and the portfolio manager has a market opinion that the base currency is likely to depreciate, then *over*-hedging through a short position in P/B forward contracts might be implemented—that is, the manager might use a hedge ratio higher than 100%. Similarly, if the manager's market opinion is that the base currency is likely to appreciate, the currency exposure might be *under*-hedged.

A variant of this approach would be to adjust the hedge ratio based on exchange rate movements: to increase the hedge ratio if the base currency depreciated, but decrease the hedge ratio if the base currency appreciated. Essentially, this approach is a form of "delta hedging" that tries to mimic the payoff function of a put option on the base currency. That is, this form of dynamic hedging with forward contracts tries to increasingly participate in any upside moves of the base currency, but increasingly

18 Examples of implementing a hedge by *buying* the base currency will be provided in some of the practice examples.

hedge any downside moves. Doing so adds "convexity" to the portfolio, meaning that the hedge's payoff function will be a convex curve when this function is graphed with profit on the vertical axis and the spot rate on the horizontal axis. (Note that this concept of convexity is identical in intent to the concept of convexity describing bonds; as convexity increases the price of a bond rises more quickly in a declining yield environment and drops more slowly in a rising yield environment. Convexity is a desirable characteristic in both the fixed-income and currency-hedging contexts.)

6.3.2 *Protective Put Using OTM Options*

In the previous section, we examined a dynamic hedging strategy using forward contracts that tries to mimic the payoff function of an option and put convexity into the hedge's payoff function. The payoff functions for options are naturally convex to begin with. However, this can be a costly form of convexity (relatively high option premiums), and fully hedging a currency position with a protective put strategy using an ATM option is the most expensive means of all to buy convexity.

One way to reduce the cost of using options is to accept some downside risk by using an OTM option, such as a 25- or 10-delta option. These options will be less costly, but also do not fully protect the portfolio from adverse currency movements. Conversely, it makes sense to insure against larger risks but accept some smaller day-to-day price movements in currencies. As an analogy, it may be possible to buy a home or car insurance policy with a zero deductible—but the premiums would be exorbitant. It may be more rational to have a cheaper insurance policy and accept responsibility for minor events, but insure against extreme damage.

6.3.3 *Risk Reversal (or Collar)*

Another set of option strategies involves *selling* options (also known as writing options) to earn income that can be used to offset the cost of buying a put option, which forms the "core" of the hedge. Recall that in this section, we are using the simplifying convention that the manager is long the base currency in the P/B quote; hence puts and not calls would be used for hedging in this case.

One strategy to obtain downside protection at a lower cost than a straight protective put position is to *buy* an OTM put option and *write* an OTM call option. Essentially, the portfolio manager is selling some of the upside potential for movements in the base currency (writing a call) and using the option's premiums to help pay the cost of the long put option being purchased. This approach is similar to creating a collar in fixed-income markets. The portfolio is protected against downside movements, but its upside is limited to the strike price on the OTM call option; the exchange rate risk is confined to a corridor or "collar."

In professional FX markets, having a long position in a call option and a short position in a put option is called a **risk reversal**. For example, buying a 25-delta call and writing a 25-delta put is referred to as a *long* position in a 25-delta risk reversal. The position used to create the collar position we just described (buying a put, writing a call) would be a *short* position in a risk reversal.

The majority of currency hedging for foreign-currency asset portfolios and corporate accounts is based on the use of forward contracts and simple option strategies (protective puts/covered calls and risk reversals/collars). We now begin to transition to more active trading strategies that are designed to express market views for speculative profit.

6.3.4 *Put Spread*

A variation of the short risk reversal position is a **put spread**, which is also used to reduce the upfront cost of buying a protective put. The short risk reversal is structured by buying a put option and writing a call option: the premiums received by writing the call help cover the cost of the put. Similarly, the put spread position involves buying a put option and writing another put option to help cover the cost of the long put's premiums. This position is typically structured by buying an OTM put, and writing a deeper-OTM put to gain income from premiums; both options involved have the same maturity.

To continue our previous example, with the current spot rate at 1.3550, the portfolio manager might set up the following put spread: buy a put with a strike of 1.3500 and write a put with a strike of 1.3450. The payoff on the put spread position will then be as follows: there is no hedge protection between 1.3550 and 1.3500; the portfolio is hedged from 1.3500 down to 1.3450; at spot rates below 1.3450, the portfolio becomes unhedged again. The put spread reduces the cost of the hedge, but at the cost of more limited downside protection. The portfolio manager would then use this spread only for cases in which a modest decline in the spot exchange rate was expected, and this position would have to be closely monitored against adverse exchange rate movements.

Note that the put spread structure will not be zero-cost because the deeper-OTM put (1.3450) being written will be cheaper than the less-OTM put (1.3500) being bought. However, there are approaches that will make the put spread (or almost any other option spread position) cheaper or possibly zero-cost: the manager could alter: (a) the strike prices of the options; (b) the notional amounts of the options; or (c) some combination of these two measures.

Altering the strike prices of the put options would mean moving them closer together (and hence more equal in cost). However, this would reduce the downside protection on the hedge. Instead, the portfolio manager could write a larger notional amount for the deeper-OTM option; for example, the ratio for the notionals for the options written versus bought might be 1:2. (In standard FX market notation, this would be a 1 × 2 put spread—the option with exercise price closest to being ATM is given first. However, to avoid confusion it is good practice to specify explicitly in the price quote which is the long and short positions, and what their deltas/strike prices are.) Although this structure may now be (approximately) zero-cost it is not without risks: for spot rates below 1.3450 the portfolio has now seen its exposure to the base currency double-up (because of the 1:2 proportion of notionals) and at a worse spot exchange rate for the portfolio on top of it. Creating a zero-cost structure with a 1 × 2 put spread is equivalent to adding leverage to the options position, because you are selling more options than you are buying. This means that this put spread position will have to be carefully managed. For example, the portfolio manager might choose to close out the short position in the deep-OTM put (by going long/buying an equivalent put option) before the base currency depreciates to the 1.3450 strike level. This may be a costly position exit, however, as the market moves against the manager's original positioning. Because of this, this sort of 1 × 2 structure may be more appropriate for expressing directional opinions rather than as a pure hedging strategy.

6.3.5 *Seagull Spread*

An alternative, and somewhat safer approach, would be to combine the original put spread position (1:1 proportion of notionals) with a covered call position. This is simply an extension of the concept behind risk reversals and put spreads. The "core" of the hedge (for a manager long the base currency) is the long position in a put option. This is expensive. To reduce the cost, a short risk reversal position writes a call option while a put spread writes a deep-OTM put option. Of course, the manager can always do both: that is, be long a protective put and then write *both* a call and a deep-OTM put. This option structure is sometimes referred to as a **seagull spread**.

As with the names for other option strategies based on winged creatures, the "seagull" indicates an option structure with at least three individual options, and in which the options at the most distant strikes—the wings—are on the opposite side of the market from the middle strike(s)—the body. For example, if the current spot price is 1.3550, a seagull could be constructed by going *long* an ATM put at 1.3550 (the middle strike is the "body"), *short* an OTM put at 1.3500, and *short* an OTM call at 1.3600 (the latter two options are the "wings"). Because the options in the "wings" are being written (sold) this is called a *short* seagull position. The risk/return profile of this structure gives full downside protection from 1.3550 to 1.3500 (at which point the short put position neutralizes the hedge) and participation in the upside potential in spot rate movements to 1.3600 (the strike level for the short call option).

Note that because *two* options are now being written to gain premiums instead of one, this approach allows the strike price of the long put position to be ATM, increasing the downside protection. The various strikes and/or notional sizes of these options (and hence their premiums) can always be adjusted up or down until a zero-cost structure is obtained. However, note that this particular seagull structure gives away some upside potential (the short call position) as well as takes on some downside risk (if the short put position is triggered, it will disable the hedge coverage coming from the long put position). As always, lower structure costs come with some combination of lower downside protection and/or less upside potential.

There are many variants of these seagull strategies, each of which provides a different risk–reward profile (and net cost). For example, for the portfolio manager wishing to hedge a long position in the base currency in the P/B quote when the current spot rate is 1.3550, another seagull structure would be to write an ATM call at 1.3550 and use the proceeds to buy an OTM put option at 1.3500 and an OTM call option at 1.3600. Note that in this seagull structure, the "body" is now a *short* option position, not a long position as in the previous example, and the "wings" are the long position. Hence, it is a *long* seagull spread. This option structure provides cheap downside protection (the hedge kicks in at the put's 1.3500 strike) while providing the portfolio manager with unlimited participation in any rally in the base currency beyond the 1.3600 strike of the OTM call option. As before, the various option strikes and/or notional sizes on the options bought and written can be adjusted so that a zero-cost structure is obtained.

6.3.6 *Exotic Options*

In this section, we move even further away from derivatives and trading strategies used mainly for hedging, and toward the more speculative end of the risk spectrum dominated by active currency management. Exotic options are often used by more sophisticated players in the professional trading market—for example, currency overlay managers—and are less frequently used by institutional investors, investment funds, or corporations for hedging purposes. There are several reasons for this relatively light usage of "exotics" for hedging purposes, some related to the fact that many smaller entities lack familiarity with these products. Another reason involves the difficulty of getting hedge accounting treatment in many jurisdictions, which is more advantageous for financial reporting reasons. Finally, the specialized terms of such instruments make them difficult to value for regulatory and accounting purposes.

In general, the term "exotic" refers to all options that are not "vanilla." In FX, vanilla refers essentially to European-style put and call options. The full range of exotic options is both very broad and constantly evolving; many are extraordinarily complex both to price and even to understand. However, all exotics, no matter how complex, typically share one defining feature in common: They are designed to customize the risk exposures desired by the client and provide them at the lowest possible price.[19] Much like the trading strategies described previously, they usually involve some combination of

19 Although the price is low for the client compared with vanilla options, exotics are typically nonetheless high profit margin items for investment dealers.

lower downside protection and/or lower upside potential while providing the client with the specific risk exposures they are prepared to manage, and to do so at what is generally a lower cost than vanilla options.

The two most common type of exotic options encountered in foreign exchange markets are those with **knock-in/knock-out** features and digital options.

An option with a knock-in feature is essentially a vanilla option that is created only when the spot exchange rate touches a pre-specified level (this trigger level, called the "barrier," is not the same as the strike price). Similarly a knock-out option is a vanilla option that ceases to exist when the spot exchange rate touches some pre-specified barrier level. Because these options only exist (i.e., get knocked-in or knocked-out) under certain circumstances, they are more restrictive than vanilla options and hence are cheaper. But again, the knock-in/out features provide less upside potential and/or downside protection.

Digital options are also called binary options, or all-or-nothing options. They are called this because they pay a *fixed* amount if they "touch" their exercise level at any time before expiry (even if by a single pip). This characteristic of "extreme payoff" options makes them almost akin to a lottery ticket. Because of these large payoffs, digital options usually cost more than vanilla options with the same strike price. But digitals also provide highly leveraged exposure to movements in the spot rate. This makes these exotic products more appropriate as trading tools for active currency management, rather than as hedging tools. In practice, digital options are typically used by more sophisticated speculative accounts in the FX market to express directional views on exchange rates.

A full exposition of exotic options is beyond the scope of this reading, but the reader should be aware of their existence and why they exist.

6.3.7 *Section Summary*

Clearly, loosening the constraint of a fully hedged portfolio begins to introduce complicated active currency management decisions. The following steps can be helpful to sort things out:

a First, identify the *base* currency in the P/B quote (currency pair) you are dealing with. Derivatives are typically quoted in terms of either buying or selling the *base* currency when the option is exercised. A move upward in the P/B quote is an appreciation of the base currency.

b Then, identify whether the base currency must be *bought* or *sold* to establish the hedge. These are the price movements you will be protecting against.

c If *buying* the base currency is required to implement the hedge, then the core hedge structure will be based on some combination of a long call option and/or a long forward contract. The cost of this core hedge can be reduced by buying an OTM call option or writing options to earn premiums. (But keep in mind, lower hedging costs equate to less downside protection and/or upside potential.)

d If *selling* the base currency is required to implement the hedge, then the core hedge structure will be based on some combination of a long put option and/or a short forward contract. The cost of this core hedge can be reduced by buying an OTM put option or writing options to earn premiums.

e The higher the allowed discretion for active management, the lower the risk aversion; and the firmer a particular market view is held, the more the hedge is likely to be structured to allow risk exposures in the portfolio. This approach involves positioning in derivatives that "lean the same way" as the market view. (For example, a market view that the base currency will depreciate would use some combination of short forward contracts, writing call options, buying put options, and using "bearish" exotic strategies.) This directional bias to the trading position would be superimposed on the core hedge position described in steps "c" and "d," creating an active-trading "tilt" in the portfolio.

f For these active strategies, varying the strike prices and notional amounts of the options involved can move the trading position toward a zero-cost structure. But as with hedges, keep in mind that lower cost implies less downside protection and/or upside potential for the portfolio.

A lot of different hedging tools and strategies have been named and covered in this section. Rather than attempting to absorb all of them by rote memorization (a put spread is "X" and a seagull is "Y"), the reader is encouraged instead to focus on the intuition behind a hedge, and how and why it is constructed. It matters less what name (if any) is given to any specific approach; what is important is understanding how all the moving parts fit together. The reader should focus on a "building blocks" approach in understanding how and why the parts of the currency hedge are assembled in a given manner.

EXAMPLE 6

Alternative Hedging Strategies

Brixworth & St. Ives Asset Management, the UK-based investment firm, has hedged the exposure of its Aggressive Growth Fund to the MXN with a long position in a MXN/GBP forward contract. The fund's foreign-currency asset exposure to the ZAR is hedged by buying an ATM call option on the ZAR/GBP currency pair. The portfolio managers at Brixworth & St. Ives are looking at ways to modify the risk–reward trade-offs and net costs of their currency hedges.

Jasmine Khan, one of the analysts at Brixworth & St. Ives, proposes an option-based hedge structure for the long-ZAR exposure that would replace the hedge based on the ATM call option with either long or short positions in the following three options on ZAR/GBP:

a ATM put option

b 25-delta put option

c 25-delta call option

Khan argues that these three options can be combined into a hedge structure that will have some limited downside risk, but provide complete hedge protection starting at the relevant 25-delta strike level. The structure will also have unlimited upside potential, although this will not start until the ZAR/GBP exchange rate moves to the relevant 25-delta strike level. Finally, this structure can be created at a relatively low cost because it involves option writing.

1 The *best* method for Brixworth & St. Ives to gain some upside potential for the hedge on the Aggressive Growth Fund's MXN exposure using MXN/GBP options is to replace the forward contract with a:

  A long position in an OTM put.

  B short position in an ATM call.

  C long position in a 25-delta risk reversal.

2 While keeping the ATM call option in the ZAR/GBP, the method that would lead to *greatest* cost reduction on the hedge would be to:

  A buy a 25-delta put.

  B write a 10-delta call.

C write a 25-delta call.

3 Setting up Khan's proposed hedge structure would *most likely* involve being:

A long the 25-delta options and short the ATM option.

B long the 25-delta call, and short both the ATM and 25-delta put options.

C short the 25-delta call, and long both the ATM and 25-delta put options.

Solution to 1:

C is correct. The Aggressive Growth Fund has a long foreign-currency exposure to the MXN in its asset portfolio, which is hedged by selling the MXN against the GBP, or equivalently, buying the GBP—the base currency in the P/B quote—against the MXN. This need to protect against an *appreciation* in the GBP is why the hedge is using a *long* position in the forward contract. To set a collar around the MXN/GBP rate, Brixworth & St. Ives would want a long call option position with a strike greater than the current spot rate (this gives upside potential to the hedge) and a short put position with a strike less than the current spot rate (this reduces net cost of the hedge). A long call and a short put defines a long position in a risk reversal.

Choice A is incorrect because, if exercised, buying a put option would increase the fund's exposure to the MXN (sell GBP, buy MXN). Similarly, Choice B is incorrect because, if exercised, the ATM call option would increase the MXN exposure (the GBP is "called" away from the fund at the strike price with MXN delivered). Moreover, although writing the ATM call option would gain some income from premiums, writing options (on their own) is never considered the "best" hedge because the premium income earned is fixed but the potential losses on adverse currency moves are potentially unlimited.

Solution to 2:

C is correct. As before, the hedge is implemented in protecting against an *appreciation* of the base currency of the P/B quote, the GBP. The hedge is established with an ATM call option (a long position in the GBP). Writing an OTM call option (i.e., with a strike that is more than the current spot rate of 5.1050) establishes a call spread (although hedge protection is lost if ZAR/GBP expires at or above the strike level). Writing a 25-delta call earns more income from premiums than a deeper-OTM 10-delta call (although the 25-delta call has less hedge protection). Buying an option would increase the cost of the hedge, and a put option on the ZAR/GBP would increase the fund's ZAR exposure if exercised (the GBP is "put" to the counterparty at the strike price and ZAR received).

Solution to 3:

A is correct. Once again, the hedge is based on hedging the need to sell ZAR/buy GBP, and GBP is the base currency in the ZAR/GBP quote. This means the hedge needs to protect against an *appreciation* of the GBP (an appreciation of the ZAR/GBP rate). Based on Khan's description, the hedge provides protection after a certain loss point, which would be a long 25-delta call. Unlimited upside potential after favorable (i.e., down) moves in the ZAR/GBP past a certain level means a long 25-delta put. Getting the low net cost that Khan refers to means that the cost of these two long positions is financed by selling the ATM option. (Together these three positions define a long seagull spread). Choice B is incorrect because although the first two legs of the position are right, a short position in the put does not provide any unlimited upside potential (from a down-move in

ZAR/GBP). Choice C is incorrect because any option-based hedge, given the need to hedge against an up-move in the ZAR/GBP rate, is going to be based on a long call position. C does not contain any of these.

6.4 Hedging Multiple Foreign Currencies

We now expand our discussion to hedging a portfolio with multiple foreign-currency assets. The hedging tools and strategies are very similar to those discussed for hedging a single foreign-currency asset, except now the currency hedge must consider the *correlation* between the various foreign-currency risk exposures.

For example, consider the case of a US-domiciled investor who has exposures to foreign-currency assets in Australia and New Zealand. These two economies are roughly similar in that they are resource-based and closely tied to the regional economy of the Western Pacific, especially the large emerging markets in Asia. As a result, the movements in their currencies are often closely correlated; the USD/AUD and USD/NZD currency pairs will tend to move together. If the portfolio manager has the discretion to take short positions, the portfolio may (for example) possibly have a net long position in the Australian foreign-currency asset and a net short position in the New Zealand foreign-currency asset. In this case, there may be less need to hedge away the AUD and NZD currency exposures separately because the portfolio's long exposure to the AUD is diversified by the short position on the NZD.

6.4.1 *Cross Hedges and Macro Hedges*

A **cross hedge** occurs when a position in one asset (or a derivative based on the asset) is used to hedge the risk exposures of a different asset (or a derivative based on it). Normally, cross hedges are not needed because, as we mentioned earlier, forward contracts and other derivatives are widely available in almost every conceivable currency pair. However, if the portfolio already has "natural" cross hedges in the form of negatively correlated residual currency exposures—as in the long-AUD/short-NZD example in Section 6.4—this helps moderate portfolio risk ($\sigma[R_{DC}]$) without having to use a direct hedge on the currency exposure.

Sometimes a distinction is made between a "proxy" hedge and a "cross" hedge. When this distinction is made, a *proxy hed*ge removes the foreign currency risk by hedging it back to the investor's domestic currency—such as in the example with USD/AUD and USD/NZD discussed in the text. In contrast, a *cross hed*ge moves the currency risk from one foreign currency to another foreign currency. For example, a US-domiciled investor may have an exposure to both the Indonesian rupiah (IDR) and the Thai baht (THB), but based on a certain market view, may only want exposure to the THB. In this context, the manager might use currency derivatives as a cross hedge to convert the IDR/USD exposure to a THB/USD exposure. But not all market participants make this sharp of a distinction between proxy hedges and cross hedges, and these terms are often used interchangeably. The most common term found among practitioners in most asset classes is simply a cross hedge, as we are using the term here: hedging an exposure with a closely correlated product (i.e., a proxy hedge when this distinction is made). The cross hedge of moving currency exposures between various *foreign* currencies is more of a special-case application of this concept. In our example, a US investor wanting to shift currency exposures between the IDR and THB would only need to shift the relative size of the IDR/USD and THB/USD forward contracts *already* being used. As mentioned earlier, forwards are available on almost every currency pair, so a cross hedge from foreign currency "A" to foreign currency "B" would be a special case when derivatives on one of the currencies are not available.

EXAMPLE 7

Cross Hedges

Mai Nguyen works at Cape Henlopen Advisors, which runs a US-domiciled fund that invests in foreign-currency assets of Australia and New Zealand. The fund currently has equally weighted exposure to one-year Australian and New Zealand treasury bills (i.e., both of the portfolio weights, $\omega_i = 0.5$). Because the foreign-currency return on these treasury bill assets is risk-free and known in advance, their expected $\sigma(R_{FC})$ is equal to zero.

Nguyen wants to calculate the USD-denominated returns on this portfolio as well as the cross hedging effects of these investments. She collects the following information:

Expected Values	Australia	New Zealand
Foreign-currency asset return R_{FC}	4.0%	6.0%
Foreign-currency return R_{FX}	5.0%	5.0%
Asset risk $\sigma(R_{FC})$	0%	0%
Currency risk $\sigma(R_{FX})$	8.0%	10.0%
Correlation (USD/AUD; USD/NZD)	+0.85	

Using Equation 1, Nguyen calculates that the expected domestic-currency return for the Australian asset is

$$(1.04)(1.05) - 1 = 0.092$$

or 9.2%. Likewise, she determines that the expected domestic-currency return for the New Zealand asset is

$$(1.06)(1.05) - 1 = 0.113$$

or 11.3%. Together, the result is that the expected domestic-currency return (R_{DC}) on the equally weighted foreign-currency asset portfolio is the weighted average of these two individual country returns, or

$$R_{DC} = 0.5(9.2\%) + 0.5(11.3\%) = 10.3\%$$

Nguyen now turns her attention to calculating the portfolio's investment risk [$\sigma(R_{DC})$]. To calculate the expected risk for the domestic-currency return, the currency risk of R_{FX} needs to be multiplied by the *known* return on the treasury bills. The portfolio's investment risk, $\sigma(R_{DC})$, is found by calculating the standard deviation of the right-hand-side of:

$$R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1$$

Although R_{FX} is a random variable—it is not known in advance—the R_{FC} term is in fact known in advance because the asset return is risk-free. Because of this Nguyen can make use of the statistical rules that, first, $\sigma(kX) = k\sigma(X)$, where X is a random variable and k is a constant; and second, that the correlation between a random variable and a constant is zero. These results greatly simplify the calculations because, in this case, she does not need to consider the correlation between exchange rate movements and foreign-currency asset returns. Instead, Nguyen needs to calculate the risk only on the currency side. Applying these statistical rules to the above formula leads to the following results:

A The expected risk (i.e., standard deviation) of the domestic-currency return for the Australian asset is equal to $(1.04) \times 8\% = 8.3\%$.

B The expected risk (i.e., standard deviation) of the domestic-currency return for the New Zealand asset is equal to $(1.06) \times 10\% = 10.6\%$.

Adding all of these numerical values into Equation 4 leads Nguyen to calculate:

$$\sigma^2(R_{DC}) = (0.5)^2(8.3\%)^2 + (0.5)^2(10.6\%)^2 + [(2)0.5(8.3\%)0.5(10.6\%)0.85]$$
$$= 0.8\%$$

The standard deviation of this amount—that is, $\sigma(R_{DC})$—is 9.1%. Note that in the expression, all of the units are in percent, so for example, 8.3% is equivalent to 0.083 for calculation purposes. The careful reader may also note that Nguyen is able to use an exact expression for calculating the variance of the portfolio returns, rather than the approximate expressions shown in Equations 3 and 5. This is because, with risk-free foreign-currency assets, the variance of these foreign-currency returns $\sigma^2(R_{FC})$ is equal to zero.

Nguyen now considers an alternative scenario in which, instead of an equally weighted portfolio (where the $\omega_i = 0.5$), the fund has a long exposure to the New Zealand asset and a short exposure to the Australian asset (i.e., the ω_i are +1 and −1, respectively; this is similar to a highly leveraged carry trade position). Putting these weights into Equations 2 and 4 leads to

$$R_{DC} = -1.0(9.2\%) + 1.0(11.3\%) = 2.1\%$$

$$\sigma^2(R_{DC}) = (1.0)^2(8.3\%)^2 + (1.0)^2(10.6\%)^2 + [-2.0(8.3\%)(10.6\%)0.85]$$
$$= 0.3\%$$

The standard deviation—that is, $\sigma(R_{DC})$—is now 5.6%, less than either of the expected risks for foreign-currency asset returns (results A and B). Nguyen concludes that having long and short positions in positively correlated currencies can lead to much lower portfolio risk, through the benefits of cross hedging. (Nguyen goes on to calculate that if the expected correlation between USD/AUD and USD/NZD increases to 0.95, with all else equal, the expected domestic-currency return risk on the long–short portfolio drops to 3.8%.)

Some types of cross hedges are often referred to as macro hedges. The reason is because the hedge is more focused on the entire portfolio, particularly when individual asset price movements are highly correlated, rather than on individual assets or currency pairs. Another way of viewing a macro hedge is to see the portfolio not just as a collection of financial assets, but as a collection of risk exposures. These various risk exposures are typically defined in categories, such as term risk, credit risk, and liquidity risk. These risks can also be defined in terms of the potential financial scenarios the portfolio is exposed to, such as recession, financial sector stress, or inflation. Often macro hedges are defined in terms of the financial scenario they are designed to protect the portfolio from.

Putting gold in the portfolio sometimes serves this purpose by helping to provide broad portfolio protection against extreme market events. Using a volatility overlay program can also hedge the portfolio against such risks because financial stress is typically associated with a spike in exchange rates' implied volatility. Using a derivative product based on an index, rather than specific assets or currencies, can also define a macro hedge. One macro hedge specific to foreign exchange markets uses derivatives based on fixed-weight baskets of currencies (such derivatives are available in both exchange-traded and OTC form). In a multi-currency portfolio, it may not always be cost efficient to hedge each single currency separately, and in these situations a macro hedge using currency basket derivatives is an alternative approach.

6.4.2 *Minimum-Variance Hedge Ratio*

A mathematical approach to determining the optimal cross hedging ratio is known as the **minimum-variance hedge ratio**. Recall that regression analysis based on ordinary least squares (OLS) is used to minimize the variance of $\hat{\varepsilon}$, the residual between actual and fitted values of the regression

$$y_t = \alpha + \beta x_t + \varepsilon_t \text{ where } \hat{\varepsilon}_t = y_t - \left(\hat{\alpha} + \hat{\beta} x_t\right)$$

This same principle can be used to minimize the tracking error between the value of the hedged asset and the hedging instrument. In the regression formula, we substitute the percentage change in the value of the asset to be hedged for y_t, and the percentage change in value of the hedging instrument for x_t (both of these values are measured in terms of the investor's domestic currency). The calculated coefficient in this regression ($\hat{\beta}$) gives the optimal hedging ratio, which means it minimizes the variance of $\hat{\varepsilon}$ and minimizes the tracking error between changes in the value of the hedge and changes in the value of the asset it is hedging. It can be shown that the formula for the minimum-variance hedge ratio—the formula for calculating the $\hat{\beta}$ coefficient in the regression—is mathematically equal to:

$$\frac{\text{covariance }(y,x)}{\text{variance }(x)} = \text{correlation }(y,x) \times \left[\frac{\text{std. dev. }(y)}{\text{std. dev. }(x)}\right]$$

where y and x are defined as before, the change in the domestic-currency value of the asset and the hedge, respectively.

Calculating the minimum-variance hedge ratio typically applies only for "indirect" hedges based on cross hedging or macro hedges; it is not typically applied to a "direct" hedge in which exposure to a spot rate is hedged with a forward contract in that same currency pair. This is because the correlation between movements in the spot rate and its forward contract is likely to be very close to +1. Likewise, the variance in spot price movements and movements in the price of the forward contract are also likely to be approximately equal. Therefore, calculating the minimum-variance hedge ratio by regressing changes in the spot exchange rate against changes in the forward rate will almost always result is a $\hat{\beta}$ regression estimate very close to 1, and hence a minimum-variance hedge ratio close to 100%. So, undertaking the regression analysis is superfluous.

But the minimum-variance hedge ratio can be quite different from 100% when the hedge is *jointly* optimized over *both* exchange rate movements R_{FX} and changes in the foreign-currency value of the asset R_{FC}. A sidebar discusses this case.

There can also be cases when the optimal hedge ratio may not be 100% because of the market characteristics of a specific currency pair. For example, a currency pair may not have a (liquid) forward contract available and hence an alternative cross hedging instrument or a macro hedge must be used instead. We examine when such situations might come up in Section 7.

6.4.3 *Basis Risk*

The portfolio manager must be aware that any time a direct currency hedge (i.e., a spot rate hedged against its own forward contract) is replaced with an indirect hedge (cross hedge, macro hedge), **basis risk** is brought into the portfolio. This risk reflects the fact that the price movements in the exposure being hedged and the price movements in the cross hedge instrument are not perfectly correlated, and that the correlation will change with time—and sometimes both dramatically and unexpectedly. For a minimum-variance hedge ratio, this risk is expressed as instability in the $\hat{\beta}$ coefficient estimate as more data become available.

For an example of basis risk, return to the illustration earlier of the foreign-currency asset portfolio that cross hedged a long USD/AUD exposure with a short USD/NZD exposure. It is not only possible, but highly likely, that the correlation between movements in the USD/AUD and the USD/NZD spot rates will vary with time. This varying correlation would reflect movements in the NZD/AUD spot rate. Another example of basis risk would be that the correlation between a multi-currency portfolio's domestic-currency market value and the value of currency basket derivatives being used as a macro hedge will neither be perfect nor constant.

At a minimum, this means that all cross hedges and macro hedges will have to be carefully monitored and, as needed, rebalanced to account for the drift in correlations. It also means that minimum-variance hedge ratios will have to be re-estimated as more data become available. The portfolio manager should beware that sudden, unexpected spikes in basis risk can sometimes turn what was once a minimum-variance hedge or an effective cross hedge into a position that is highly correlated with the underlying assets being hedged—the opposite of a hedge.

Basis risk is also used in the context of forward and futures contracts because the price movements of these derivatives products do not always correspond exactly with those of the underlying currency. This is because the price of the forward contract also reflects the interest rate differential between the two countries in the currency pair as well as the term to contract maturity. But with futures and forwards, the derivatives price converges to the price of the underlying as maturity approaches, which is enforced by arbitrage. This convergence is not the case with cross hedges, which potentially can go disastrously wrong with sudden movements in market risk (price correlations), credit risk, or liquidity risk.

OPTIMAL MINIMUM-VARIANCE HEDGES

For simple foreign-currency asset portfolios, it may be possible to use the single-variable OLS regression technique to do a *joint* optimization of the hedge over both the foreign-currency value of the asset R_{FC} and the foreign-currency risk exposure R_{FX}. This approach will reduce the variance of the all-in domestic-currency return R_{DC}, which is the risk that matters most to the investor, not just reducing the variance of the foreign exchange risk R_{FX}.

Calculating the minimum-variance hedge for the foreign exchange risk R_{FX} proceeds by regressing changes in the spot rate against changes in the value of the hedging instrument (i.e., the forward contract). But as indicated in the text, performing this regression is typically unnecessary; for all intents and purposes, the minimum-variance hedge for a spot exchange rate using a forward contract will be close to 100%.

But when there is only a *single* foreign-currency asset involved, one can perform a joint optimization over both of the foreign-currency risks (i.e., both R_{FC} and R_{FX}) by regressing changes in the domestic-currency return (R_{DC}) against percentage changes in the value of the hedging instrument. Basing the optimal hedge ratio on the OLS estimate for β in this regression will minimize the variance of the domestic-currency return $\sigma^2(R_{DC})$. The result will be a better hedge ratio than just basing the regression on R_{FX} alone because this joint approach will also pick up any *correlations* between R_{FX} and R_{FC}. (Recall from Section 4.3.1 that the asset mix in the portfolio, and hence the correlations between R_{FX} and R_{FC}, can affect the optimal hedge ratio.) This single-variable OLS approach, however, will only work if there is a single foreign-currency asset in the portfolio.

Work by Campbell (2010) has shown that the optimal hedge ratio based jointly on movements in R_{FC} and R_{FX} for international *bond* portfolios is almost always close to 100%. However, the optimal hedge ratio for single-country foreign *equity* portfolios varies widely between currencies, and will depend on *both* the investor's domestic currency and the currency of the foreign investment. For example, the optimal hedge ratio for a US equity portfolio will be different for UK and eurozone-based investors; and for eurozone investors, the optimal hedge ratio for a US equity portfolio can be different from that of a Canadian equity portfolio. The study found that the optimal hedge ratio for foreign equity exposures can vary widely from 100% between countries. But as the author cautions, these optimal hedge ratios are calculated on historical data that may not be representative of future price dynamics.

Minimum-Variance Hedge Ratio Example

Annie McYelland is an analyst at Scotland- based Kilmarnock Capital. Her firm is considering an investment in an equity index fund based on the Swiss Stock Market Index (SMI). The SMI is a market-cap weighted average of the twenty largest and most liquid Swiss companies, and captures about 85% of the overall market capitalization of the Swiss equity market.

McYelland is asked to formulate a currency-hedging strategy. Because this investment involves only one currency pair and one investment (the SMI), she decides to calculate the minimum-variance hedge ratio for the entire risk exposure, not just the currency exposure. McYelland collects 10 years of monthly data on the CHF/GBP spot exchange rate and movements in the Swiss Market Index.

McYelland notes that the GBP is the base currency in the CHF/GBP quote and that the formula for domestic-currency returns (R_{DC}) shown in Equation 1 requires that the domestic currency be the price currency. Accordingly, she starts by inverting the CHF/GBP quote to a GBP/CHF quote ($S_{GBP/CHF}$). Then she calculates the monthly percentage changes for this adjusted currency series ($\%\Delta S_{GBP/CHF}$) as well as for the SMI (%ΔSMI). This allows her to calculate the monthly returns of an unhedged investment in the SMI with these unhedged returns measured in the "domestic" currency, the GBP:

$$R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1$$

where R_{FC} = %ΔSMI and $R_{FX} = \%\Delta S_{GBP/CHF}$. Because McYelland wants to minimize the variance of these unhedged domestic-currency returns, she calculates the minimum-variance hedge ratio with the following OLS regression:

$$R_{DC} = \alpha + \beta(\%\Delta S_{GBP/CHF}) + \varepsilon$$

The calculated regression coefficients show that $\hat{\alpha} = -0.21$ and $\hat{\beta} = 1.35$. McYelland interprets these results to mean that the estimated $\hat{\beta}$-coefficient is the minimum-variance hedge ratio. This conclusion makes sense because $\hat{\beta}$ represents the sensitivity of the domestic-currency return on the portfolio to percentage changes in the spot rate. In this case, the return on the SMI seems very sensitive to the appreciation of the CHF. Indeed, over the 10 years of data she collected, McYelland notices that the correlation between %ΔSMI and $\%\Delta S_{GBP/CHF}$ is equal to +0.6.

On the basis of these calculations, she recommends that the minimum-variance hedge ratio for Kilmarnock Capital's exposure to the SMI be set at approximately 135%. This recommendation means that a *long* CHF1,000,000 exposure to the SMI should be hedged with a *short* position in CHF against the GBP of approximately CHF1,350,000. Because forward contracts in professional FX markets are quoted in terms of CHF/GBP for this currency pair, this would mean a *long* position in the forward contract ($F_{CHF/GBP}$)—that is, *selling* the CHF means *buying* the base currency GBP.

McYelland cautions the Investment Committee at Kilmarnock Capital that this minimum-variance hedge ratio is only approximate and must be closely monitored because it is estimated over historical data that may not be representative of future price dynamics. For example, the +0.6 correlation estimated between %ΔSMI and $\%\Delta S_{GBP/CHF}$ is the 10-year *average* correlation; future market conditions may not correspond to this historical average.

6.5 Basic Intuitions for Using Currency Management Tools

This section has covered only some of the most common currency management tools and strategies used in FX markets—there are a great many other derivatives products and strategies that have not been covered. The key points are that there are *many* different hedging and active trading strategies, there are many possible *variations* within each of these strategies, and these strategies can be used in *combination* with each other. There is no need to cover all of what would be a very large number of possible permutations and combinations. Instead, we will close this section with a key thought: Each of these many approaches to either hedging or expressing a directional view on currency movements has its advantages and disadvantages, its risks, and its costs.

As a result, there is no single "correct" approach to initiating and managing currency exposures. Instead, at the strategic level, the IPS of the portfolio sets guidelines for risk exposures, permissible hedging tools, and strategies, which will vary among investors. At the tactical level, at which the portfolio manager has discretion on risk exposures, currency strategy will depend on the manager's management style, market view, and risk tolerance. It will also depend on the manager's perceptions of the relative costs and benefit of any given strategy. Market conditions will affect the cost/benefit calculations behind the hedging decision, as movements in forward points (expected roll yield) or exchange rate volatility (option premiums) affect the expected cost of the hedge; the same hedge structure can be "rich" or "cheap" depending on current market conditions.

Reflecting all of these considerations, different managers will likely make different decisions when confronted with the same opportunity set; and each manager will likely have a good reason for their individual decision. The most important point is that the portfolio manager be aware of all the benefits, costs, and risks of the chosen strategy and be comfortable that any remaining residual currency risks in the hedge are acceptable.

To summarize the key insights of Section 6—and continuing our example of a portfolio manager who is long the base currency in the P/B quote and wants to hedge that price risk—the manager needs to understand the following:

1 Because the portfolio has a *long* exposure to base currency, to neutralize this risk the hedge will attempt to build a *short* exposure out of that currency's derivatives using some combination of forward and/or option contracts.

2 A currency hedge is not a free good, particularly a complete hedge. The hedge cost, real or implied, will consist of some combination of lost upside potential, potentially negative roll yield (forward points at a discount or time decay on long option positions), and upfront payments of option premiums.

3 The cost of any given hedge structure will vary depending on market conditions (i.e., forward points and implied volatility).

4 The cost of the hedge is focused on its "core." For a manager with a long exposure to a currency, the cost of this "core" hedge will be the implicit costs of a short position in a forward contract (no upside potential, possible negative roll yield) or the upfront premium on a long position in a put option. Either of these two forms of insurance can be expensive. However, there are various cost mitigation methods that can be used alone or in combination to reduce these core hedging costs:

   a Writing options to gain upfront premiums.

   b Varying the strike prices of the options written or bought.

   c Varying the notional amounts of the derivative contracts.

   d Using various "exotic" features, such as knock-ins or knock-outs.

5 There is nothing inherently wrong with any of these cost mitigation approaches—but the manager *must* understand that these invariably involve some combination of reduced upside potential and/or reduced downside protection. A reduced cost (or even a zero-cost) hedge structure is perfectly acceptable, but only as long as the portfolio manager fully understands all of the residual risks in the hedge structure and is prepared to accept and manage them.

6 There are often "natural" hedges within the portfolio, in which some residual risk exposures are uncorrelated with each other and offer portfolio diversification effects. Cross hedges and macro hedges bring basis risk into the portfolio, which will have to be monitored and managed.

7 There is no single or "best" way to hedge currency risk. The portfolio manager will have to perform a due diligence examination of potential hedge structures and make a rational decision on a cost/benefit basis.

EXAMPLE 8

Hedging Strategies

Ireland-based Old Galway Capital runs several investment trusts for its clients. Fiona Doyle has just finished rebalancing the dynamic currency hedge for Overseas Investment Trust III, which has an IPS mandate to be fully hedged using forward contracts. Shortly after the rebalancing, Old Galway receives notice that one of its largest investors in the Overseas Investment Trust III has served notice of a large withdrawal from the fund.

Padma Bhattathiri works at Malabar Coast Capital, an India-based investment company. Her mandate is to seek out any alpha opportunities in global FX markets and aggressively manage these for speculative profit. The Reserve Bank of New Zealand (RBNZ) is New Zealand's central bank, and is scheduled to announce its policy rate decision within the week. The consensus forecast among economists is that the RBNZ will leave rates unchanged, but Bhattathiri believes that the RBNZ will surprise the markets with a rate hike.

Jasmine Khan, analyst at UK-based Brixworth & St. Ives Asset Management, has been instructed by the management team to reduce hedging costs for the firm's Aggressive Growth Fund, and that more currency exposure—both downside risk and upside potential—will have to be accepted and managed. Currently, the fund's ZAR-denominated foreign-currency asset exposures are being hedged with a 25-delta risk reversal (on the ZAR/GBP cross rate). The current ZAR/GBP spot rate is 13.1350.

Bao Zhang is a market analyst at South Korea–based Kwangju Capital, an investment firm that offers several actively managed investment trusts for its clients. She notices that the exchange rate for the Philippines Peso (PHP/USD) is increasing (PHP is depreciating) toward its 200-day moving average located in the 42.2500 area (the current spot rate is 42.2475). She mentions this to Akiko Takahashi, a portfolio manager for one of the firm's investment vehicles. Takahashi's view, based on studying economic fundamentals, is that the PHP/USD rate should continue to increase, but after speaking with Zhang she is less sure. After further conversation, Zhang and Takahashi come to the view that the PHP/USD spot rate will either break through the 42.2500 level and gain upward momentum through the 42.2600 level, or stall at the 42.2500 level and then drop down through the 42.2400 level as frustrated long positions exit the market. They decide that either scenario has equal probability over the next month.

Annie McYelland is an analyst at Scotland-based Kilmarnock Capital. The firm is considering a USD10,000,000 investment in an S&P 500 Index fund. McYelland is asked to calculate the minimum-variance hedge ratio. She collects the following statistics based on 10 years of monthly data:

$\sigma(\%\Delta S_{GBP/USD})$	$\sigma(R_{DC})$	$\rho(R_{DC};\%\Delta S_{GBP/USD})$
2.7%	4.4%	0.2

Source: Data are from Bloomberg.

1 Given the sudden liquidity need announced, Doyle's *best* course of action with regard to the currency hedge is to:
   A do nothing.
   B reduce the hedge ratio.
   C over-hedge by using currency options.
2 Given her market view, Bhattathiri would *most likely* choose which of the following long positions?
   A 5-delta put option on NZD/AUD
   B 10-delta put option on USD/NZD
   C Put spread on JPY/NZD using 10-delta and 25-delta options
3 Among the following, replacing the current risk reversal hedge with a long position in which of the following would *best* meet Khan's instructions? (All use the ZAR/GBP.)
   A 10-delta risk reversal
   B Put option with a 13.1300 strike
   C Call option with a 13.1350 strike
4 Which of the following positions would *best* implement Zhang's and Takahashi's market view?
   A Long a 42.2450 put and long a 42.2550 call
   B Long a 42.2450 put and short a 42.2400 put
   C Long a 42.2450 put and short a 42.2550 call
5 Which of the following positions would *best* implement Kilmarnock Capital's minimum-variance hedge?
   A Long a USD/GBP forward contract with a notional size of USD1.2 million
   B Long a USD/GBP forward contract with a notional size of USD3.3 million
   C Short a USD/GBP forward contract with a notional size of USD2.0 million

Solution to 1:

A is correct. After rebalancing, the Overseas Investment Trust III is fully hedged; currency risk is at a minimum, which is desirable if liquidity needs have increased. Choices B and C are incorrect because they increase the currency risk exposures.

Solution to 2:

A is correct. The surprise rate hike should cause the NZD to appreciate against most currencies. This appreciation would mean a depreciation of the NZD/AUD rate, which a put option can profit from. A 5-delta option is deep-OTM, but the price reaction on the option premiums will be more extreme than a higher-delta option. That is to say, the *percentage* change in the premiums for a 5-delta option for a given percentage change in the spot exchange rate will be higher than the percentage change in premiums for a 25-delta option. In a sense, a very low delta option is like a highly leveraged lottery ticket on the event occurring. With a surprise rate hike, the odds would swing in Bhattathiri's favor. Choice B is incorrect because the price reaction in the USD/NZD spot rate after the surprise rate hike would likely cause the NZD to appreciate; so Bhattathiri would want a call option on the USD/NZD currency pair. Choice C is incorrect because an appreciation of the NZD after the surprise rate hike would best be captured by a call spread on the JPY/NZD rate, which will likely increase (the NZD is the base currency).

Solution to 3:

A is correct. Moving to a 10-delta risk reversal will be cheaper (these options are deeper-OTM than 25-delta options) and widen the bands in the corridor being created for the ZAR/GBP rate. Choice B is incorrect because a long put provides no protection against an upside movement in the ZAR/GBP rate, which Brixworth & St. Ives is trying to hedge (recall that the fund is long ZAR in its foreign-currency asset exposure and hence needs to sell ZAR/buy GBP to hedge). Also, if Brixworth & St. Ives exercises the option, they would "put" GBP to the counterparty at the strike price and receive ZAR in return. Although this option position may be considered profitable in its own right, it nonetheless causes the firm to double-up its ZAR exposure. Choice C is incorrect because although an ATM call option on ZAR/GBP will provide complete hedge protection, it will be expensive and clearly more expensive than the current 25-delta risk reversal.

Solution to 4:

A is correct. Zhang's and Takahashi's market view is that, over the next month, a move in PHP/USD to either 42.2400 or 42.2600 is equally likely. A strangle would express this view of heightened volatility but without a directional bias, and would require a long put and a long call positions. Choice B is incorrect because it is a put spread; it will profit by a move in PHP/USD between 42.2450 and 42.2400. If it moves below 42.2400 the short put gets exercised by the counterparty and neutralizes the long put. Although less costly than an outright long put position, this structure is not positioned to profit from a move higher in PHP/USD. Choice C is incorrect because it is a short risk reversal position. It provides relatively cheap protection for a down-move in PHP/USD but is not positioned to profit from an up-move in PHP/USD.

Solution to 5:

B is correct. The formula for the minimum-variance hedge ratio (h) is:

$$h = \rho(R_{DC};R_{FX}) \times \left[\frac{\sigma(R_{DC})}{\sigma(R_{FX})}\right]$$

After inputting the data from the table, this equation solves to 0.33. This means that for a USD10 million investment in the S&P 500 (long position), Kilmarnock Capital would want to be *short* approximately USD3.3 million in a forward contract. Because the standard market quote for this currency pair is USD/GBP, to be short the USD means one would have to buy the GBP; that is, a *long* position in a USD/GBP forward contract. Choice A is incorrect because it inverts the ratio in the formula. Choice C is incorrect because it shows a short position in the USD/GBP forward, and because it only uses the correlation to set the contract size.

7 CURRENCY MANAGEMENT FOR EMERGING MARKET CURRENCIES

Most of the material in this reading has focused on what might be described as the major currencies, such as the EUR, GBP, or JPY. This focus is not a coincidence: The vast majority of daily flow in global FX markets is accounted for by the top half dozen currencies. Moreover, the vast majority of investable assets globally, as measured by market capitalization, are denominated in the major currencies. Nonetheless, more investors are looking at emerging markets, as well as "frontier markets," for potential investment opportunities. And many developing economies are beginning to emerge as major forces in the global economy. In the following sections, we survey the challenges for currency management and the use of non-deliverable forwards as one tool to address them.

7.1 Special Considerations in Managing Emerging Market Currency Exposures

Managing emerging market currency exposure involves unique challenges. Perhaps the two most important considerations are (1) higher trading costs than the major currencies under "normal" market conditions, and (2) the increased likelihood of extreme market events and severe illiquidity under stressed market conditions.

Many emerging market currencies are thinly traded, causing higher transaction costs (bid–offer spreads). There may also be fewer derivatives products to choose from, especially exchange-traded products. Although many global investment banks will quote spot rates and OTC derivatives for almost any conceivable currency pair, many of these are often seen as "specialty" products and often come with relatively high mark-ups. This mark-up increases trading and hedging costs. (In addition, the underlying foreign-currency asset in emerging markets can be illiquid and lack the full array of derivatives products.)

These higher currency trading costs would especially be the case for "crosses" in these currency pairs. For example, there is no reason why an investor in Chile (which uses the Chilean peso, currency code CLP) could not have an investment in assets denominated in the Thai baht (THB). But the CLP/THB cross is likely to be very thinly traded; there simply are not enough trade or capital flows between these two countries. Typically, any trade between these two currencies would go through a major intermediary currency, usually the USD. Hence, the trade would be broken into two legs: a trade in the CLP/USD pair and another in the THB/USD pair. These trades might go through different traders or trading desks at the same bank; or perhaps one leg of the trade would be done at one bank and the other leg through a different bank. There may also be time zone issues affecting liquidity; one leg of the trade may be relatively liquid at the same time as the other leg of the trade may be more thinly traded. The reason is because liquidity in most emerging market currencies is typically deepest in their domestic time zones. In any event, there are two bid–offer spreads—one for each leg of the trade—to be covered. This is often the case for many of the cross-rate currency pairs among developed market currencies as well. However, the bid–offer spreads are usually tighter for major currency pairs.

The liquidity issue is especially important when trades in these less-liquid currencies get "crowded," for example, through an excessive build-up of carry trades or through a fad-like popularity among investors for investing in a particular region or trading theme. Trades can be much easier to gradually enter into than to quickly exit, particularly under stressed market conditions. For example, after a long period of slow build-up, carry trades into these currencies can occasionally be subject to panicked unwinds as market conditions suddenly turn. This situation typically causes market liquidity to evaporate and leaves traders locked into positions that continue to accumulate losses.

The investment return probability distributions for currency (and other) trades subject to such relatively frequent extreme events have fatter tails than the normal distribution as well as a pronounced negative skew. Risk measurement and control tools (such as value at risk, or VaR) that depend on normal distributions can be misleading under these circumstances and greatly understate the risks the portfolio is actually exposed to. Many investment performance measures are also based on the normal distribution. Historical investment performance measured by such indexes as the Sharpe ratio can look very attractive during times of relative tranquility; but this seeming outperformance can disappear into deep losses faster than most investors can react (investors typically do a poor job of timing crises). As mentioned in the prior section on volatility trading, price volatility in financial markets is very cyclical and implied volatility can be subject to sharp spikes. These volatility spikes can severely affect both option prices and hedging strategies based on options. Even if the initial option protection is in place, it will eventually have to be rolled as options expire—but then at much higher prices for the option buyer.

The occurrence of currency crises can also affect hedging strategies based on forward contracts. Recall that hedging a long exposure to a foreign currency typically involves selling the foreign currency forward. However, when currencies are under severe downward pressure, central banks often react by hiking the policy rate to support the domestic currency. But recall that the higher interest rates go in a country, then, all else equal, the deeper the forward discount for its currency (enforced by the arbitrage conditions of covered interest rate parity). Having to sell the currency forward at increasingly deep discounts will cause losses through negative roll yield and undermine the cost effectiveness of the hedging program.

Extreme price movements in financial markets can also undermine many hedging strategies based on presumed diversification. Crises not only affect the volatility in asset prices but also their correlations, primarily through "contagion" effects. The history of financial markets (circa 2012) has been characterized by a "risk-on, risk-off" environment dominated by swings in investor sentiment between speculative enthusiasm and pronounced flight-to-safety flows. In the process, there is often little differentiation between individual currencies, which tend to get traded together in broader baskets (such as "haven currencies"—USD, JPY, and CHF—and "commodity currencies"—AUD, NZD, and ZAR). Investors who may have believed that they had diversified their portfolio through a broad array of exposures in emerging markets may find instead in crises that they doubled-up their currency exposures. (Likewise, there can be correlated and extreme movements in the underlying assets of these foreign-currency exposures.)

Another potential factor affecting currency management in these "exotic" markets is government involvement in setting the exchange rate through such measures as foreign exchange market intervention, capital controls, and pegged (or at least tightly managed) exchange rates. These measures too can lead to occasional extreme events in markets; for example, when central banks intervene or when currency pegs change or get broken. Short-term stability in these government-influenced markets can lull traders into a false sense of overconfidence and over-positioning. When currency pegs break, the break can happen quickly. Assuming that investment returns will be normally distributed according to parameters estimated on recent historical data, or that correlation factors and liquidity will not change suddenly, can be lethal.

It bears noting that currency crises and government involvement in FX markets is not limited to emerging market currencies, but often occur among the major currencies as well. The central banks of major currencies will, on occasion, intervene in their own currencies or use other polices (such as sharp movements in policy rates) to influence exchange rate levels. These too can lead to extreme events in currency markets.

7.2 Non-Deliverable Forwards

Currencies of many emerging market countries trade with some form of capital controls. Where capital controls exist and delivery in the controlled currency is limited by the local government, it is often possible to use what are known as **non-deliverable forwards** (NDFs). These are similar to regular forward contracts, but they are cash settled (in the non-controlled currency of the currency pair) rather than physically settled (the controlled currency is neither delivered nor received). The non-controlled currency for NDFs is usually the USD or some other major currency. A partial list of some of the most important currencies with NDFs would include the Chinese yuan (CNY), Korean won (KRW), Russian ruble (RUB), Indian rupee (INR), and Brazilian real (BRL). The NDF is essentially a cash-settled "bet" on the movement in the spot rate of these currencies.

For example, a trader could enter into a long position in a three-month NDF for the BRL/USD. Note that the BRL—the currency with capital controls—is the price currency and the base currency, the USD, is the currency that settlement of the NDF will be made in. Assume that the current all-in rate for the NDF is 2.0280 and the trader uses an NDF with a notional size of USD1,000,000. Suppose that three months later the BRL/USD spot rate is 2.0300 and the trader closes out the existing NDF contract with an equal and offsetting spot transaction at this rate. Settlement proceeds by noting that the USD amounts net to zero (USD1,000,000 both bought and sold on settlement date), so the net cash flow generated would normally be in BRL if this was an ordinary forward contract. The net cash flow to the long position in this case would be calculated as

$$(2.0300 - 2.0280) \times 1{,}000{,}000 = \text{BRL}2{,}000$$

But with an NDF, there is no delivery in the controlled currency (hence the name *non-deliverable* forward). Settlement must be in USD, so this BRL amount is converted to USD at the then-current spot rate of 2.0300. This leads to a USD cash inflow for the long position in the NDF of

$$\text{BRL}2{,}000 \div 2.0300 \text{ BRL/USD} = \text{USD}985.22$$

The credit risk of an NDF is typically lower than for the outright forward because the principal sums in the NDF do not move, unlike with an outright "vanilla" forward contract. For example, in the illustration the cash pay-off to the "bet" was the relatively small amount of USD985.22—there was no delivery of USD1,000,000 against receipt of BRL2,028,000. Conversely, as noted previously, NDFs exist because of some form of government involvement in foreign exchange markets. Sudden changes in government policy can lead to sharp movements in spot and NDF rates, often reversing any investment gains earned during long periods of seeming (but artificial) market calm. The implicit market risk of the NDF embodies an element of "tail risk."

Finally, we note that when capital controls exist, the free cross-border flow of capital that enforces the arbitrage condition underlying covered interest rate parity no longer functions consistently. Therefore, the pricing on NDFs need not be exactly in accord with the covered interest rate parity theorem. Instead, NDF pricing will reflect the individual supply and demand conditions (and risk premia) in the offshore market, which need not be the same as the onshore market of the specific emerging market country. Some of the most active participants in the NDF market are offshore hedge funds and proprietary traders making directional bets on the emerging market currency, rather than corporate or institutional portfolio managers hedging currency exposures. Volatility in the net speculative demand for emerging market exposure can affect the level of forward points. We also note that the type and strictness of capital controls can vary among emerging markets; hence, the need for knowledge of local market regulations is another factor influencing currency risk management in these markets.

SUMMARY

In this reading, we have examined the basic principles of managing foreign exchange risk within the broader investment process. International financial markets create a wide range of opportunities for investors, but they also create the need to recognize, measure, and control exchange rate risk. The management of this risk starts with setting the overall mandate for the portfolio, encoding the investors' investment objectives and constraints into the investment policy statement and providing strategic guidance on how currency risk will be managed in the portfolio. It extends to tactical positioning when portfolio managers translate market views into specific trading strategies within the overall risk management guidelines set by the IPS. We have examined some of these trading strategies, and how a range of portfolio management tools—positions in spot, forward, option, and FX swap contracts—can be used either to hedge away currency risk, or to express a market opinion on future exchange rate movements.

What we have emphasized throughout this reading is that there is no simple or single answer for the "best" currency management strategies. Different investors will have different strategic mandates (IPS), and different portfolio managers will have different market opinions and risk tolerances. There is a near-infinite number of possible currency trading strategies, each with its own benefits, costs, and risks. Currency risk management—both at the strategic and tactical levels—means having to manage the trade-offs between all of these various considerations.

Some of the main points covered in this reading are as follows:

- In professional FX markets, currencies are identified by standard three-letter codes, and quoted in terms of a price and a base currency (P/B).
- The spot exchange rate is typically for $T + 2$ delivery, and forward rates are for delivery for later periods. Both spot and forward rates are quoted in terms of a bid–offer price. Forward rates are quoted in terms of the spot rate plus forward points.
- An FX swap is a simultaneous spot and forward transaction; one leg of the swap is buying the base currency and the other is selling it. FX swaps are used to renew outstanding forward contracts once they mature, to "roll them forward."
- The domestic-currency return on foreign-currency assets can be broken into the foreign-currency asset return and the return on the foreign currency (the percentage appreciation or depreciation of the foreign currency against the domestic currency). These two components of the domestic-currency return are multiplicative.
- When there are several foreign-currency assets, the portfolio domestic-currency return is the weighted average of the individual domestic-currency returns (i.e., using the portfolio weights, which should sum to one)
- The risk of domestic-currency returns (its standard deviation) can be approximated by using a variance formula that recognizes the individual variances and covariances (correlations) among the foreign-currency asset returns and exchange rate movements.

- The calculation of the domestic-currency risk involves a large number of variables that must be estimated: the risks and correlations between all of the foreign-currency asset returns and their exchange rate risks.
- Guidance on where to target the portfolio along the risk spectrum is part of the IPS, which makes this a *strategic* decision based on the investment goals and constraints of the beneficial owners of the portfolio.
- If the IPS allows currency risk in the portfolio, the amount of desired currency exposure will depend on both portfolio diversification considerations and cost considerations.
  - Views on the diversifying effects of foreign-currency exposures depend on the time horizon involved, the type of foreign-currency asset, and market conditions.
  - Cost considerations also affect the hedging decision. Hedging is not free: It has both direct transactional costs as well as opportunity costs (the potential for favorable outcomes is foregone). Cost considerations make a perfect hedge difficult to maintain.
- Currency management strategies can be located along a spectrum stretching from:
  - passive, rules-based, complete hedging of currency exposures;
  - discretionary hedging, which allows the portfolio manager some latitude on managing currency exposures;
  - active currency management, which seeks out currency risk in order to manage it for profit; and to
  - currency overlay programs that aggressively manage currency "alpha."
- There are a variety of methods for forming market views.
  - The use of macroeconomic fundamentals to predict future currency movements is based on estimating the "fair value" for a currency with the expectation that spot rates will eventually converge on this equilibrium value.
  - Technical market indicators assume that, based on market psychology, historical price patterns in the data have a tendency to repeat. Technical indicators can be used to predict support and resistance levels in the market, as well as to confirm market trends and turning points.
  - The carry trade is based on violations of uncovered interest rate parity, and is also based on selling low-yield currencies in order to invest in high-yield currencies. This approach is equivalent to trading the forward rate bias, which means selling currencies trading at a forward premium and buying currencies trading at a forward discount.
  - Volatility trading uses the option market to express views on the distribution of future exchange rates, not their levels.
- Passive hedging will typically use forward contracts (rather than futures contracts) because they are more flexible. However, currency futures contracts are an option for smaller trading sizes and are frequently used in private wealth management.
- Forward contracts have the possibility of negative roll yield (the forward points embedded in the forward price can work for or against the hedge). The portfolio manager will have to balance the advantages and costs of hedging with forward contracts.
- Foreign-currency options can reduce opportunity costs (they allow the upside potential for favorable foreign-currency movements). However, the upfront option premiums must be paid.

- There are a variety of means to reduce the cost of the hedging with either forward or option contracts, but these cost-reduction measures always involve some combination of less downside protection and/or less upside potential.
- Hedging multiple foreign currencies uses the same tools and strategies used in hedging a single foreign-currency exposure; except now the correlation between residual currency exposures in the portfolio should be considered.
- Cross hedges introduce basis risk into the portfolio, which is the risk that the correlation between exposure and its cross hedging instrument may change in unexpected ways. Forward contracts typically have very little basis risk compared with movements in the underlying spot rate.
- The number of trading strategies that can be used, for hedging or speculative purposes, either for a single foreign currency or multiple foreign currencies, is near infinite. The manager must assess the costs, benefits, and risks of each in the context of the investment goals and constraints of the portfolio. There is no single "correct" approach.

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PRACTICE PROBLEMS

The following information relates to Questions 1–9

Kamala Gupta, a currency management consultant, is hired to evaluate the performance of two portfolios. Portfolio A and Portfolio B are managed in the United States and performance is measured in terms of the US dollar (USD). Portfolio A consists of British pound (GBP) denominated bonds and Portfolio B holds euro (EUR) denominated bonds.

Gupta calculates a 19.5% domestic-currency return for Portfolio A and 0% domestic-currency return for Portfolio B.

1 **Analyze** the movement of the USD against the foreign currency for Portfolio A. **Justify** your choice.

Template for Question 1

Asset	Foreign-Currency Portfolio Return	USD Relative to Foreign-Currency (circle one)
Portfolio A	15%	appreciated depreciated

Justification

2 **Analyze** the foreign-currency return for Portfolio B. **Justify** your choice.

Template for Question 2

Asset	Percentage Movement in the Spot Exchange Rate	Foreign-Currency Portfolio Return (circle one)
Portfolio B	EUR appreciated 5% against the USD	positive negative

(Continued)

Justification

The fund manager of Portfolio B is evaluating an internally-managed 100% foreign-currency hedged strategy.

3 **Discuss** *two* forms of trading costs associated with this currency management strategy.

Gupta tells the fund manager of Portfolio B:

> "We need to seriously consider the potential costs associated with favorable currency rate movements, given that a 100% hedge-ratio strategy is being applied to this portfolio."

4 **Explain** Gupta's statement in light of the strategic choices in currency management available to the portfolio manager.

The investment policy statement (IPS) for Portfolio A provides the manager with discretionary authority to take directional views on future currency movements. The fund manager believes the foreign currency assets of the portfolio could be fully hedged internally. However, the manager also believes existing firm personnel lack the expertise to actively manage foreign-currency movements to generate currency alpha.

5 **Recommend** a solution that will provide the fund manager the opportunity to earn currency alpha through active foreign exchange management.

Gupta and the fund manager of Portfolio A discuss the differences among several active currency management methods.

6 **Evaluate** each statement independently and select the active currency approach it *best* describes. **Justify** each choice.

Template for Question 6

Gupta's Statements	Active Currency Approach (circle one)	Justification
"Many traders believe that it is not necessary to examine factors like the current account deficit, inflation, and interest rates because current exchange rates already reflect the market view on how these factors will affect future exchange rates."	carry trade technical analysis economic fundamental	
"The six-month interest rate in India is 8% compared to 1% in the United States. This presents a yield pick-up opportunity."	carry trade technical analysis economic fundamental	
"The currency overlay manager will estimate the fair value of the currencies with the expectation that observed spot rates will converge to long-run equilibrium values described by parity conditions."	carry trade technical analysis economic fundamental	

The following information is used for Question 7

Gupta interviews a currency overlay manager on behalf of Portfolio A. The foreign currency overlay manager describes volatility-based trading, compares volatility-based trading strategies and explains how the firm uses currency options to establish positions in the foreign exchange market. The overlay manager states:

Statement 1 "Given the current stability in financial markets, several traders at our firm take advantage of the fact that most options expire out-of-the money and therefore are net-short volatility."

Statement 2 "Traders that want to minimize the impact of unanticipated price volatility are net-long volatility."

7 **Compare** Statement 1 and Statement 2 and **identify** which *best* explains the view of a speculative volatility trader and which best explains the view of a hedger of volatility. **Justify** your response.

The following information is used for Questions 8 and 9

The fund manager of Portfolio B believes that setting up a full currency hedge requires a simple matching of the *current* market value of the foreign-currency exposure in the portfolio with an equal and offsetting position in a forward contract.

8 **Explain** how the hedge, as described by the fund manager, will eventually expose the portfolio to currency risk.

9 **Recommend** an alternative hedging strategy that will keep the hedge ratio close to the target hedge ratio. **Identify** the main disadvantage of implementing such a strategy.

The following information relates to Questions 10–15

Guten Investments GmbH, based in Germany and using the EUR as its reporting currency, is an asset management firm providing investment services for local high net worth and institutional investors seeking international exposures. The firm invests in the Swiss, UK, and US markets, after conducting fundamental research in order to select individual investments. Exhibit 1 presents recent information for exchange rates in these foreign markets.

Exhibit 1 Exchange Rate Data

	One Year Ago	Today
Euro-dollar (USD/EUR)*	1.2730	1.2950
Euro-sterling (GBP/EUR)	0.7945	0.8050
Euro-Swiss (CHF/EUR)	1.2175	1.2080

* The amount of USD required to buy one EUR

In prior years, the correlation between movements in the foreign-currency asset returns for the USD-denominated assets and movements in the exchange rate was estimated to be +0.50. After analyzing global financial markets, Konstanze Ostermann, a portfolio manager at Guten Investments, now expects that this correlation will increase to +0.80, although her forecast for foreign-currency asset returns is unchanged.

Ostermann believes that currency markets are efficient and hence that long-run gains cannot be achieved from active currency management, especially after netting out management and transaction costs. She uses this philosophy to guide hedging decisions for her discretionary accounts, unless instructed otherwise by the client.

Ostermann is aware, however, that some investors hold an alternative view on the merits of active currency management. Accordingly, their portfolios have different investment guidelines. For these accounts, Guten Investments employs a currency specialist firm, Umlauf Management, to provide currency overlay programs specific to each client's investment objectives. For most hedging strategies, Umlauf Management develops a market view based on underlying fundamentals in exchange rates. However, when directed by clients, Umlauf Management uses options and a variety of trading strategies to unbundle all of the various risk factors (the "Greeks") and trade them separately.

Ostermann conducts an annual review for three of her clients and gathers the summary information presented in Exhibit 2.

Exhibit 2 Select Clients at Guten Investments

Client	Currency Management Objectives
Adele Kastner – A high net worth individual with a low risk tolerance.	Keep the portfolio's currency exposures close, if not equal to, the benchmark so that the domestic-currency return is equal to the foreign-currency return.
Braunt Pensionskasse – A large private-company pension fund with a moderate risk tolerance.	Limited discretion which allows the actual portfolio currency risk exposures to vary plus-or-minus 5% from the neutral position.
Franz Trading GmbH – An exporting company with a high risk tolerance.	Discretion with respect to currency exposure is allowed in order to add alpha to the portfolio.

10 Based on Exhibit 1, the domestic-currency return over the last year (measured in EUR terms) was *higher* than the foreign-currency return for:

A USD-denominated assets.

B GBP-denominated assets.

C CHF-denominated assets.

11 Based on Ostermann's correlation forecast, the expected domestic-currency return (measured in EUR terms) on USD-denominated assets will *most* likely:

A increase.

B decrease.

C remain unchanged.

12 Based on Ostermann's views regarding active currency management, the percentage of currency exposure in her discretionary accounts that is hedged is *most likely:*

A 0%.

B 50%.

C 100%.

13 The active currency management approach that Umlauf Management is *least* likely to employ is based on:

A volatility trading.

B technical analysis.

C economic fundamentals.

14 Based on Exhibit 2, the currency overlay program *most* appropriate for Braunt Pensionskasse would:

A be fully passive.

B allow limited directional views.

C actively manage foreign exchange as an asset class.

15 Based on Exhibit 2, the client *most likely* to benefit from the introduction of an additional overlay manager is:

A Adele Kastner.

B Braunt Pensionskasse.

C Franz Trading GmbH.

The following information relates to Questions 16–19

Li Jiang is an international economist operating a subscription website through which she offers financial advice on currency issues to retail investors. One morning she receives four subscriber e-mails seeking guidance.

Subscriber 1	"As a French national now working in the United States, I hold US dollar-denominated assets currently valued at USD 700,000. The USD/EUR exchange rate has been quite volatile and now appears oversold based on historical price trends. With my American job ending soon, I will return to Europe. I want to protect the value of my USD holdings, measured in EUR terms, before I repatriate these funds back to France. To reduce my currency exposure I am going to use currency futures contracts. Can you explain the factors most relevant to implementing this strategy?"
Subscriber 2	"I have observed that many of the overseas markets for Korean export goods are slowing, while the United States is experiencing a rise in exports. Both trends can combine to possibly affect the value of the won (KRW) relative to the US dollar. As a result, I am considering a speculative currency trade on the KRW/USD exchange rate. I also expect the volatility in this exchange rate to increase."
Subscriber 3	"India has relatively high interest rates compared to the United States and my market view is that this situation is likely to persist. As a retail investor actively trading currencies, I am considering borrowing in USD and converting to the Indian rupee (INR). I then intend to invest these funds in INR-denominated bonds, but without using a currency hedge."
Subscriber 4	"I was wondering if trading in emerging market currencies provides the more opportunities for superior returns through active management than trading in Developed Market currencies."

16 For Subscriber 1, the *most* significant factor to consider would be:

- **A** margin requirements.
- **B** transaction costs of using futures contracts.
- **C** different quoting conventions for future contracts.

17 For Subscriber 2, and assuming all of the choices relate to the KRW/USD exchange rate, the *best* way to implement the trading strategy would be to:

- **A** write a straddle.
- **B** buy a put option.
- **C** use a long NDF position.

18 Which of the following market developments would be *most* favorable for Subscriber 3's trading plan?

- **A** A narrower interest rate differential.
- **B** A higher forward premium for INR/USD.
- **C** Higher volatility in INR/USD spot rate movements.

19 Jiang's *best* response to Subscriber 4 would be that active trading in trading in emerging market currencies:

- **A** typically leads to return distributions that are positively skewed.
- **B** should not lead to higher returns because FX markets are efficient.
- **C** often leads to higher returns through carry trades, but comes with higher risks and trading costs.

The following information relates to Questions 20–23

Rika Björk runs the currency overlay program at a large Scandinavian investment fund, which uses the Swedish krona (SEK) as its reporting currency. She is managing the fund's exposure to GBP-denominated assets, which are currently hedged with a GBP 100,000,000 forward contract (on the SEK/GBP cross rate, which is currently at 10.6875 spot). The maturity for the forward contract is December 1, which is still several months away. However, since the contract was initiated the value of the fund's assets has declined by GBP 7,000,000. As a result, Björk wants to rebalance the hedge immediately.

Next Björk turns her attention to the fund's Swiss franc (CHF) exposures. In order to maintain some profit potential Björk wants to hedge the exposure using a currency option, but at the same time, she wants to reduce hedging costs. She believes that there is limited upside for the SEK/CHF cross rate.

Björk then examines the fund's EUR-denominated exposures. Due to recent monetary tightening by the Riksbank (the Swedish central bank) forward points for the SEK/EUR rate have swung to a premium. The fund's EUR-denominated exposures are hedged with forward contracts.

Finally Björk turns her attention to the fund's currency exposures in several emerging markets. The fund has large positions in several Latin American bond markets, but Björk does not feel that there is sufficient liquidity in the related foreign exchange derivatives to easily hedge the fund's Latin American bond markets exposures. However, the exchange rates for these countries, measured against the SEK, are correlated with the MXN/SEK exchange rate. (The MXN is the Mexican peso, which is considered to be among the most liquid Latin American currencies). Björk considers using forward positions in the MXN to cross-hedge the fund's Latin American currency exposures.

20 To rebalance the SEK/GBP hedge, and assuming all instruments are based on SEK/GBP, Björk would buy:

A GBP 7,000,000 spot.

B GBP 7,000,000 forward to December 1.

C SEK 74,812,500 forward to December 1.

21 Given her investment goals and market view, and assuming all options are based on SEK/CHF, the *best* strategy for Björk to manage the fund's CHF exposure would be to buy an:

A ATM call option.

B ITM call option and write an OTM call option.

C OTM put option and write an OTM call option.

22 Given the recent movement in the forward premium for the SEK/EUR rate, Björk can expect that the hedge will experience higher:

A basis risk.

B roll yield.

C premia income.

23 The *most* important risk to Björk's Latin American currency hedge would be changes in:

A forward points.

B exchange rate volatility.

C cross-currency correlations.

The following information relates to Question 24

Kalila Al-Khalili has been hired as a consultant to a Middle Eastern sovereign wealth fund. The fund's oversight committee has asked her to examine the fund's financial characteristics and recommend an appropriate currency management strategy given the fund's Investment Policy Statement. After a thorough study of the fund and its finances, Al-Khalili reaches the following conclusions:

- The fund's mandate is focused on the long-term development of the country, and the royal family (who are very influential on the fund's oversight committee) are prepared to take a long-term perspective on the fund's investments.
- The fund's strategic asset allocation is tilted towards equity rather than fixed-income assets.
- Both its fixed-income and equity portfolios have a sizeable exposure to emerging market assets.

- Currently, about 90% of exchange rate exposures are hedged although the IPS allows a range of hedge ratios.
- Liquidity needs of the fund are minimal, since the government is running a balanced budget and is unlikely to need to dip into the fund in the near term to cover fiscal deficits. Indeed, the expected lifetime of country's large oil reserves has been greatly extended by recent discoveries, and substantial oil royalties are expected to persist into the future.

24 Based on her investigation, Al-Khalili would *most* likely recommend:

A active currency management.

B a hedging ratio closer to 100%.

C a narrow discretionary band for currency exposures.

SOLUTIONS

1

Template for Question 1

Asset	Foreign-Currency Portfolio Return	USD Relative to Foreign-Currency (circle one)
Portfolio A	**15%**	appreciated
		depreciated

Justification

The 19.5% domestic-currency return for Portfolio A is higher than the 15% foreign-currency portfolio return in GBP; therefore, the USD necessarily depreciated relative to the GBP.

The domestic-currency return on a foreign portfolio will reflect both the foreign-currency return on the portfolio and the percentage movements in the spot exchange rate between the domestic and foreign currency. The domestic-currency return is multiplicative with respect to these two factors:

$$R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1$$

where R_{DC} is the domestic-currency return (in percent), R_{FC} is the foreign-currency return of the asset (portfolio), and R_{FX} is the percentage change of the foreign currency against the domestic currency. (Note that in the R_{FX} expression the domestic currency—the USD in this case—is the price currency.)

Solving for R_{FX}: $(1 + 15\%)(1 + R_{FX}) - 1 = 19.50\%$; $R_{FX} = 3.91\%$

Thus, the USD depreciated relative to the GBP. That is, the GBP appreciated against the USD because R_{FX} is quoted in terms of USD/GBP, with the USD as the price currency and GBP as the base currency, and in this example R_{FX} is a positive number (3.91%).

2

Template for Question 2

Asset	Percentage Movement in the Spot Exchange Rate	Foreign-Currency Portfolio Return (circle one)
Portfolio B	EUR appreciated 5% against the USD	positive
		negative

Justification

The domestic-currency return for Portfolio B is 0%, and the EUR appreciated 5% against the USD; therefore, the foreign-currency return for Portfolio B is necessarily negative.

The domestic-currency return on a foreign portfolio will reflect both the foreign-currency return on the portfolio and the percentage movements in the spot exchange rate between the domestic and foreign currency. The domestic-currency return is multiplicative with respect to these two factors:

$$R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1$$

where R_{DC} is the domestic-currency return (in percent), R_{FC} is the foreign-currency return of the asset (portfolio), and R_{FX} is the percentage change of the foreign currency against the domestic currency. (Note that once again, the domestic currency—the USD—is the price currency in the USD/EUR quote for R_{FX}.)

Solving for R_{FC}: $(1 + R_{FC})(1 + 5\%) - 1 = 0\%$; $R_{FC} = -4.76\%$

3 Any *two* of the following four points is acceptable:

- Trading requires dealing on the bid/offer spread offered by dealers. Dealer profit margin is based on these spreads. Maintaining a 100% hedge will require frequent rebalancing of minor changes in currency movements and could prove to be expensive. "Churning" the hedge portfolio would progressively add to hedging costs and reduce the hedge's benefits.
- A long position in currency options involves an upfront payment. If the options expire out-of-the-money, this is an unrecoverable cost.
- Forward contracts have a maturity date and need to be "rolled" forward with an FX swap transaction to maintain the hedge. Rolling hedges typically generate cash inflows and outflows, based on movements in the spot rate as well as roll yield. Cash may have to be raised to settle the hedging transactions (increases the volatility in the organization's cash accounts). The management of these cash flow costs can accumulate and become a large portion of the portfolio's value, and they become more expensive for cash outflows as interest rates increase.
- Hedging requires maintaining the necessary administrative infrastructure for trading (personnel and technology systems). These overhead costs can become a significant portion of the overall costs of currency trading.

4 Optimal hedging decisions require balancing the benefits of hedging against the costs of hedging. Hedging costs come mainly in two forms: trading costs and opportunity costs. Gupta is referring to the opportunity cost of the 100% hedge strategy. The opportunity cost of the 100% hedge strategy for Portfolio B is the forgone opportunity of benefiting from favorable currency rate movements. Gupta is implying that accepting some currency risk has the potential to enhance portfolio return. A complete hedge eliminates this possibility.

5 A solution is to put in place a currency overlay program for active currency management. Because internal resources for active management are lacking, the fund manager would outsource currency exposure management to a sub-advisor that specializes in foreign exchange management. This approach would allow the fund manager of Portfolio A to separate the currency hedging function (currency beta), which can be done effectively internally, and the active currency management function (currency alpha) which can be managed externally by a foreign currency specialist.

6

Template for Question 6

Gupta's Statements	Active Currency Approach (circle one)	Justification
"Many traders believe that it is not necessary to examine factors like the current account deficit, inflation, and interest rates because current exchange rates already reflect the market view on how these factors will affect future exchange rates."	carry trade **technical analysis** economic fundamentals	Gupta is describing active currency management based on market technicals. Market technicians believe that in a liquid, freely-traded market the historical price data already incorporates all relevant information on future price movements. Technicians believe that it is not necessary to look outside the market at data like the current account deficit, inflation and interest rates because current exchange rates already reflect the market consensus view on how these factors will affect future exchange rates.
"The six-month interest rate in India is 8% compared to 1% in the United States. This presents a yield pick-up opportunity."	**carry trade** technical analysis economic fundamentals	Gupta is describing active currency management based on the carry trade. This strategy is implemented by borrowing in low-yield currencies (USD at 1%) and investing in high-yield currencies (INR at 8%).
"The currency overlay manager will estimate the fair value of the currencies with the expectation that observed spot rates will converge to long-run equilibrium values described by parity conditions."	carry trade technical analysis **economic fundamentals**	Gupta is describing active currency management based on economic fundamentals. This approach assumes that, in free markets, exchange rates are determined by logical economic relationships that can be modeled. A fundamentals-based approach estimates the "fair value" of the currency, with the expectation that observed spot rates will converge to long-run equilibrium values described by parity conditions.

7 Statements 1 and 2 compare differences between speculative volatility traders and hedgers of volatility. Statement 1 best explains the view of a speculative volatility trader. Speculative volatility traders often want to be net-short volatility, if they believe that market conditions will remains stable. The reason for this is that most options expire out-of-the money, and the option writer can then keep the option premium as a payment earned for accepting volatility risk. (Speculative volatility traders would want to be long volatility if they thought volatility was likely to increase.) Statement 2 best describes the view of a hedger of volatility. Most hedgers are net-long volatility since they want to buy protection from unanticipated price volatility. Buying currency risk protection generally means a long option position. This can be thought of as paying an insurance premium for protection against exchange rate volatility.

8 In practice, matching the *current* market value of the foreign-currency exposure in the portfolio with an equal and offsetting position in a forward contract is likely to be ineffective over time because the market value of foreign-currency assets will change with market conditions. A static hedge (i.e., an unchanging hedge) will tend to accumulate unwanted currency exposures as the value of

the foreign-currency assets change. This will result in a mismatch between the market value of the foreign-currency asset portfolio and the nominal size of the forward contract used for the currency hedge (resulting in currency risk). For this reason, the portfolio manager will generally need to implement a dynamic hedge by rebalancing the portfolio periodically.

9 The fund manager should implement a dynamic hedging approach. Dynamic hedging requires rebalancing the portfolio periodically. The rebalancing would require adjusting some combination of the size, number, and maturities of the foreign-currency contracts.

Although rebalancing a dynamic hedge will keep the actual hedge ratio close to the target hedge ratio, it has the disadvantage of increased transaction costs compared to a static hedge.

10 C is correct. The domestic-currency return is a function of the foreign-currency return and the percentage change of the foreign currency against the domestic currency. Mathematically, the domestic-currency return is expressed as:

$$R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1$$

where R_{DC} is the domestic-currency return (in percent), R_{FC} is the foreign-currency return, and R_{FX} is the percentage change of the foreign currency against the domestic currency. Note that this R_{FX} expression is calculated using the investor's domestic currency (the EUR in this case) as the *price* currency in the P/B quote. This is different than the market-standard currency quotes in Exhibit 1, where the EUR is the *base* currency in each of these quotes. Therefore, for the foreign currency (USD, GBP, or CHF) to *appreciate* against the EUR, the market-standard quote (USD/EUR, GBP/EUR, or CHF/EUR, respectively) must *decrease*; i.e. the EUR must depreciate.

The Euro-Swiss (CHF/EUR) is the only spot rate with a negative change (from 1.2175 to 1.2080), meaning the EUR depreciated against the CHF (the CHF/EUR rate decreased). Or put differently, the CHF appreciated against the EUR, adding to the EUR-denominated return for the German investor holding CHF-denominated assets. This would result in a higher domestic-currency return (R_{DC}), for the German investor, relative to the foreign-currency return (R_{FC}) for the CHF-denominated assets. Both the Euro-dollar (USD/EUR) and Euro-sterling (GBP/EUR) experienced a positive change in the spot rate, meaning the EUR appreciated against these two currencies (the USD/EUR rate and the GBP/EUR rate both increased). This would result in a lower domestic-currency return (R_{DC}) for the German investor relative to the foreign-currency return (R_{FC}) for the USD- and GBP-denominated assets.

A is incorrect because the Euro-dollar (USD/EUR) experienced a positive change in the spot rate, meaning the EUR appreciated against the USD (the USD/EUR rate increased). This would result in a lower domestic-currency (i.e. EUR-denominated) return relative to the foreign-currency return for the USD-denominated assets, since the USD has depreciated against the EUR.

B is incorrect because the Euro-sterling (GBP/EUR) experienced a positive change in the spot rate, meaning the EUR appreciated against the GPB (the GBP/EUR rate increased). This would result in a lower domestic-currency (i.e. EUR-denominated) return relative to the foreign-currency return for the GBP-denominated assets, since the GBP has depreciated against the EUR.

11 C is correct. An increase in the expected correlation between movements in the foreign-currency asset returns and movements in the spot exchange rates from 0.50 to 0.80 would increase the domestic-currency return *risk* but would not change the *level* of expected domestic-currency return. The domestic-currency return risk is a function of the foreign-currency return risk [$\sigma(R_{FC})$] the exchange rate risk [$\sigma(R_{FX})$] and the correlation between the foreign-currency returns and exchange rate movements. Mathematically, this is expressed as:

$$\sigma^2(R_{DC}) \approx \sigma^2(R_{FC}) + \sigma^2(R_{FX}) + 2\sigma(R_{FC})\sigma(R_{FX})\rho(R_{FC}R_{FX})$$

If the correlation increases from +0.50 to +0.80, then the *variance* of the expected domestic-currency return will increase—but this will not affect the *level* of the expected domestic-currency return (R_{DC}). Refer to the equation shown for the answer in Question 1 and note that Ostermann's expected R_{FC} has not changed. (Once again, note as well that R_{FX} is defined with the domestic currency as the price currency.)

A and B are incorrect. An increase in the expected correlation between movements in the foreign-currency asset returns and movements in the spot rates from 0.50 to 0.80 would increase the domestic-currency return risk but would not impact the expected domestic-currency return.

12 A is correct. Guten believes that, due to efficient currency markets, there should not be any long-run gains for speculating (or active management) in currencies, especially after netting out management and transaction costs. Therefore, both currency hedging and actively trading currencies represent a cost to the portfolio with little prospect of consistently positive active returns. Given a long investment horizon and few immediate liquidity needs, Guten is most likely to choose to forgo currency hedging and its associated costs.

B and C are incorrect because given a long investment horizon and little immediate liquidity needs, Guten is most likely to choose to forgo currency hedging and its associated costs. Guten believes that due to efficient currency markets there should not be any long-run gains when speculating in currencies, especially after netting out management and transaction costs.

13 B is correct. Umlauf develops a market view based on underlying fundamentals in exchange rates (an economic fundamental approach). When directed by clients, Umlauf uses options and a variety of trading strategies to *unbundle* all of the various risk factors and trades them separately (a volatility trading approach). A market technical approach would entail forming a market view based on technical analysis (i.e., a belief that historical prices incorporate all relevant information on future price movements and that such movements have a tendency to repeat).

A is incorrect because, in using options and a variety of trading strategies to *unbundle* all of the various risk factors and trade them separately, Umlauf is likely to periodically employ volatility trading-based currency strategies.

C is incorrect because, in developing a market view based on underlying fundamentals in exchange rates, Umlauf does utilize an economic fundamentals approach.

14 B is correct. Braunt Pensionskasse provides the manager with limited discretion in managing the portfolio's currency risk exposures. This would be most consistent with allowing the currency overlay manager to take directional views on future currency movements (within predefined bounds) where the currency overlay is limited to the currency exposures already in the foreign asset portfolio. It would not be appropriate to use a fully-passive hedging approach since it would eliminate any alpha from currency movements. Further, a currency overlay program, which considers "foreign exchange as an asset class", would likely expose Braunt's portfolio to more currency risk than desired given the given primary performance objectives.

A is incorrect because a directional view currency overlay program is most appropriate given the limited discretion Braunt Pensionskasse has given the manager. A fully passive currency overlay program is more likely to be used when a client seeks to hedge all the currency risk.

C is incorrect because a directional view currency overlay program is most appropriate given the limited discretion Braunt Pensionskasse has given the manager. In contrast, the concept of "foreign exchange as an asset class" allows the currency overlay manager to take currency exposure positions in any currency pair where there is value-added to be harvested.

15 C is correct. The primary performance objective of Franz Trading GmbH is to add alpha to the portfolio, and thus has given the manager discretion in trading currencies. This is essentially a "foreign exchange as an asset class" approach. Braunt Pensionskasse and Kastner have more conservative currency strategies, and thus are less likely to benefit from the different strategies that a new overlay manager might employ.

A is incorrect because Franz Trading GmbH is more likely to benefit from the introduction of an additional overlay manager. Kastner is more likely to have a fully passive currency overlay program.

B is incorrect because Franz Trading GmbH is more likely to benefit from the introduction of an additional overlay manager. Braunt is more likely to have a currency overlay program where the manager takes a directional view on future currency movements.

16 A is correct. Exchange-traded futures contract not only have initial margin requirements, they also have daily mark-to-market and, as a result, can be subject to daily margin calls. Market participants must have sufficient liquidity to meet margin calls, or have their positions involuntarily liquidated by their brokers. Note that the risk of daily margin calls is not a feature of most forwards contracts; nor is initial margin. (However, this is changing among the largest institutional players in FX markets as many forward contracts now come with what are known as Collateral Support Annexes—CSAs—in which margin can be posted. Posting additional margin would typically not be a daily event, however, except in the case of extreme market moves.)

B is incorrect because futures contracts have low transactions costs. C is incorrect because whether the EUR is the price or the base currency in the quote will not affect the hedging process. In fact, on the CME the quote would be the market-standard USD/EUR quote, with the EUR as the base currency.

17 C is correct. Based on predicted export trends, Subscriber 2 most likely expects the KRW/USD rate to increase (i.e., the won—the price currency—to depreciate relative to the USD). This would require a long forward position in a forward contract, but as a country with capital controls, a NDF would be used instead. (Note: While forward contracts offered by banks are generally an institutional product, not retail, the retail version of a non-deliverable forward contract is known as a "contract for differences" (CFD) and is available at several retail FX brokers.)

A is incorrect because Subscriber 2 expects the KRW/USD rate to increase. A short straddle position would be used when the direction of exchange rate movement is unknown and volatility is expected to remain low.

B is incorrect because a put option would profit from a decrease of the KRW/USD rate, not an increase (as expected). Higher volatility would also make buying a put option more expensive.

18 B is correct. Subscriber 3's carry trade strategy is equivalent to trading the forward rate bias, based on the historical evidence that the forward rate is not the center of the distribution for the spot rate. Applying this bias involves buying currencies selling at a forward discount and selling currencies trading at a forward premium. So a higher forward premium on the lower yielding currency—the USD, the base currency in the INR/USD quote—would effectively reflect a more profitable trading opportunity. That is, a higher premium for buying or selling the USD forward is associated with a lower US interest rate compared to India. This would mean a wider interest rate differential in favor of Indian instruments, and hence potentially more carry trade profits.

A is incorrect because Subscriber 3's carry trade strategy depends on a wide interest rate differential between the high-yield country (India) and the low-yield country (the United States). The differential should be wide enough to compensate for the unhedged currency risk exposure.

C is incorrect because a guide to the carry trade's riskiness is the volatility of spot rates on the involved currencies, with rapid movements in exchange rates often associated with a panicked unwinding of carry trades. All things being equal, higher volatility is worse for carry trades.

19 C is correct. Emerging market currencies are often the investment currencies in the carry trade. This reflects the higher yields often available in their money markets compared to Developed Market economies (funding currencies are typically low-yield currencies such as the JPY). This can lead to higher holding returns, but these higher returns can also come with higher risks: carry trades are occasionally subject to panicked unwinds in stressed market conditions. When this occurs, position exit can be made more difficult by market illiquidity and higher trading costs (wider bid/offer spreads). The leverage involved in the carry trade can magnify trading losses under these circumstances.

A is incorrect because return distributions are often *negatively* skewed, reflecting the higher event risk (panicked carry trade unwinds, currency pegs being re-set, etc.) associated with the carry trade.

B is incorrect because although FX markets are typically efficient (or very close thereto) this does not mean that higher returns are not available. The key question is whether these are abnormally high *risk-adjusted* returns. Higher return in an efficient market comes with higher risk. The higher (short-term) return in the carry trade reflects the risk premia for holding unhedged currency risk, in the context of a favorable interest rate differential.

20 B is correct. The GBP value of the assets has declined, and hence the hedge needs to be *reduced* by GBP 7,000,000. This would require buying the GBP forward to net the outstanding (short) forward contract to an amount less than GBP 100,000,000.

A is incorrect because to rebalance the hedge (reduce the net size of the short forward position) the GBP must be bought *forward*, not with a spot transaction.

C is incorrect because the GBP must be bought, not sold. Buying SEK against the GBP is equivalent to selling GBP. Moreover, the amount of SEK that would be sold forward (to buy GBP 7,000,000 forward) would be determined by the *forward* rate, not the spot rate (7,000,000 × 10.6875 = 74,812,500).

21 C is correct. The fund holds CHF-denominated assets and hence Björk wants to protect against a depreciation of the CHF against the SEK, which would be a down-move in the SEK/CHF cross rate. An OTM put option provides some downside protection against such a move, while writing an OTM call option helps reduce the cost of this option structure. Note that Björk does not expect that the SEK/CHF rate will increase, so this option (in her view) will likely expire OTM and allow her to keep the premia. This hedging structure is known as a short risk reversal (or a collar) and is a popular hedging strategy.

A is incorrect because the ATM call option will not protect against a decrease in the SEK/CHF rate. An ATM option is also expensive (compared to an OTM option). Note that Björk does not expect the SEK/CHF rate to increase, so would not want a long call option position for this rate.

B is incorrect because this structure is expensive (via the long ITM call option) and does not protect against a decrease in the SEK/CHF rate.

22 B is correct. To hedge the EUR-denominated assets Björk will be selling forward contracts on the SEK/EUR cross rate. A higher forward premium will result in higher roll return as Björk is selling the EUR forward at a higher all-in forward rate, and closing out the contract at a lower rate (all else equal), given that the forward curve is in contango.

A is incorrect because Björk is hedging EUR-denominated assets with a EUR-denominated forward contract. While it is true that the gap between spot and forward rates will be higher the higher the interest rate differential between countries, this gap (basis) converges to zero near maturity date, when the forward contracts would be rolled.

C is incorrect because forward contracts do not generate premia income; writing options does.

23 C is correct. A cross hedge exposes the fund to basis risk; that is, the risk that the hedge fails to protect against adverse currency movements because the correlations between the value of the assets being hedged and the hedging instrument change.

A is incorrect because movements in forward points (and hence roll yield) would be of secondary importance compared to the basis risk of a cross hedge.

B is incorrect because exchange rate volatility would not necessarily affect a hedge based on forward contracts, as long as the correlations between the underlying assets and the hedge remained stable. Although relevant, volatility in itself is not the "most" important risk to consider for a cross-hedge. (However, movements in volatility would affect hedges based on currency options.)

24 A is correct. The fund has a long-term perspective, few immediate liquidity needs, and a lower weight in fixed income that in equities (bond portfolios are typically associated with hedge ratios closer to 100% than equity portfolios). The emerging market exposure would also support active management, given these countries' typically higher yields (carry trade) and often volatile exchange rates.

B is incorrect because the characteristics of the fund and the beneficial investor (in this case, the royal family) do not argue for a conservative currency strategy.

C is incorrect because a more active currency management strategy would be more suitable for this fund.

Glossary

Absolute return benchmark A minimum target return that an investment manager is expected to beat.

Accounting defeasance Also called in-substance defeasance, accounting defeasance is a way of extinguishing a debt obligation by setting aside sufficient high-quality securities to repay the liability.

Accumulation phase Phase where the government predominantly contributes to a sovereign wealth pension reserve fund.

Active management An approach to investing in which the portfolio manager seeks to outperform a given benchmark portfolio.

Active return The portfolio's return in excess of the return on the portfolio's benchmark.

Active risk The annualized standard deviation of active returns, also referred to as *tracking error* (also sometimes called *tracking risk*).

Active risk budgeting Risk budgeting that concerns active risk (risk relative to a portfolio's benchmark).

Active share A measure, ranging from 0% to 100%, of how similar a portfolio is to its benchmark. The measure is based on the differences in a portfolio's holdings and weights relative to its benchmark's holdings and their weights. A manager who precisely replicates the benchmark will have an active share of zero; a manager with no holdings in common with the benchmark will have an active share of one.

Active Share A measure of how similar a portfolio is to its benchmark. A manager who precisely replicates the benchmark will have an Active Share of zero; a manager with no holdings in common with the benchmark will have an Active Share of one.

Activist short selling A hedge fund strategy in which the manager takes a short position in a given security and then publicly presents his/her research backing the short thesis.

Adaptive markets hypothesis (AMH) A hypothesis that applies principles of evolution—such as competition, adaptation, and natural selection—to financial markets in an attempt to reconcile efficient market theories with behavioral alternatives.

Agency trade A trade in which the broker is engaged to find the other side of the trade, acting as an agent. In doing so, the broker does not assume any risk for the trade.

Alpha decay In a trading context, alpha decay is the erosion or deterioration in short term alpha after the investment decision has been made.

Alternative trading systems (ATS) Non-exchange trading venues that bring together buyers and sellers to find transaction counterparties. Also called *multilateral trading facilities (MTF)*.

Anchoring and adjustment An information-processing bias in which the use of a psychological heuristic influences the way people estimate probabilities.

Anchoring and adjustment bias An information-processing bias in which the use of a psychological heuristic influences the way people estimate probabilities.

Anomalies Apparent deviations from market efficiency.

Arithmetic attribution An attribution approach which explains the arithmetic difference between the portfolio return and its benchmark return. The single-period attribution effects sum to the excess return, however, when combining multiple periods, the sub-period attribution effects will not sum to the excess return.

Arrival price In a trading context, the arrival price is the security price at the time the order was released to the market for execution.

Aspirational risk bucket In goal-based portfolio planning, that part of wealth allocated to investments that have the potential to increase a client's wealth substantially.

Asset location The type of account an asset is held within, e.g., taxable or tax deferred.

Asset-only With respect to asset allocation, an approach that focuses directly on the characteristics of the assets without explicitly modeling the liabilities.

Authorized participants Broker/dealers who enter into an agreement with the distributor of the fund.

Availability bias An information-processing bias in which people take a heuristic approach to estimating the probability of an outcome based on how easily the outcome comes to mind.

Back-fill bias The distortion in index or peer group data which results when returns are reported to a database only after they are known to be good returns.

Barbell A fixed income portfolio combining securities concentrated in short and long maturities relative to the benchmark.

Base With respect to a foreign exchange quotation of the price of one unit of a currency, the currency referred to in "one unit of a currency."

Base-rate neglect A type of representativeness bias in which the base rate or probability of the categorization is not adequately considered.

Basis risk The risk resulting from using a hedging instrument that is imperfectly matched to the investment being hedged; in general, the risk that the basis will change in an unpredictable way.

Bayes' formula A mathematical rule explaining how existing probability beliefs should be changed given new information; it is essentially an application of conditional probabilities.

Bear spread An option strategy that becomes more valuable when the price of the underlying asset declines, so requires buying one option and writing another with a *lower* exercise price. A put bear spread involves buying a put with a higher exercise price and selling a put with a lower exercise price. A bear spread can also be executed with calls.

Behavioral biases A tendency to behave in a way that is not strictly rational.

Behavioral finance macro A focus on market level behavior that considers market anomalies that distinguish markets from the efficient markets of traditional finance.

Behavioral finance micro A focus on individual level behavior that examines the behavioral biases that distinguish individual investors from the rational decision makers of traditional finance.

Benchmark spread The yield on a credit security over the yield on a security with little or no credit risk (benchmark bond) and with a similar duration.

Best-in-class An ESG implementation approach that seeks to identify the most favorable companies and sectors based on ESG considerations. Also called *positive screening*.

Bid price In a price quotation, the price at which the party making the quotation is willing to buy a specified quantity of an asset or security.

Bottom-up approach A credit strategy approach that involves selecting the individual bonds or issuers that the investor views as having the best relative value from among a set of bonds or issuers with similar features.

Bounded rationality The notion that people have informational and cognitive limitations when making decisions and do not necessarily optimize when arriving at their decisions.

Breadth The number of truly independent decisions made each year.

Brinson model The approach to return attribution established in various papers co-authored by Gary Brinson; the Brinson–Hood–Beebower and Brinson–Fachler models viewed as a group. The value added by the portfolio manager is decomposed in allocation, selection, and interaction effects.

Buffering Establishing ranges around breakpoints that define whether a stock belongs in one index or another.

Bull spread An option strategy that becomes more valuable when the price of the underlying asset rises, so requires buying one option and writing another with a *higher* exercise price. A call bull spread involves buying a call with a lower exercise price and selling a call with a higher exercise price. A bull spread can also be executed with puts.

Bullet A fixed income portfolio made up of securities targeting a single segment of the curve.

Business cycle Fluctuations in GDP in relation to long-term trend growth, usually lasting 9-11 years.

Butterfly spread An option strategy that combines two bull or bear spreads and has three exercise prices, or, a measure of yield curve curvature.

Calendar rebalancing Rebalancing a portfolio to target weights on a periodic basis; for example, monthly, quarterly, semiannually, or annually.

Calendar spread A strategy in which one sells an option and buys the same type of option but with different expiration dates, on the same underlying asset and with the same strike. When the investor buys the more distant (near-term) call and sells the near-term (more distant) call, it is a long (short) calendar spread.

Canada model Characterized by a high allocation to alternatives. Unlike the endowment model, however, the Canada model relies more on internally managed assets. The innovative features of the Canada model are the: a) reference portfolio, b) total portfolio approach, and c) active management.

Capital market expectations (CME) Expectations concerning the risk and return prospects of asset classes.

Capital needs analysis See *capital sufficiency analysis.*

Capital sufficiency analysis The process by which a wealth manager determines whether a client has, or is likely to accumulate, sufficient financial resources to meet his or her objectives; also known as *capital needs analysis*.

Capture ratio A measure of the manager's gain or loss relative to the gain or loss of the benchmark.

Carhart model A four factor model used in performance attribution. The four factors are: market (RMRF), size (SMB), value (HML), and momentum (WML).

Carry trade A trading strategy that involves buying a security and financing it at a rate that is lower than the yield on that security.

Cash drag Tracking error caused by temporarily uninvested cash.

Cash flow matching Immunization approach that attempts to ensure that all future liability payouts are matched precisely by cash flows from bonds or fixed-income derivatives, such as interest rate futures, options, or swaps.

Cash-secured put An option strategy involving the writing of a put option and simultaneously depositing an amount of money equal to the exercise price into a designated account (this strategy is also called a fiduciary put).

Cell approach See *stratified sampling*.

Certainty equivalent The maximum sum of money a person would pay to participate or the minimum sum of money a person would accept to not participate in an opportunity.

Civil law A legal system derived from Roman law, in which judges apply general, abstract rules or concepts to particular cases. In civil systems, law is developed primarily through legislative statutes or executive action.

Closet indexer A fund that advertises itself as being actively managed but is substantially similar to an index fund in its exposures.

Code of ethics An established guide that communicates an organization's values and overall expectations regarding member behavior. A code of ethics serves as a general guide for how community members should act.

Cognitive dissonance The mental discomfort that occurs when new information conflicts with previously held beliefs or cognitions.

Cognitive errors Behavioral biases resulting from faulty reasoning; cognitive errors stem from basic statistical, information processing, or memory errors.

Collar An option position in which the investor is long shares of stock and then buys a put with an exercise price below the current stock price and writes a call with an exercise price above the current stock price. Collars allow a shareholder to acquire downside protection through a protective put but reduce the cash outlay by writing a covered call.

Common law A legal system which draws abstract rules from specific cases. In common law systems, law is developed primarily through decisions of the courts.

Community property regime A marital property regime under which each spouse has an indivisible one-half interest in property received during marriage.

Company-specific risk The non-systematic or idiosyncratic risk specific to a particular company's operations, reputation, and business environment.

Completion overlay A type of overlay that addresses an indexed portfolio that has diverged from its proper exposure.

Confirmation bias A belief perseverance bias in which people tend to look for and notice what confirms their beliefs, to ignore or undervalue what contradicts their beliefs, and to misinterpret information as support for their beliefs.

Conjunction fallacy An inappropriate combining of probabilities of independent events to support a belief. In fact, the probability of two independent events occurring in conjunction is never greater than the probability of either event occurring alone; the probability of two independent events occurring together is equal to the multiplication of the probabilities of the independent events.

Conservatism bias A belief perseverance bias in which people maintain their prior views or forecasts by inadequately incorporating new information.

Contingent immunization Hybrid approach that combines immunization with an active management approach when the asset portfolio's value exceeds the present value of the liability portfolio.

Controlled foreign corporation A company located outside a taxpayer's home country and in which the taxpayer has a controlling interest as defined under the home country law.

Convexity A measure of how interest rate sensitivity changes with a change in interest rates.

Core capital The amount of capital required to fund spending to maintain a given lifestyle, fund goals, and provide adequate reserves for unexpected commitments.

Covered call An option strategy in which a long position in an asset is combined with a short position in a call on that asset.

Creation units Large blocks of ETF shares often traded against a basket of underlying securities.

Credit method When the residence country reduces its taxpayers' domestic tax liability by the amount of taxes paid to a foreign country that exercises source jurisdiction.

Credit risk The risk of loss caused by a counterparty's or debtor's failure to make a timely payment or by the change in value of a financial instrument based on changes in default risk. Also called *default risk*.

Cross-currency basis swap A swap in which notional principals are exchanged because the goal of the transaction is to issue at a more favorable funding rate and swap the amount back to the currency of choice.

Cross hedge A hedge involving a hedging instrument that is imperfectly correlated with the asset being hedged; an example is hedging a bond investment with futures on a non-identical bond.

Cross-sectional consistency A feature of expectations setting which means that estimates for all classes reflect the same underlying assumptions and are generated with methodologies that reflect or preserve important relationships among the asset classes, such as strong correlations. It is the internal consistency across asset classes.

Cross-sectional momentum A managed futures trend following strategy implemented with a cross-section of assets (within an asset class) by going long those that are rising in price the most and by shorting those that are falling the most. This approach generally results in holding a net zero (market-neutral) position and works well when a market's out- or underperformance is a reliable predictor of its future performance.

Currency overlay A type of overlay that helps hedge the returns of securities held in foreign currency back to the home country's currency.

Currency overlay programs A currency overlay program is a program to manage a portfolio's currency exposures for the case in which those exposures are managed separately from the management of the portfolio itself.

Custom security-based benchmark Benchmark that is custom built to accurately reflect the investment discipline of a particular investment manager. Also called a *strategy benchmark* because it reflects a manager's particular strategy.

Decision price In a trading context, the decision price is the security price at the time the investment decision was made.

Decision-reversal risk The risk of reversing a chosen course of action at the point of maximum loss.

Decumulation phase Phase where the government predominantly withdraws from a sovereign wealth pension reserve fund.

Dedicated short-selling A hedge fund strategy in which the manager takes short-only positions in equities deemed to be expensively priced versus their deteriorating fundamental situations. Short exposures may vary only in terms of portfolio sizing by, at times, holding higher levels of cash.

Deduction method When the residence country allows taxpayers to reduce their taxable income by the amount of taxes paid to foreign governments in respect of foreign-source income.

Deemed dispositions Tax treatment that assumes property is sold. It is sometimes seen as an alternative to estate or inheritance tax.

Deemed distribution When shareholders of a controlled foreign corporation are taxed as if the earnings were distributed to shareholders, even though no distribution has been made.

Default risk The probability that a borrower defaults or fails to meet its obligation to make full and timely payments of principal and interest, according to the terms of the debt security.

Deferred annuity An annuity that enables an individual to purchase an income stream that will begin at a later date.

Defined benefit A retirement plan in which a plan sponsor commits to paying a specified retirement benefit.

Defined contribution A retirement plan in which contributions are defined but the ultimate retirement benefit is not specified or guaranteed by the plan sponsor.

Delay cost The (trading related) cost associated with not submitting the order to the market in a timely manner.

Delta The change in an option's price in response to a change in price of the underlying, all else equal.

Delta hedging Hedging that involves matching the price response of the position being hedged over a narrow range of prices.

Demand deposits Accounts that can be drawn upon regularly and without notice. This category includes checking accounts and certain savings accounts that are often accessible through online banks or automated teller machines (ATMs).

Diffusion index An index that measures how many indicators are pointing up and how many are pointing down.

Direct market access (DMA) Access in which market participants can transact orders directly with the order book of an exchange using a broker's exchange connectivity.

Disability income insurance A type of insurance designed to mitigate earnings risk as a result of a disability in which an individual becomes less than fully employed.

Discretionary portfolio management An arrangement in which a wealth manager has a client's pre-approval to execute investment decisions.

Discretionary trust A trust structure in which the trustee determines whether and how much to distribute in the sole discretion of the trustee.

Dispersion The weighted *variance* of the times to receipt of cash flow; it measures the extent to which the payments are spread out around the duration.

Disposition effect As a result of loss aversion, an emotional bias whereby investors are reluctant to dispose of losers. This results in an inefficient and gradual adjustment to deterioration in fundamental value.

Dividend capture A trading strategy whereby an equity portfolio manager purchases stocks just before their ex-dividend dates, holds these stocks through the ex-dividend date to earn the right to receive the dividend, and subsequently sells the shares.

Domestic asset An asset that trades in the investor's domestic currency (or home currency).

Domestic currency The currency of the investor, i.e., the currency in which he or she typically makes consumption purchases, e.g., the Swiss franc for an investor domiciled in Switzerland.

Domestic-currency return A rate of return stated in domestic currency terms from the perspective of the investor; reflects both the foreign-currency return on an asset as well as percentage movement in the spot exchange rate between the domestic and foreign currencies.

Donor-advised fund A fund administered by a tax-exempt entity in which the donor advises on where to grant the money that he or she has donated.

Double inflection utility function A utility function that changes based on levels of wealth.

Downside capture ratio A measure of capture when the benchmark return is negative in a given period; downside capture less (greater) than 100% generally suggests out (under) performance relative to the benchmark.

Drawdown A decline in value (represented by a series of negative returns only) following a peak fund valuation.

Due diligence Investigation and analysis in support of an investment action, decision, or recommendation.

Duration matching Immunization approach based on the duration of assets and liabilities. Ideally, the liabilities being matched (the liability portfolio) and the portfolio of assets (the bond portfolio) should be affected similarly by a change in interest rates.

Dynamic asset allocation A strategy incorporating deviations from the strategic asset allocation that are motivated by longer-term valuation signals or economic views than usually associated with tactical asset allocation.

Dynamic hedge A hedge requiring adjustment as the price of the hedged asset changes.

Earnings risk The risk associated with the earning potential of an individual.

Econometrics The application of quantitative modeling and analysis grounded in economic theory to the analysis of economic data.

Economic balance sheet A balance sheet that provides an individual's total wealth portfolio, supplementing traditional balance sheet assets with human capital and pension wealth, and expanding liabilities to include consumption and bequest goals. Also known as *holistic balance sheet*.

Economic indicators Economic statistics provided by government and established private organizations that contain information on an economy's recent past activity or its current or future position in the business cycle.

Economic net worth The difference between an individual's assets and liabilities; extends traditional financial assets and liabilities to include human capital and future consumption needs.

Effective convexity A second-order effect that describes how a bond's interest rate sensitivity changes with changes in yield. Effective convexity is used when the bond has cash flows that change when yields change (as in the case of callable bonds or mortgage-backed securities).

Effective duration Duration adjusted to account for embedded options.

Effective federal funds (FFE) rate The fed funds rate actually transacted between depository institutions, not the Fed's target federal funds rate.

Emotional biases Behavioral biases resulting from reasoning influenced by feelings; emotional biases stem from impulse or intuition.

Empirical duration A measure of interest rate sensitivity that is determined from market data.

Endowment bias An emotional bias in which people value an asset more when they hold rights to it than when they do not.

Endowment model Characterized by a high allocation to alternative investments (private investments and hedge funds), significant active management, and externally managed assets.

Enhanced indexing strategy Method investors use to match an underlying market index in which the investor purchases fewer securities than the full set of index constituents but matches primary risk factors reflected in the index.

Environmental, social, and corporate governance (ESG) Also called socially responsible investing, refers to the explicit inclusion of ethical, environmental, or social criteria when selecting a portfolio.

Equity forward sale contract A private contract for the forward sale of an equity position.

Equity monetization The realization of cash for an equity position through a manner other than an outright sale.

Estate All of the property a person owns or controls; may consist of financial assets, tangible personal assets, immovable property, or intellectual property.

Estate planning The process of preparing for the disposition of one's estate (e.g., the transfer of property) upon death and during one's lifetime.

Estate tax freeze A plan usually involving a corporation, partnership, or limited liability company with the goal to transfer *future* appreciation to the next generation at little or no gift or estate tax cost.

Ethical principles Beliefs regarding what is good, acceptable, or obligatory behavior and what is bad, unacceptable, or forbidden behavior.

Evaluated pricing See *matrix pricing*.

Excess capital An investor's capital over and above that which is necessary to fund their lifestyle and reserves.

Excess return Used in various senses appropriate to context: 1) The difference between the portfolio return and the benchmark return; 2) The return in excess of the risk-free rate.

Exchange-traded fund Exchange-traded Funds or ETFs are hybrid investment products with many features of mutual funds combined with the trading features of common stocks or bonds. Essentially, ETFs are typically portfolios of stocks or bonds or commodities that trade throughout the day like common stocks.

Execution cost The difference between the (trading related) cost of the real portfolio and the paper portfolio, based on shares and prices transacted.

Exemption method When the residence country imposes no tax on foreign-source income by providing taxpayers with an exemption, in effect having only one jurisdiction impose tax.

Exhaustive An index construction strategy that selects every constituent of a universe.

Expected shortfall The average loss conditional on exceeding the VaR cutoff; sometimes referred to as *conditional VaR* or *expected tail loss*.

Expected tail loss See *expected shortfall*.

Extended portfolio assets and liabilities Assets and liabilities beyond those shown on a conventional balance sheet that are relevant in making asset allocation decisions; an example of an extended asset is human capital.

Factor-model-based benchmarks Benchmarks constructed by examining a portfolio's sensitivity to a set of factors, such as the return for a broad market index, company earnings growth, industry, or financial leverage.

Fiduciary duty The obligation to act in the best interest of the client, exercising a reasonable level of care, skill, and diligence.

Financial buyers Buyers who lack a strategic motive.

Financial capital The tangible and intangible assets (excluding human capital) owned by an individual or household.

Fixed trust A trust structure in which distributions to beneficiaries are prescribed in the trust document to occur at certain times or in certain amounts.

Forced heirship rules Legal ownership principles whereby children have the right to a fixed share of a parent's estate.

Foreign assets Assets denominated in currencies other than the investor's home currency.

Foreign currency Currency that is not the currency in which an investor makes consumption purchases, e.g., the US dollar from the perspective of a Swiss investor.

Foreign-currency return The return of the foreign asset measured in foreign-currency terms.

Forward conversion with options The construction of a synthetic short forward position against the asset held long.

Forward rate bias Persistent violation of uncovered interest rate parity that is exploited by the carry trade.

Framing An information-processing bias in which a person answers a question differently based on the way in which it is asked (framed).

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Fulcrum securities Partially-in-the-money claims (not expected to be repaid in full) whose holders end up owning the reorganized company in a corporate reorganization situation.

Full replication approach When every issue in an index is represented in the portfolio, and each portfolio position has approximately the same weight in the fund as in the index.

Fund-of-funds A fund of hedge funds in which the fund-of-funds manager allocates capital to separate, underlying hedge funds (e.g., single manager and/or multi-manager funds) that themselves run a range of different strategies.

Funding currencies The low-yield currencies in which borrowing occurs in a carry trade.

G-spread The yield on a credit security over the yield of an actual or interpolated government bond.

Gamblers' fallacy A misunderstanding of probabilities in which people wrongly project reversal to a long-term mean.

Gamma The change in an option's delta for a change in price of the underlying, all else equal.

General account Account holding assets to fund future liabilities from traditional life insurance and fixed annuities, the products in which the insurer bears all the risks—particularly mortality risk and longevity risk.

Goals-based With respect to asset allocation or investing, an approach that focuses on achieving an investor's goals (for example, related to supporting lifestyle needs or aspirations) based typically on constructing sub-portfolios aligned with those goals.

Goals-based investing An investment industry term for approaches to investing for individuals and families focused on aligning investments with goals (parallel to liability-driven investing for institutional investors).

Grinold–Kroner model An expression for the expected return on a share as the sum of an expected income return, an expected nominal earnings growth return, and an expected repricing return.

Hague Conference on Private International Law An intergovernmental organization working toward the convergence of private international law. Its 69 members consist of countries and regional economic integration organizations.

Halo effect An emotional bias that extends a favorable evaluation of some characteristics to other characteristics.

Hard-catalyst event-driven approach An event-driven approach in which investments are made in reaction to an already announced corporate event (mergers and acquisitions, bankruptcies, share issuances, buybacks, capital restructurings, re-organizations, accounting changes) in which security prices related to the event have yet to fully converge.

Health insurance A type of insurance used to cover health care and medical costs.

Health risk The risk associated with illness or injury.

Hedge ratio The relationship of the quantity of an asset being hedged to the quantity of the derivative used for hedging.

Herding When a group of investors trade on the same side of the market in the same securities, or when investors ignore their own private information and act as other investors do.

High-water mark A specified net asset value level that a fund must exceed before performance fees are paid to the hedge fund manager.

Hindsight bias A bias with selective perception and retention aspects in which people may see past events as having been predictable and reasonable to expect.

Holdings-based attribution A "buy and hold" attribution approach which calculates the return of portfolio and benchmark components based upon the price and foreign exchange rate changes applied to daily snapshots of portfolio holdings.

Holdings-based style analysis A bottom-up style analysis that estimates the risk exposures from the actual securities held in the portfolio at a point in time.

Holistic balance sheet See *economic balance sheet*.

Home bias A preference for securities listed on the exchanges of one's home country.

Home-country bias The favoring of domestic over non-domestic investments relative to global market value weights.

Home currency See *domestic currency*.

Horizon matching Hybrid approach that combines cash flow and duration matching approaches. Under this approach, liabilities are categorized as short-and long-term liabilities.

Human capital An implied asset; the net present value of an investor's future expected labor income weighted by the probability of surviving to each future age. Also called *net employment capital*.

I-spread The yield on a credit security over the swap rate (denominated in the same currency as the credit security). Also known as interpolated spread.

Illusion of control A bias in which people tend to believe that they can control or influence outcomes when, in fact, they cannot. Illusion of knowledge and self-attribution biases contribute to the overconfidence bias.

Illusion of control bias A bias in which people tend to believe that they can control or influence outcomes when, in fact, they cannot. Illusion of knowledge and self-attribution biases contribute to the overconfidence bias.

Immediate annuity An annuity that provides a guarantee of specified future monthly payments over a specified period of time.

Immunization An asset/liability management approach that structures investments in bonds to match (offset) liabilities' weighted-average duration; a type of dedication strategy.

Impact investing Investment approach that seeks to achieve targeted social or environmental objectives along with measurable financial returns through engagement with a company or by direct investment in projects or companies.

Implementation shortfall (IS) The difference between the return for a notional or paper portfolio, where all transactions are assumed to take place at the manager's decision price, and the portfolio's actual return, which reflects realized transactions, including all fees and costs.

Implied volatility The outlook for the future volatility of the underlying asset's price. It is the value (i.e., standard deviation of underlying's returns) that equates the model (e.g., Black–Scholes–Merton model) price of an option to its market price.

Implied volatility surface A three-dimensional plot, for put and call options on the same underlying asset, of days to expiration (x-axis), option strike prices (y-axis), and implied volatilities (z-axis). It simultaneously shows the volatility skew (or smile) and the term structure of implied volatility.

Indexing A common passive approach to investing that involves holding a portfolio of securities designed to replicate the returns on a specified index of securities.

Indifference curve analysis A decision-making approach whereby curves of consumption bundles, among which the decision-maker is indifferent, are constructed to identify and choose the curve within budget constraints that generates the highest utility.

Information coefficient Formally defined as the correlation between forecast return and actual return. In essence, it measures the effectiveness of investment insight.

Input uncertainty Uncertainty concerning whether the inputs are correct.

Interaction effect The attribution effect resulting from the interaction of the allocation and selection decisions.

Intertemporal consistency A feature of expectations setting which means that estimates for an asset class over different horizons reflect the same assumptions with respect to the potential paths of returns over time. It is the internal consistency over various time horizons.

Intestate Having made no valid will; a decedent without a valid will or with a will that does not dispose of their property is considered to have died intestate.

Intrinsic value The difference between the spot exchange rate and the strike price of a currency option.

Investment currencies The high-yielding currencies in a carry trade.

Investment policy statement A written planning document that describes a client's investment objectives and risk tolerance over a relevant time horizon, along with the constraints that apply to the client's portfolio.

Investment style A natural grouping of investment disciplines that has some predictive power in explaining the future dispersion of returns across portfolios.

Irrevocable trust A trust arrangement wherein the settlor has no ability to revoke the trust relationship.

Joint ownership with right of survivorship Jointly owned; assets held in joint ownership with right of survivorship automatically transfer to the surviving joint owner or owners outside the probate process.

Key person risk The risk that results from over-reliance on an individual or individuals whose departure would negatively affect an investment manager.

Key rate duration A method of measuring the interest rate sensitivities of a fixed-income instrument or portfolio to shifts in key points along the yield curve.

Knock-in/knock-out Features of a vanilla option that is created (or ceases to exist) when the spot exchange rate touches a pre-specified level.

Leading economic indicators A set of economic variables whose values vary with the business cycle but at a fairly consistent time interval before a turn in the business cycle.

Leveraged recapitalization A leveraging of a company's balance sheet, usually accomplished by working with a private equity firm.

Liability-driven investing An investment industry term that generally encompasses asset allocation that is focused on funding an investor's liabilities in institutional contexts.

Liability driven investing (LDI) model In the LDI model, the primary investment objective is to generate returns sufficient to cover liabilities, with a focus on maximizing expected surplus return (excess return of assets over liabilities) and managing surplus volatility.

Liability glide path A specification of desired proportions of liability-hedging assets and return-seeking assets and the duration of the liability hedge as funded status changes and contributions are made.

Liability insurance A type of insurance used to manage liability risk.

Liability-relative With respect to asset allocation, an approach that focuses directly only on funding liabilities as an investment objective.

Liability risk The possibility that an individual or household may be held legally liable for the financial costs associated with property damage or physical injury.

Life-cycle finance A concept in finance that recognizes as an investor ages, the fundamental nature of wealth and risk evolves.

Life insurance A type of insurance that protects against the loss of human capital for those who depend on an individual's future earnings.

Life settlement The sale of a life insurance contract to a third party. The valuation of a life settlement typically requires detailed biometric analysis of the individual policyholder and an understanding of actuarial analysis.

Lifetime gratuitous transfer A lifetime gift made during the lifetime of the donor; also known as *inter vivos* transfers.

Limited-life foundations A type of foundation where founders seek to maintain control of spending while they (or their immediate heirs) are still alive.

Liquidity budget The portfolio allocations (or weightings) considered acceptable for the liquidity categories in the liquidity classification schedule (or time-to-cash table).

Liquidity classification schedule A liquidity management classification (or table) that defines portfolio liquidity "buckets" or categories based on the estimated time it would take to convert assets in that particular category into cash.

Longevity risk The risk associated with living to an advanced age in retirement, including the uncertainty surrounding how long retirement will last; the risk of outliving one's financial resources.

Loss-aversion bias A bias in which people tend to strongly prefer avoiding losses as opposed to achieving gains.

Loss given default See *loss severity*.

Loss severity The amount of loss if a default occurs. Also called *loss given default*.

Macaulay duration The percentage change in price for a percentage change in yield. The term, named for one of the economists who first derived it, is used to distinguish the calculation from modified duration. (See also *modified duration*).

Macro attribution Attribution at the sponsor level.

Manager peer group See *manager universe*.

Manager universe A broad group of managers with similar investment disciplines. Also called *manager peer group*.

Market risk bucket In goal-based portfolio planning, that part of wealth allocated to investments intended to maintain the client's current standard of living.

Matrix pricing An approach for estimating the prices of thinly traded securities based on the prices of securities with similar attributions, such as similar credit rating, maturity, or economic sector. Also called *evaluated pricing*.

Mental accounting bias An information-processing bias in which people treat one sum of money differently from another equal-sized sum based on which mental account the money is assigned to.

Micro attribution Attribution at the portfolio manager level.

Minimum-variance hedge ratio A mathematical approach to determining the optimal cross hedging ratio.

Mismatch in character The potential tax inefficiency that can result if the instrument being hedged, and the tool that is being used to hedge it, produce income and loss of a different character.

Mission-related investing Aims to direct a significant portion of assets in excess of annual grants into projects promoting a foundation's mission.

Model uncertainty Uncertainty as to whether a selected model is correct.

Modified duration An adjustment of the duration for the level of the yield. Contrast with *Macaulay duration*.

Monetize To access an item's cash value without transferring ownership of it.

Money duration A measure of the price change in units of the currency in which the bond is denominated given a change in its yield-to-maturity.

Mortality table A table that indicates individual life expectancies at specified ages.

Multi-class trading An equity market-neutral strategy that capitalizes on misalignment in prices and involves buying and selling different classes of shares of the same company, such as voting and non-voting shares.

Multi-manager fund Can be of two types—one is a multi-strategy fund in which teams of portfolio managers trade and invest in multiple different strategies within the same fund; the second type is a fund of hedge funds (or fund-of-funds) in which the manager allocates capital to separate, underlying hedge funds that themselves run a range of different strategies.

Multi-strategy fund A fund in which teams of portfolio managers trade and invest in multiple different strategies within the same fund.

Multilateral trading facilities (MTF) See *Alternative trading systems (ATS)*.

Mutual funds A professionally managed investment pool in which investors in the fund typically each have a pro-rata claim on the income and value of the fund.

Negative screening An ESG implementation approach that excludes certain sectors or companies that deviate from an investor's accepted standards.

Net asset value Value established at the end of each trading day based on the fund's valuation of all existing assets minus liabilities, divided by the total number of shares outstanding.

Net employment capital See *human capital*.

Net worth tax or net wealth tax A tax based on a person's assets, less liabilities.

Non-deliverable forwards Forward contracts that are cash settled (in the non-controlled currency of the currency pair) rather than physically settled (the controlled currency is neither delivered nor received).

Nonstationarity A characteristic of series of data whose properties, such as mean and variance, are not constant through time. When analyzing historical data it means that different parts of a data series reflect different underlying statistical properties.

Norway model Characterized by an almost exclusive reliance on public equities and fixed income (the traditional 60/40 equity/bond model falls under the Norway model), with largely passively managed assets and with very little to no allocation to alternative investments.

Offer price The price at which a counterparty is willing to sell one unit of the base currency.

Opportunity cost The (trading related) cost associated with not being able to transact the entire order at the decision price.

Option-adjusted spread The constant spread that, when added to all the one-period forward rates on the interest rate tree, makes the arbitrage-free value of the bond equal to its market price.

Optional stock dividends A type of dividend in which shareholders may elect to receive either cash or new shares.

Overbought When a market has trended too far in one direction and is vulnerable to a trend reversal, or correction.

Overconfidence bias A bias in which people demonstrate unwarranted faith in their own intuitive reasoning, judgments, and/or cognitive abilities.

Overlay A derivative position (or positions) used to adjust a pre-existing portfolio closer to its objectives.

Oversold The opposite of overbought; see *overbought.*

Packeting Splitting stock positions into multiple parts.

Pairs trading An equity market-neutral strategy that capitalizes on the misalignment in prices of pairs of similar under- and overvalued equities. The expectation is the differential valuations or trading relationships will revert to their long-term mean values or their fundamentally-correct trading relationships, with the long position rising and the short position declining in value.

Parameter uncertainty Uncertainty arising because a quantitative model's parameters are estimated with error.

Participant/cohort option Pools the DC plan member with a cohort that has a similar target retirement date.

Participant-switching life-cycle options Automatically switch DC plan members into a more conservative asset mix as their age increases. There may be several automatic de-risking switches at different age targets.

Passive investment Investment that seeks to mimic the prevailing characteristics of the overall investments available in terms of credit quality, type of borrower, maturity, and duration rather than express a specific market view.

Passive management A buy-and-hold approach to investing in which an investor does not make portfolio changes based upon short-term expectations of changing market or security performance.

Percent-range rebalancing An approach to rebalancing that involves setting rebalancing thresholds or trigger points, stated as a percentage of the portfolio's value, around target values.

Performance attribution Attribution, including return attribution and risk attribution; often used as a synonym for return attribution.

Permanent life insurance A type of life insurance that provides lifetime coverage.

Personal risk bucket In goal-based portfolio planning, that part of wealth allocated to investments intended to protect the client from a drastic decrease in lifestyle.

Portfolio overlay An array of derivative positions managed separately from the securities portfolio to achieve overall intended portfolio characteristics.

Position delta The overall or portfolio delta. For example, the position delta of a covered call, consisting of long 100 shares and short one at-the-money call, is +50 (= +100 for the shares and -50 for the short ATM call).

Positive screening An ESG implementation approach that seeks to identify the most favorable companies and sectors based on ESG considerations. Also called *best-in-class*.

Premature death risk The risk of an individual dying earlier than anticipated; sometimes referred to as *mortality risk*.

Premium Regarding life insurance, the asset paid by the policy holder to an insurer who, in turn, has a contractual obligation to pay death benefit proceeds to the beneficiary named in the policy.

Prepaid variable forward A collar and loan combined within a single instrument.

Present value of distribution of cash flows methodology Method used to address a portfolio's sensitivity to rate changes along the yield curve, this approach seeks to approximate and match the yield curve risk of an index over discrete time periods.

Price value of a basis point (PVBP) The change in the bond price for a 1 basis point change in yield. Also called *basis point value* (BPV).

Primary capital Assets held outside a concentrated position that are at least sufficient to provide for the owner's lifetime spending needs.

Principal trade A trade in which the market maker or dealer becomes a disclosed counterparty and assumes risk for the trade by transacting the security for their own account. Also called *broker risk trades.*

Probate The legal process to confirm the validity of a will so that executors, heirs, and other interested parties can rely on its authenticity.

Profession An occupational group that has specific education, expert knowledge, and a framework of practice and behavior that underpins community trust, respect, and recognition.

Program trading A strategy of buying or selling many stocks simultaneously.

Property insurance A type of insurance used by individuals to manage property risk.

Property risk The possibility that a person's property may be damaged, destroyed, stolen, or lost.

Prospect theory An alternative to expected utility theory, it assigns value to gains and losses (changes in wealth) rather than to final wealth, and probabilities are replaced by decision weights. In prospect theory, the shape of a decision maker's value function is assumed to differ between the domain of gains and the domain of losses.

Protective put An option strategy in which a long position in an asset is combined with a long position in a put on that asset.

Pure indexing Method investors use to match an underlying market index in which the investor aims to replicate an existing market index by purchasing all of the constituent securities in the index to minimize tracking risk.

Put spread A strategy used to reduce the upfront cost of buying a protective put, it involves buying a put option and writing another put option.

Quantitative market-neutral An approach to building market-neutral portfolios in which large numbers of securities are traded and positions are adjusted on a daily or even an hourly basis using algorithm-based models.

Rational economic man A self-interested, risk-averse individual who has the ability to make judgments using all available information in order to maximize his/her expected utility.

Re-base With reference to index construction, to change the time period used as the base of the index.

Realized volatility Historical volatility, the square root of the realized variance of returns, which is a measure of the range of past price outcomes for the underlying asset.

Rebalancing In the context of asset allocation, a discipline for adjusting the portfolio to align with the strategic asset allocation.

Rebalancing overlay A type of overlay that addresses a portfolio's need to sell certain constituent securities and buy others.

Rebalancing range A range of values for asset class weights defined by trigger points above and below target weights, such that if the portfolio value passes through a trigger point, rebalancing occurs. Also known as a corridor.

Rebate rate The portion of the collateral earnings rate that is repaid to the security borrower by the security lender.

Reduced-form models Models that use economic theory and other factors such as prior research output to describe hypothesized relationships. Can be described as more compact representations of underlying structural models. Evaluate endogenous variables in terms of observable exogenous variables.

Regime The governing set of relationships (between variables) that stem from technological, political, legal, and regulatory environments. Changes in such environments or policy stances can be described as changes in regime.

Regret The feeling that an opportunity has been missed; typically an expression of *hindsight bias*.

Regret-aversion bias An emotional bias in which people tend to avoid making decisions that will result in action out of fear that the decision will turn out poorly.

Relative value volatility arbitrage A volatility trading strategy that aims to source and buy cheap volatility and sell more expensive volatility while netting out the time decay aspects normally associated with options portfolios.

Repo rate The interest rate on a repurchase agreement.

Representativeness bias A belief perseverance bias in which people tend to classify new information based on past experiences and classifications.

Repurchase agreements (repos) In a repurchase agreement, a security owner agrees to sell a security for a specific cash amount, while simultaneously agreeing to repurchase the security at a specified future date (typically one day later) and price.

Request for quote (RFQ) A non-binding quote provided by a market maker or dealer to a potential buyer or seller upon request. Commonly used in fixed income markets these quotes are only valid at the time they are provided.

Reserve portfolio The component of an insurer's general account that is subject to specific regulatory requirements and is intended to ensure the company's ability to meet its policy liabilities. The assets in the reserve portfolio are managed conservatively and must be highly liquid and low risk.

Residence jurisdiction A framework used by a country to determine the basis for taxing income, based on residency.

Residence–residence conflict When two countries claim residence of the same individual, subjecting the individual's income to taxation by both countries.

Residence–source conflict When tax jurisdiction is claimed by an individual's country of residence and the country where some of their assets are sourced; the most common source of double taxation.

Resistance levels Price points on dealers' order boards where one would expect to see a clustering of offers.

Return attribution A set of techniques used to identify the sources of the excess return of a portfolio against its benchmark.

Returns-based attribution An attribution approach that uses only the total portfolio returns over a period to identify the components of the investment process that have generated the returns. The Brinson–Hood–Beebower approach is a returns-based attribution approach.

Returns-based benchmarks Benchmarks constructed by examining a portfolio's sensitivity to a set of factors, such as the returns for various style indexes (e.g., small-cap value, small-cap growth, large-cap value, and large-cap growth).

Returns-based style analysis A top-down style analysis that involves estimating the sensitivities of a portfolio to security market indexes.

Reverse repos Repurchase agreement from the standpoint of the lender.

Revocable trust A trust arrangement wherein the settlor (who originally transfers assets to fund the trust) retains the right to rescind the trust relationship and regain title to the trust assets.

Risk attribution The analysis of the sources of risk.

Risk aversion The degree of an investor's unwillingness to take risk; the inverse of risk tolerance.

Risk budgeting The establishment of objectives for individuals, groups, or divisions of an organization that takes into account the allocation of an acceptable level of risk.

Risk capacity The ability to accept financial risk.

Risk perception The subjective assessment of the risk involved in the outcome of an investment decision.

Risk premium An extra return expected by investors for bearing some specified risk.

Risk reversal A strategy used to profit from the existence of an implied volatility skew and from changes in its shape over time. A combination of long (short) calls and short (long) puts on the same underlying with the same expiration is a long (short) risk reversal.

Risk tolerance The capacity to accept risk; the level of risk an investor (or organization) is willing and able to bear.

Sale and leaseback A transaction wherein the owner of a property sells that property and then immediately leases it back from the buyer at a rate and term acceptable to the new owner and on financial terms consistent with the marketplace.

Sample-size neglect A type of representativeness bias in which financial market participants incorrectly assume that small sample sizes are representative of populations (or "real" data).

Satisfice A combination of "satisfy" and "suffice" describing decisions, actions, and outcomes that may not be optimal, but are adequate.

Scenario analysis A risk assessment technique involving the examination of the performance of a portfolio under specified situations.

Seagull spread An extension of the risk reversal foreign exchange option strategy that limits downside risk.

Securities lending A form of collateralized lending that may be used to generate income for portfolios.

Selective An index construction methodology that targets only those securities with certain characteristics.

Self-attribution bias A bias in which people take personal credit for successes and attribute failures to external factors outside the individual's control.

Self-control bias A bias in which people fail to act in pursuit of their long-term, overarching goals because of a lack of self-discipline.

Separate accounts Accounts holding assets to fund future liabilities from variable life insurance and variable annuities, the products in which customers make investment decisions from a menu of options and themselves bear investment risk.

Separate property regime A marital property regime under which each spouse is able to own and control property as an individual.

Settlor (or grantor) An entity that transfers assets to a trustee, to be held and managed for the benefit of the trust beneficiaries.

Shari'a The law of Islam. In addition to the law of the land, some follow guidance provided by Shari'a or Islamic law.

Sharpe ratio The average return in excess of the risk-free rate divided by the standard deviation of return; a measure of the average excess return earned per unit of standard deviation of return. Also known as the *reward-to-variability ratio*.

Short-biased A hedge fund strategy in which the manager uses a less extreme version of dedicated short-selling. It involves searching for opportunities to sell expensively priced equities, but short exposure may be balanced with some modest value-oriented, or index-oriented, long exposure.

Short sale against the box Shorting a security that is held long.

Shortfall probability The probability of failing to meet a specific liability or goal.

Shrinkage estimation Estimation that involves taking a weighted average of a historical estimate of a parameter and some other parameter estimate, where the weights reflect the analyst's relative belief in the estimates.

Single-manager fund A fund in which one portfolio manager or team of portfolio managers invests in one strategy or style.

Situational influences External factors, such as environmental or cultural elements, that shape our behavior.

Smart beta Involves the use of simple, transparent, rules-based strategies as a basis for investment decisions.

Smart order routers (SOR) Smart systems used to electronically route small orders to the best markets for execution based on order type and prevailing market conditions.

Social proof A bias in which individuals tend to follow the beliefs of a group.

Soft-catalyst event-driven approach An event-driven approach in which investments are made proactively in anticipation of a corporate event (mergers and acquisitions, bankruptcies, share issuances, buybacks, capital restructurings, re-organizations, accounting changes) that has yet to occur.

Sole ownership Owned by one person; assets held in sole ownership are typically considered part of a decedent's estate. The transfer of their ownership is dictated by the decedent's will through the probate process.

Source jurisdiction A framework used by a country to determine the basis for taxing income or transfers. A country that taxes income as a source within its borders imposes source jurisdiction.

Source–source conflict When two countries claim source jurisdiction of the same asset; both countries may claim that the income is derived from their jurisdiction.

Special dividends A dividend paid by a company that does not pay dividends on a regular schedule, or a dividend that supplements regular cash dividends with an extra payment.

Spread curve The fitted curve of credit spreads for each bond of an issuer plotted against either the maturity or duration of each of those bonds.

Spread duration A measure used in determining a portfolio's sensitivity to changes in credit spreads.

Standards of conduct Behaviors required by a group; established benchmarks that clarify or enhance a group's code of ethics.

Static hedge A hedge that is not sensitive to changes in the price of the asset hedged.

Status quo bias An emotional bias in which people do nothing (i.e., maintain the "status quo") instead of making a change.

Stock lending Securities lending involving the transfer of equities.

Stop-losses A trading order that sets a selling price below the current market price with a goal of protecting profits or preventing further losses.

Stops Stop-loss orders involve leaving bids or offers away from the current market price to be filled if the market reaches those levels.

Straddle An option combination in which one buys *both* puts and calls, with the same exercise price and same expiration date, on the same underlying asset. In contrast to this long straddle, if someone *writes* both options, it is a short straddle.

Strangle A variation on a straddle in which the put and call have different exercise prices; if the put and call are held long, it is a long strangle; if they are held short, it is a short strangle.

Strategic asset allocation 1) The process of allocating money to IPS-permissible asset classes that integrates the investor's return objectives, risk tolerance, and investment constraints with long-run capital market expectations. 2) The result of the above process, also known as the policy portfolio.

Strategic buyers Buyers who have a strategic motive (e.g., realization of synergies) for seeking to buy a company.

Stratified sampling A sampling method that guarantees that subpopulations of interest are represented in the sample. Also called *representative sampling* or *cell approach*.

Structural models Models that specify functional relationships among variables based on economic theory. The functional form and parameters of these models are derived from the underlying theory. They may include unobservable parameters.

Structural risk Risk that arises from portfolio design, particularly the choice of the portfolio allocations.

Stub trading An equity market-neutral strategy that capitalizes on misalignment in prices and entails buying and selling stock of a parent company and its subsidiaries, typically weighted by the percentage ownership of the parent company in the subsidiaries.

Support levels Price points on dealers' order boards where one would expect to see a clustering of bids.

Surplus The difference between the value of assets and the present value of liabilities. With respect to an insurance company, the net difference between the total assets and total liabilities (equivalent to policyholders' surplus for a mutual insurance company and stockholders' equity for a stock company).

Surplus capital Capital that is in excess of primary capital.

Surplus portfolio The component of an insurer's general account that is intended to realize higher expected returns than the reserve portfolio and so can assume some liquidity risk. Surplus portfolio assets are often managed aggressively with exposure to alternative assets.

Survival probability The probability an individual survives in a given year; used to determine expected cash flow required in retirement.

Survivorship bias Bias that arises in a data series when managers with poor track records exit the business and are dropped from the database whereas managers with good records remain; when a data series of a given date reflects only entitites that have survived to that date.

Synthetic long forward position The combination of a long call and a short put with identical strike price and expiration, traded at the same time on the same underlying.

Synthetic short forward position The combination of a short call and a long put at the same strike price and maturity (traded at the same time on the same underlying).

Tactical asset allocation Asset allocation that involves making short-term adjustments to asset class weights based on short-term predictions of relative performance among asset classes.

Tail risk The risk that there are more actual events in the tail of a probability distribution than would be predicted by probability models.

Tax avoidance Developing strategies that minimize tax, while conforming to both the spirit and the letter of the tax codes of jurisdictions with taxing authority.

Tax evasion The practice of circumventing tax obligations by illegal means such as misreporting or not reporting relevant information to tax authorities.

Taylor rule A rule linking a central bank's target short-term interest rate to the rate of growth of the economy and inflation.

Temporary life insurance A type of life insurance that covers a certain period of time, specified at purchase. Commonly referred to as "term" life insurance.

Term deposits Interest-bearing accounts that have a specified maturity date. This category includes savings accounts and certificates of deposit (CDs).

Term structure of volatility The plot of implied volatility (y-axis) against option maturity (x-axis) for options with the same strike price on the same underlying. Typically, implied volatility is not constant across different maturities – rather, it is often in contango, meaning that the implied volatilities for longer-term options are higher than for near-term ones.

Territorial tax system A framework used by a country to determine the basis for taxing income or transfers. A country that taxes income as a source within its borders imposes source jurisdiction.

Testamentary gratuitous transfer The bequeathing or transfer of assets upon one's death. From a recipient's perspective, it is called an inheritance.

Testator A person who makes a will.

Thematic investing An investment approach that focuses on companies within a specific sector or following a specific theme, such as energy efficiency or climate change.

Theta The daily change in an option's price, all else equal. Theta measures the sensitivity of the option's price to the passage of time, known as time decay.

Time deposits Interest-bearing accounts that have a specified maturity date. This category includes savings accounts and certificates of deposit (CDs).

Time-series estimation Estimators that are based on lagged values of the variable being forecast; often consist of lagged values of other selected variables.

Time-series momentum A managed futures trend following strategy in which managers go long assets that are rising in price and go short assets that are falling in price. The manager trades on an absolute basis, so be net long or net short depending on the current price trend of an asset. This approach works best when an asset's own past returns are a good predictor of its future returns.

Time-to-cash table See *liquidity classification schedule*.

Time value The difference between the market price of an option and its intrinsic value, determined by the uncertainty of the underlying over the remaining life of the option.

Top-down approach A credit strategy approach that involves formulating a view on major macroeconomic trends and then selecting the bonds that the investor expects to perform best in the expected environment.

Total factor productivity A variable which accounts for that part of Y not directly accounted for by the levels of the production factors (K and L).

Total return equity swap A swap contract that involves a series of exchanges of the total return on a specified asset or equity index in return for specified fixed or floating rate payments.

Total return payer Party responsible for paying the reference obligation cash flows and return to the receiver, but will also be compensated by the receiver for any depreciation in the index or default losses incurred on the portfolio.

Total return receiver Party receives both the cash flows from the underlying index as well as any appreciation in the index over the period in exchange for paying Libor plus a pre-determined spread.

Total return swap A swap in which one party agrees to pay the total return on a security. Often used as a credit derivative, in which the underlying is a bond.

Tracking error The standard deviation of the differences between a portfolio's returns and its benchmark's returns; a synonym of active risk. Also called *tracking risk*.

Tracking risk The standard deviation of the differences between a portfolio's returns and its benchmark's returns; a synonym of active risk. Also called *tracking error*.

Trade urgency A reference to how quickly or slowly an order is executed over the trading time horizon.

Transactions-based attribution An attribution approach that captures the impact of intra-day trades and exogenous events such as a significant class action settlement.

Transfer coefficient The ability to translate portfolio insights into investment decisions without constraint.

Trigger points In the context of portfolio rebalancing, the endpoints of a rebalancing range (corridor).

Unsmoothing An adjustment to the reported return series if serial correlation is detected. Various approaches are available to unsmooth a return series.

Upside capture ratio A measure of capture when the benchmark return is positive in a given period; upside capture greater (less) than 100% generally suggests out (under) performance relative to the benchmark.

Utility The level of relative satisfaction received from the consumption of goods and services.

Utility theory Theory whereby people maximize the present value of utility subject to a present value budget constraint.

Variance notional The notional amount of a variance swap; it equals vega notional divided by two times the volatility strike price [i.e., (vega notional)/(2 × volatility strike)].

Vega The change in an option's price for a change in volatility of the underlying, all else equal.

Vega notional The trade size for a variance swap, which represents the average profit and loss of the variance swap for a 1% change in volatility from the strike.

Vesting A term indicating that employees only become eligible to receive a pension after meeting certain criteria, typically a minimum number of years of service.

Volatility clustering The tendency for large (small) swings in prices to be followed by large (small) swings of random direction.

Volatility skew The skewed plot (of implied volatility (y-axis) against strike price (x-axis) for options on the same underlying with the same expiration) that occurs when the implied volatility increases for OTM puts and decreases for OTM calls, as the strike price moves away from the current price.

Volatility smile The U-shaped plot (of implied volatility (y-axis) against strike price (x-axis) for options on the same underlying with the same expiration) that occurs when the implied volatilities priced into both OTM puts and calls trade at a premium to implied volatilities of ATM options.

Will A document associated with estate planning that outlines the rights others will have over one's property after death. Also called *testament*.

Z-spread The yield spread that must be added to each point of the implied spot yield curve to make the present value of a bond's cash flows equal its current market price. Also known as zero-volatility spread.