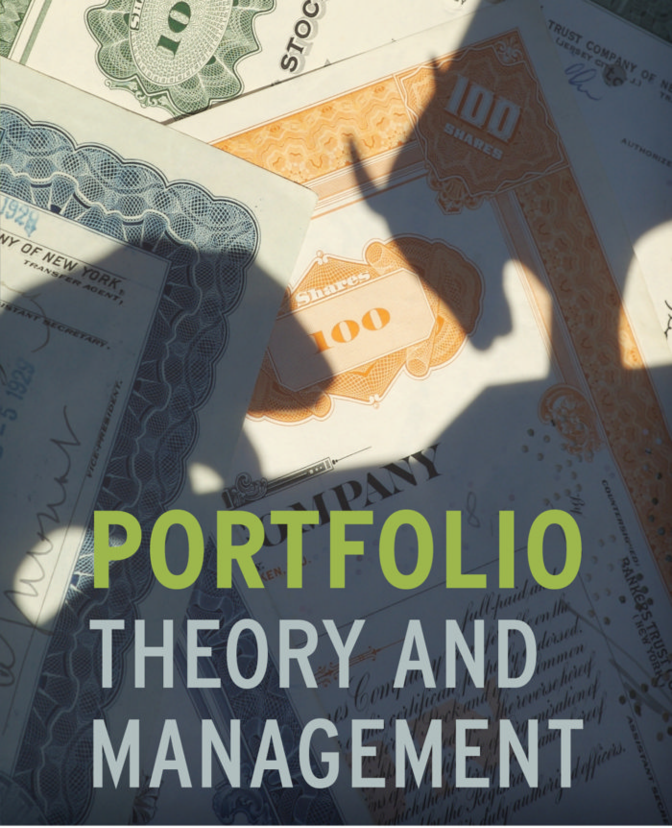

PORTFOLIO THEORY AND MANAGEMENT

Edited by

H. KENT BAKER and GREG FILBECK

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and

GREG FILBECK

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Portfolio Theory and Management

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Introduction

Portfolio management is an ongoing process of constructing portfolios that balances an investor's objectives with the portfolio manager's expectations about the future. This dynamic process provides the payoff for investors. In portfolio management, individual assets or investments are evaluated by their contribution to the risk and return of an investor's portfolio rather than in isolation. This is called the *portfolio perspective*. In this process, by constructing a diversified portfolio, a portfolio manager can reduce risk for a given level of expected return, compared to investing in an individual asset or security. According to modern portfolio theory (MPT), investors who do not follow a portfolio perspective bear risk that is not rewarded with greater expected return. Portfolio diversification works best when financial markets are operating normally, compared to periods of market turmoil, such as during the financial crisis of 2007–2008. During periods of turmoil, correlations tend to increase, thus reducing the benefits of diversification. *Correlation* is a standardized measure of comovement between returns of two securities or markets.

Portfolio Management Process

The *portfolio management process* consists of an integrated set of steps that a portfolio manager undertakes in a consistent manner to create and maintain an appropriate portfolio to meet a client's objectives. The objectives of different types of investors vary, reflecting their diverse needs and characteristics. That the objectives of individuals and other types of investors, such as banks, endowments, insurance companies, pension funds, mutual funds, and others, vary widely is not surprising. Thus, portfolio managers must tailor portfolios to meet the different objectives of their clients.

The portfolio management process consists of three major steps: planning, execution, and feedback (Maginn, Tuttle, Pinto, and McLeavey, 2007). Planning involves four major tasks: (1) understanding the client's needs, circumstances, and constraints; (2) creating an investment policy statement (IPS); (3) developing an investment strategy consistent with the IPS; and (4) specifying a performance benchmark. A portfolio manager is unlikely to produce good results for a client without understanding the client's needs, circumstances, and constraints. Thus, the planning step begins by analyzing an investor's risk tolerance and return objectives within the context of a variety of *constraints*, both *internal* (the client's liquidity needs, time horizon, and unique circumstances) and *external* (his tax situation and legal and regulatory requirements). *Risk tolerance* refers to an investor's capacity to accept risk. A client's overall risk tolerance depends not only on his ability to take risk, which relates to financial factors, but also on his willingness to take risk, which relates to psychological factors.

This analysis results in the portfolio manager creating an *investment policy statement*, which is a document clearly detailing the investor's investment objectives, constraints, and risk preferences. An IPS contains the following components: (1) a description of the client's circumstances, (2) the purpose of the IPS, (3) the duties and responsibilities of all parties, (4) procedures to update the IPS and to resolve problems, (5) the client's investment objectives and constraints, (6) investment guidelines, (7) an evaluation of performance, including a benchmark, and (8) appendices detailing the strategic asset allocation, permitted deviations, and rebalancing procedures.

The portfolio manager then needs to determine an overall investment strategy that is consistent with the IPS. An IPS provides a plan for achieving investment success through forcing investment discipline and ensuring that objectives are realistic. In devising a strategy, the portfolio manager forms long-term expectations about the capital markets, including forecasts of the risk-and-return characteristics of various asset classes. Part of this strategy entails developing a *strategic asset allocation* (SAA) specifying the percentage of allocations to each of the asset classes to be included in the portfolio. SAA provides the basic structure of a portfolio that the portfolio manager uses to determine the long-term policy for asset weights in a portfolio, which are modified infrequently. The SAA is based on the risk, returns, and correlations (comovements) of the asset classes. The final planning task is to identify or create a *benchmark*, which is a standard of comparison, or a comparison portfolio.

The second step in the portfolio management process is execution, which involves the following key tasks: (1) analyzing the risk-and-return characteristics of asset classes, (2) analyzing market conditions to identify attractive asset classes, (3) identifying attractive securities within asset classes (security selection), and (4) constructing the portfolio. During this step, the portfolio manager turns plans into reality. He examines the risk-and-return characteristics of each asset class and then considers how these characteristics interact from a portfolio perspective. Given that capital-market conditions affect asset classes, the manager needs to form expectations about which market conditions are likely to prevail. These tasks involve considerable research on the part of the portfolio manager. Next, the manager identifies and selects attractive securities that fall within the asset classes specified by the IPS. In constructing a portfolio, the manager considers such factors as target or strategic asset allocations, individual security weightings, and risk management. As Madhavan, Treynor, and Wagner (2007, p. 637) note, "The portfolio decision is not complete until securities are bought and sold."

The portfolio manager sometimes temporarily moves away from the SAA either to reflect an investor's current circumstances that differ from the norm or because of changes in short-term capital-market expectations. In *tactical asset allocation* (TAA), the asset class mix in the portfolio is adjusted in an attempt to take advantage of changing market conditions. For example, the portfolio manager may engage in *market timing*, which involves shorter-term tactical deviations than the SAA. In TAA, perceived changes in the relative values of the various asset classes solely drive these adjustments (Reilly and Brown, 2000).

The final step in the portfolio management process is feedback, which consists of four components: (1) monitoring and updating an investor's needs, (2) monitoring and updating market conditions, (3) rebalancing the portfolio as needed, and (4) evaluating and reporting performance. Over time, the investor's needs and circumstances and market and economic conditions change. Additionally, differences between a portfolio's current asset allocation and its SAA result from fluctuations in the market value of assets. Thus, the portfolio manager periodically reviews and updates the IPS and rebalances the portfolio accordingly. *Rebalancing* involves adjusting the actual portfolio to the current SAA because of price changes in portfolio holdings.

Portfolio evaluation has three components: performance measurement, performance attribution, and performance appraisal (Bailey, Richards, and Tierney, 2007). *Performance measurement* involves calculating the portfolio's rate of return. Because many concepts and techniques are available for measuring returns, the portfolio manager must decide on the most appropriate ones for a given portfolio. *Performance attribution* involves comparing a portfolio's performance with that of a valid benchmark identified in the IPS and identifying and quantifying the sources of differential returns. In general, a portfolio's overall performance may be attributed to three main sources: decisions involving the SAA, security selection, and market timing (Maginn et al., 2007). Of these sources, studies suggest that long-term asset allocation decisions best explain investment performance over time (Brinson, Hood, and Beebower, 1986; Brinson, Singer, and Beebower, 1991; Ibbotson and Kaplan, 2000; Xiong, Ibbotson, Idzorek, and Chen, 2010). *Performance appraisal* involves a quantitative assessment of the manager's *investment skill*, which refers to his ability to outperform a specific benchmark consistently over time. Typically, the portfolio manager uses risk-adjusted performance-appraisal measures. Once the investment's performance is evaluated, the portfolio manager needs to report the results. The *Global Investment Performance Standards* (*GIPS*) offer a recognized approach to providing performance information (Lawton and Remington, 2007).

MODERN PORTFOLIO THEORY

The world of portfolio management has expanded greatly especially during the past three decades, and along with it, so have the theoretical tools necessary to appropriately service the needs of both private-wealth and institutional clients. While the foundations of modern finance emerged during the 1950s and asset-pricing models were developed in a portfolio context in the 1960s, portfolio management has further expanded into more complex models. With respect to modern finance, the mean-variance efficient frontier framework (Markowitz, 1952, 1959), a bottom-up model for portfolio construction, has seen top-down approaches emerge. With respect to asset-pricing models, one-factor models using a single broad-market index for the basis of pricing, such as the capital-asset pricing model (CAPM; Sharpe, 1964; Lintner, 1965), have been replaced by more complex models that include other factors such as market capitalization, style, and momentum (Jagadeesh and Titman, 1993; Carhart, 1997; Fama and French, 2004; Asem and Tian, 2010).

Traditional finance models, such as the efficient market hypothesis (EMH) (Fama, 1970, 1991), are based on the assumption that the market as a whole acts rationally although some individual investors may not. In an efficient financial market, security prices always fully reflect the available information. Thus, an average investor cannot hope to consistently beat the market. If this condition holds, then expending vast resources to analyze, select, and trade securities is a wasted effort. Investors are better served by passively holding the market portfolio and ignoring active money management. As Shleifer (2000, p. 1) notes, “If the EMH holds, the market truly knows best.” However, the inefficient market makes many mistakes in pricing securities (Haugen, 2001). Haugen (2004) makes the case for an inefficient stock market, where the complexity and uniqueness of investor interactions have important market-pricing implications.

The traditional assumption of rational investor behavior with decisions made on the basis of statistical distributions has expanded to consider the behavioral attributes of clients (Kahneman and Tversky, 1979; Kahneman, Slovic, and Tversky, 1982) as well as goals-based strategies (Shefrin and Statman, 2000). For example, in assessing risk tolerance for a private-wealth client, portfolio managers must consider not only the client’s ability but also the client’s risk tolerance in determining an appropriate asset allocation.

Behavioral finance applies psychology to financial behavior and examines its effects on financial markets (Shefrin, 2000). As Nofsinger (2005, p. 5) remarks, “Even the smartest people are affected by psychological biases, but traditional finance has considered this irrelevant.” In inefficient markets, securities prices can deviate from their rational levels and be based on biased estimates of intrinsic value. Behavioral finance can help explain not only how investors actually behave and how markets function but also how improvement can occur. Baker and Nofsinger (2010) provide a comprehensive discussion of behavioral finance.

Over time, a larger menu of investment options has been another factor that has expanded choices beyond traditional asset classes (e.g., stocks and bonds), taking them into alternative investments (e.g., commodities, hedge funds, private equity, and real estate). *Alternative investments* are groups of investments with risk-and-return characteristics that differ markedly from those of traditional stock and bond investments. Because investors now have greater access to the international markets, a strong case also exists for global asset allocations. Moreover, with the rapid expansion of the derivatives market, more liquid, synthetic exposure to asset classes and risk management strategies have become more accessible and sophisticated.

Performance evaluation and presentation have taken on greater importance since the 1990s. As the development of multifactor models to explain portfolio performance emerged, the portfolio management community began to recognize the importance of appropriate benchmarking for performance so that "apples-for-apples" comparisons could be made (Bailey, 1992a, 1992b). As Bailey (1992a) points out, an appropriate benchmark should be unambiguous, reflective of current investment opinions, specified in advance, investible, measurable, and appropriate based on similarity of style. Style analysis and ultimately custom benchmarking allow managers to be evaluated using a fairer representation of portfolio performance (Sharpe, 1992; Bailey and Tierney, 1993). Style analysis can be performed in a top-down (e.g., a returns-based style analysis) or a bottom-up (e.g., a holdings-based style analysis) manner. Top-down style analysis typically involves the use of multiple regression models, with the portfolio return serving as the dependent variable and asset-class benchmarks serving as the independent variables. Bottom-up analysis consists of a security-by-security classification approach. A custom, or "normal," benchmark represents a vendor-constructed passive representation of an active manager's style. Risk management in a portfolio context is often accomplished through the use of derivative securities. Chance (2003) presents an overview of using forwards, futures, options, and swaps as a basis of altering the risk profile to desired levels for a portfolio.

GIPS, which are offered by the CFA Institute (2010), provide a standardized set of performance presentation guidelines that allows investors to compare portfolio performance once returns are properly evaluated and attributed. Beyond the impact of turnover on after-tax returns and with advancements in technology, key pieces of this assessment now include more emphasis on efficient trade execution and trading strategies as well as the analysis of implicit and explicit transaction costs (Wagner and Edwards, 1993).

Recent financial crises have called into question whether the theories developed by the financial pioneers were correct and whether practitioners "got it right" in managing assets. Alternative investments have received increased attention as investors look to benefit from eliminating or altering their systematic risk exposure in portfolios (Anson, 2006). Exchange-traded funds (ETFs), with origins going back to the late 1970s and early 1980s, are one of the most successful financial innovations of the last two decades (Gastineau, 2001). The majority of

ETFs seek to replicate the performance of specific domestic, sector, regional, or international indexes. Another innovation has been the development of socially responsible investing in an attempt to generate long-term, competitive financial returns and positive societal impact (Sparkes, 2002). As portfolio management continues to develop, foundational theoretical tools, financial innovation, and increasingly more sophisticated methods of analysis will assist academics and practitioners as they address the concerns of the investing public.

PURPOSE OF THE BOOK

Portfolio management today emerges as a dynamic process, which is continuing to evolve at a rapid pace. The purpose of *Portfolio Theory and Management* is to take readers from the foundations of portfolio management, reviewing the contributions of the financial pioneers, up to the latest trends emerging within the context of special topics. The book includes discussions of portfolio theory and management both before and after the financial crisis of 2007–2008. This volume provides a critical reflection of what worked and what did not work viewed from the perspective of the crisis. Further, the book is not restricted to the US market but takes a more global focus by highlighting cross-country differences and practices.

Readers of this book will have the opportunity to gain a historical grounding as well as an understanding of the latest trends within the field of portfolio theory and management. Those interested in a broad survey of portfolio management will benefit as well as those looking for more in-depth presentations of specific areas within the field of study. Both financial theory and empirical work are also featured. Cited research studies are presented in a straightforward manner focusing on the key findings, rather than the details of mathematical frameworks. Contributions emerge from a group of noted authors, featuring the work of a mix of academics and practitioners. The vast majority of authors hold advanced degrees, mainly doctorates, and some hold the Chartered Financial Analyst (CFA) designation, which is the industry standard for excellence in the areas of security analysis and portfolio management.

FEATURES OF THE BOOK

Portfolio Theory and Management has several distinguishing features:

- Perhaps the book's most distinctive feature is that it provides a comprehensive discussion of portfolio theory and management and empirical work and practice within the various areas covered. The book attempts not only to blend the conceptual world of scholars with the pragmatic view of practitioners in the field but also to synthesize important and relevant research studies in a succinct and clear manner, including those on recent developments.
- The book contains contributions from distinguished scholars, both academics and practitioners, from around the world. The breadth of contributors assures a variety of perspectives and a rich interplay of ideas.

- When discussing the results of empirical studies that link theory and practice, the authors' objective is to distill them to their essential content so that they are understandable to readers. The book includes theoretical and mathematical derivations to the extent that they may be necessary and useful to readers.
- Each chapter ends with a summary and conclusions that provide the key lessons of the chapter.
- All chapters except this chapter contain discussion questions that help to reinforce key principles and concepts. Guideline answers are presented at the end of the book. This feature should be especially relevant to faculty and students using the book in classes.

INTENDED AUDIENCE

Given its features, *Portfolio Theory and Management* should be of interest to a wide audience, including students, academics, practitioners, and investors. However, this book is not intended for the novice, in that it assumes readers have a good grounding in investments, economics, and quantitative methods. In fact, some chapters require a more advanced knowledge of statistics to fully grasp the mathematics underlying the content. The core audience that this book is written for is upper-level business undergraduates and graduate students (primarily those earning an MBA or an MSF (Master of Science in Finance), but doctoral students in finance are also likely to find this book useful in providing an overview of this field. Academics may use this book not only in their advanced undergraduate and graduate portfolio theory and management courses but also to understand the various strands of research emerging in this area. Practitioners can use the book to navigate through the key areas in portfolio management. Individual investors will also benefit as they attempt to expand their knowledge base and apply the concepts contained within the book to the management of their own portfolios.

Structure of the Book

The remaining 29 chapters are organized into seven sections. A brief synopsis of each chapter by section follows.

SECTION I. PORTFOLIO THEORY AND ASSET PRICING

Chapters 2 through 4 provide the foundations of modern portfolio theory and asset pricing from both traditional and behavioral finance perspectives.

Chapter 2 Modern Portfolio Theory (Eric Jacquier)

This chapter surveys modern portfolio theory, which is one of the most spectacular developments of finance in the last 50 years. It starts with the basic one-period setup, which is based on the assumption of normality, reviewing the successive contributions of Markowitz and Sharpe. The chapter then discusses the multiperiod extension and Merton's concept of optimal asset allocation. The second part of the chapter shows how to extend the framework to allow for parameter uncertainty. In the discussion, the chapter also briefly reviews needed concepts, such as predictive density, shrinkage, and how the Bayesian framework allows the incorporation of prior views to improve on the precision of estimates necessary in the portfolio construction process.

Chapter 3 Asset Pricing Theories, Models, and Tests (Nikolay Gospodinov and Cesare Robotti)

An important but still partially unanswered question in the investment field is why various assets earn substantially different returns on average. Financial economists have typically addressed this question in the context of theoretically or empirically motivated asset-pricing models. Since many of the proposed "risk" theories provide plausible explanations, a common practice in the literature is to apply the models to the data and perform "horse races" among competing asset-pricing specifications. A "good" asset-pricing model should produce small-pricing (expected-return) errors based on a set of test assets and should deliver reasonable estimates of the underlying market and economic-risk premia. This chapter provides an up-to-date review of the statistical methods that are typically used to estimate, evaluate, and compare competing asset-pricing models. The analysis also highlights several pitfalls in the current econometric practice and offers suggestions for improving empirical tests.

Chapter 4 Asset Pricing and Behavioral Finance (Hersh Shefrin)

Behavioral asset pricing focuses on the manner in which investor psychology can create gaps between the market prices of securities and their corresponding fundamental values. This chapter describes the main tenets of behavioral asset pricing by tracing its history both empirically and theoretically. Because of its focus on the gap between price and value, the behavioral framework has come to be viewed as an alternative to the neoclassical-based efficient market framework. The debate between behaviorists and neoclassicists has shed light on weaknesses in both approaches. The chapter discusses these weaknesses and concludes that going forward, the field of finance would benefit by bringing together the psychological insights from behavioral finance and the rigorous approach of neoclassical finance.

SECTION II. THE INVESTMENT POLICY STATEMENT AND FIDUCIARY DUTIES

The four chapters in this section focus on topics that are part of the first step in the portfolio management process—planning. Chapter 5 deals with risk tolerance, which is one of the key elements addressed in constructing an IPS. Chapters 6 and 7 discuss the development of an IPS from individual and institutional perspectives, respectively. Chapter 8 focuses on the responsibilities and legalities of managers of investment portfolios. When portfolio managers serve as fiduciaries, they have a special relationship of trust and responsibilities with respect to other parties.

Chapter 5 Assessing Risk Tolerance (Sherman D. Hanna, Michael A. Guillemette, and Michael S. Finke)

Assessing risk tolerance is an important part of advising clients about portfolio selections. The expected utility approach underlying portfolio advice assumes that a household has some level of risk aversion by which its utility is determined based on different wealth or consumption levels. Therefore, a household's risk aversion or the inverse—its risk tolerance—is a key factor in determining the optimal portfolio for a household. However, risk capacity, based on wealth and the investment horizon, is also crucial in determining the optimal portfolio advice. This chapter provides a discussion of methods for estimating risk tolerance and the limitations of alternative measures.

Chapter 6 Private Wealth Management (Dianna Preece)

Private wealth management is a specialized field focused on investment management for high net-worth individuals and families. The process is complex and must be customized to the individual or family. Historically, the assumption that investors were risk averse resulted in forecasts based on rational expectations, with their assets considered in a portfolio context. Increasingly, accepted behavioral models indicate that investors do not necessarily follow the tenets of modern portfolio theory but are instead loss averse, have biased expectations, and do not integrate assets. These models assume that individual financial circumstances are unique, and constructing an IPS is a critical step in understanding the investor's goals. The risk-and-return objectives of the individual or family are specified in the IPS along with constraints that are relevant to their portfolio. Liquidity needs and taxation are especially important. The portfolio asset allocation is a function of risk-and-return objectives and the investor's constraints. Retirement planning and estate planning are also part of the process.

Chapter 7 Institutional Wealth Management (Eric J. Robbins)

An *institutional investment policy statement* (IIPS) is a formal document designed to help guide the investment process for institutions. Although this document is not currently required by regulation, it is a very useful tool in managing a pool of assets in the best interests of the beneficiaries. In the volatility of modern markets, letting emotions and short-term trends dictate an investment strategy can easily happen. The IIPS is designed to help mitigate this natural tendency and instead focus on long-term goals. The primary factors considered in creating an IIPS are the company's objectives, risk tolerance, and unique constraints. Each type of institutional investor will have a different blend of needs within this framework and will require a customized plan for investing.

Chapter 8 Fiduciary Duties and Responsibilities of Portfolio Managers (Remus D. Valsan and Moin A. Yahya)

The rules governing persons occupying a fiduciary role form a dynamic area of law. With deep historical roots, fiduciary relations have expanded beyond the established categories, such as trust-beneficiary, agent-principal, or director-corporation, to include any person who has power or discretion over another's interests coupled with an express or implied undertaking to act exclusively in the other's service. Managers of investment portfolios, such as trustees, agents, financial advisers, or corporate directors, may be subject to the strict requirements of fiduciary law in various capacities. Although the default fiduciary rules are very strict, courts and legislators have proven willing to take into account commercial realities and relax the standard prohibitions of conflict of interest by imposing lower benchmarks and by allowing parties in a fiduciary relation to contract out proscriptive rules.

SECTION III. ASSET ALLOCATION AND PORTFOLIO CONSTRUCTION

The six chapters in this section deal with elements of the first and second steps in the portfolio management process—planning and execution. Chapter 9 provides an introduction to asset allocation and examines both SAA and TAA. Chapters 10 and 11 discuss various types of asset allocation models, with chapter 10 being a mathematically intensive chapter. Chapters 12 and 13 examine portfolio construction and asset allocation with an emphasis on downside risk. Chapter 14 discusses the role of alternative investments in a portfolio and focuses on their risk-and-return profiles.

Chapter 9 The Role of Asset Allocation in the Investment Decision-Making Process (James L. Farrell, Jr.)

This chapter focuses on asset allocation, which is an important aspect in the investment decision-making process. Asset allocation has the potential to add the most to longer-term performance if executed properly or to detract greatly if done poorly. SAA takes a longer-term approach. One approach to SAA, called the *historic approach,* is to simply extrapolate the risk and return of asset classes experienced over, say, a period starting 80 years prior and extending into the future. Over such a long period, the economy experiences many different economic episodes. An alternative is the *scenario approach,* which forecasts for a shorter three- to five-year period and allows for accommodating such economic episodes. The scenario approach requires greater skill and analysis to execute than the historic approach. TAA is a complementary approach to the scenario approach and looks at a much shorter-time horizon of, say, one to three years. TAA has potential to add value by taking advantage of shorter-term opportunities. At the same time, this approach presents greater risk, which the portfolio manager or investor needs to consider.

Chapter 10 Asset Allocation Models (J. Clay Singleton)

Actively managing a portfolio involves three main activities: asset allocation (designing and maintaining the relative asset-class weights), asset selection (selecting assets to match the allocation), and market timing (deciding when and how much to invest). This chapter looks at asset allocation models—theoretical and practical templates that active asset managers use to make the asset allocation decision. Many observers, influenced by a continuum of research, believe that asset allocation is by far the most influential factor explaining the variability in portfolio performance. Only recently has research supported the roughly equal importance of asset selection with asset allocation, with market timing a distant third. Regardless of the precise influence accorded to any of the three activities of active management, asset allocation is an essential ingredient in portfolio design and performance.

Chapter 11 Preference Models in Portfolio Construction and Evaluation (Massimo Guidolin)

This chapter reviews the role of preference-, or utility-, based asset allocation models in normative portfolio theory. After presenting relevant definitions and tools from the theory of decision making under uncertainty, the chapter surveys moment-based preference functionals and introduces concepts from the literature on portfolio decisions made by ambiguity-averse, robust optimizers. An illustrative back-testing exercise reveals that preference-based models may fail to deliver an ex-post–realized performance that outperforms typical benchmarks. However, this is unlikely for medium-term (6- and 12-month) risk-averse investors, who are characterized by having preferences such as power utility of smooth, ambiguity-averse preferences that overweight higher-order moments and the tail dynamics of the distribution of terminal wealth, in comparison with standard mean-variance preferences.

Chapter 12 Portfolio Construction with Downside Risk (Harald Lohre, Thorsten Neumann, and Thomas Winterfeldt)

In portfolio construction, an optimal trade-off is sought between a portfolio's mean return and its associated risk. Since risk may not be properly described by return volatility, portfolios are optimized in this chapter with respect to various measures of downside risk in an empirical out-of-sample setting. These optimizations are successful for most of the investigated measures when assuming the perfect foresight of expected returns. Moreover, some of these findings continue to hold when using more naïve return estimates. The reductions in downside risk are most convincing for semivariance, semideviation, and conditional value at risk (VaR), while VaR and skewness appear rather useless for portfolio construction purposes.

Chapter 13 Asset Allocation with Downside Risk Management (Joshua M. Davis and Sebastien Page)

The financial crisis of 2007–2008 has sparked a renewed skepticism of portfolio theory and financial engineering. As a result, key changes are taking place in how investors manage risk, now looking at it from the top down. Asset allocators have become increasingly aware of the pitfalls of a naïve approach to portfolio engineering that relies on the normal distribution and that fails to address downside risk. Additionally, asset classes are no longer the optimal way to look at diversification; instead, risk-factor diversification is becoming the focus. This chapter concentrates on these key changes. It presents the theoretical foundations behind the risk-factor approach to asset allocation, demonstrates how risk concentration leads to tail risk, and analyzes the costs and benefits of tail-risk hedging in practice.

Chapter 14 Alternative Investments (Lars Helge Hass, Denis Schweizer, and Juliane Proelss)

The monthly return distributions of alternative assets are generally not normally distributed and typically show significantly smoothed returns, which can lead to an underestimation of risk. Furthermore, portfolio optimization in the mean-variance framework that includes alternative assets is suboptimal. This is because the variance of the return distributions for these investments fails to adequately capture all risks. This chapter provides an estimate of the efficient frontier for portfolios, consisting of numerous alternative assets as well as traditional asset classes, such as equities and bonds. This estimation enables incorporating the special characteristics of alternative investments, especially downside risk, in the optimization procedure for mixed-asset portfolios. Within this approach, mixed-asset portfolios containing a majority of alternative investments can be used to illustrate the previously unknown effects of skewness and excess kurtosis on the efficient frontier. The evidence shows that alternative investments are ideally suited to reduce portfolio risk and enhance risk-adjusted performance.

SECTION IV. RISK MANAGEMENT

This section consists of two chapters. Chapters 15 and 16 examine various types of risk that portfolio managers need to consider as well as how to manage these risks.

Chapter 15 Measuring and Managing Market Risk (Christoph Kaserer)

Market risk, which is caused by fluctuating market prices, is an extremely important risk not only for all institutional investors but also for large corporations and wealthy individuals. Therefore, the appropriate measurement and management of this risk is of considerable importance. This chapter examines measurement models for market risk including their extensions that have been contributed by the recent literature. In this context, the primary stylized facts emerging from this literature are discussed, such as the fat-tails phenomenon, volatility clustering, and serial correlation. Moreover, the necessity of integrating liquidity risk into risk management models is discussed as well. Finally, the impact of model risk is investigated, pointing out that model risk is both a statistical problem and a management problem.

Chapter 16 Measuring and Managing Credit and Other Risks (Gabriele Sabato)

During the last 40 years, risk management has evolved tremendously. The technologies and methodologies to measure risks have reached impressive levels of sophistication and complexity. However, the financial crisis of 2007–2008 clearly demonstrates that substantial improvements in the way financial institutions measure and manage risks are still urgently needed. This chapter provides an analysis and discussion of risk management as well as several proposals on how the financial industry should evolve. In particular, it suggests that financial institutions need to improve their capital-allocation strategies to define a clear risk-appetite framework by taking the following actions: (1) implementing true enterprise risk management programs, which measure and aggregate all risk types; and (2) redefining the role of the risk function within the governance of financial organizations. Improving the methods used to measure risks and implementing the proposed changes in risk management would allow financial institutions to restore the trust of markets and customers and to move forward into a new risk management era.

SECTION V. PORTFOLIO EXECUTION, MONITORING, AND REBALANCING

Having created the IPS and determined the appropriate asset allocation strategy, the portfolio manager moves on to step 1, planning. In step 2, he must analyze the appropriate method for executing the strategy, and in step 3, he monitors the strategy over time and determines the parameters necessary to justify portfolio rebalancing. Chapters 17 and 18 apply quantitative-based techniques in executing trading strategies, while chapter 19 introduces successful market-timing methods based on technical analysis techniques.

Chapter 17 Trading Strategies, Portfolio Monitoring, and Rebalancing (Riccardo Cesari and Massimiliano Marzo)

Trading strategies translate the goals and constraints of asset management into dynamic, intertemporal, and coherent portfolio decisions. Under special assumptions, myopic portfolio policies are shown to be optimal and constant over time. In general, however, both optimal theoretical portfolios and current portfolio positions are subject to random movements, making periodic monitoring and rebalancing necessary. Transaction and monitoring costs create a trade-off between the cost of not being at the optimal allocation (a tracking error) and the cost of swapping a current portfolio for an optimal one. Optimal rebalancing results in the replacement of the optimal allocation with a no-trade region delimited by rebalance boundaries. The factors influencing the boundaries and the rebalancing decisions can be analytically and numerically explained. Popular rebalancing rules imply a substantial amount of excess trading costs, but they can generate positive net returns in the case of mean-reverting market regimes.

Chapter 18 Effective Trade Execution (Riccardo Cesari, Massimiliano Marzo, and Paolo Zagaglia)

This chapter examines the role of algorithmic trading in modern financial markets. Additionally, it describes order types, characteristics, and special features of algorithmic trading under the lens provided by the large development of high-frequency trading technology. Special order types are examined together with an intuitive description of the implied dynamics of the order book conditional to special orders (iceberg and hidden). The chapter provides an analysis of the transaction costs associated with trading activity and examines the most common trading strategy employed in the market. It also examines optimal execution strategy, with the description of the efficient trading frontier. These concepts represent the tools needed to understand the most recent innovations in financial markets and the most recent advances in microstructures research.

Chapter 19 Market Timing Methods and Results (Panagiotis Schizas)
This chapter provides an overview of market-timing methods and explains the concepts that modelers and finance practitioners use professionally in the world of investments. The beauty of trading is the ease of applying a predefined set of rules in order to identify market trends. The chapter also describes the set of indicators and conditions needed for each strategy to be profitable and the outcome of each of strategy. In recent years, quantitative trading has been one of the most applicable ways of investing. Recent evidence shows that a successful quantitative strategy is linked to relative pricing. Thus, this chapter focuses on several mean-reversion strategies that depend on time-varying relative returns and volatilities.

SECTION VI. EVALUATING AND REPORTING PORTFOLIO PERFORMANCE

Chapters 20, 21, and 22 discuss how portfolio performance and attribution analysis are important aspects of the portfolio management process in determining whether constructed portfolios achieve target returns on a macro level and are the drivers of that performance on a micro level. Style analysis, discussed in chapter 23, allows for portfolios to be evaluated against a benchmark of similar style. Portfolios must be constructed within the risk-tolerance constraints often achieved through the use of derivative securities, discussed in chapter 24. Chapter 25 presents industry standards for performance presentation, which allow clients to evaluate portfolio performance in a standardized manner.

Chapter 20 Evaluating Portfolio Performance: Reconciling Asset Selection and Market Timing (Arnaud Cavé, Georges Hübner, and Thomas Lejeune)
This chapter presents the major approaches for assessing portfolio performance in the presence of asset selection and market-timing skills. Given the difficulty of reconciling these two performance drivers, several ways to get a synthetic measure are proposed, but they do not fully reflect the joint qualities displayed by the portfolio manager. In a recently suggested option-replication approach, the linear and quadratic coefficients of the Treynor and Mazuy regression are combined to assess performance in the presence of market timing. This new correction has the potential to overcome the “artificial timing” bias and delivers encouraging results on a sample of 1,413 US mutual funds selected for an empirical analysis. Unlike alternative approaches proposed in the literature, most positive market timers seem to be rewarded for the convexity they add to their portfolio while negative market timers are penalized, and a correlation between abnormal performance and the convexity parameter is found.

Chapter 21 Benchmarking (Abraham Lioui and Patrice Poncet)
The practice of benchmarking is booming in the delegated portfolio management industry. As an asset-allocation tool, benchmarking is a reference to be followed by the manager in a more or less strict manner. As a tool for measuring relative performance, benchmarking helps in assessing the manager's skills involving market timing and/or security selection, and allows for meaningful definitions of the tracking error and the information ratio. The closely related issues of principal-agent contracting, compensation schemes and implicit incentives, and optimal benchmarking are discussed at length. The evolution in the design of appropriate benchmarks is also analyzed.

Chapter 22 Attribution Analysis (Nanne Brunia and Auke Plantinga)
This chapter discusses performance-attribution models that allow the observer to identify the timing and selection skills of portfolio managers. The focus is on holdings-based attribution models, because they generate more precise measurements of managers' skills than return-based models. The discussion starts with the basic attribution model and how to extend this model to accommodate internationally diversified portfolios. The basic model can also be extended to improve the precision of the measurements by allowing the user to create a risk-adjusted performance attribution without the need to run a time-series regression model. In order to capture the impact of investor timing, performance-attribution models can be extended further by including a component based on the internal rate of return.

Chapter 23 Equity Investment Styles (Andrew Mason)
Establishing a meaningful peer group or benchmark is crucial to those involved in selecting and evaluating investment funds and for those studying the risk-return profiles of those funds. This chapter outlines the developments in theoretical and empirical studies of equity-investment styles. The review considers equity-investment styles, the classification of stocks, multidimensional classification, growth-value orientation, funds styles, and the performance of investment funds. *Investment styles* are groups of portfolios sharing common characteristics that behave similarly under varying conditions. Style analysis focuses on two key areas: portfolio holdings and portfolio returns. This type of analysis has evolved toward using more sophisticated growth-value orientation methods, although there is no universally accepted approach. Such developments allow more differentiated analysis of investment-fund styles and improve the identification of peer groups and appropriate benchmarks. The recent developments in performance analysis underline the importance of establishing the appropriate benchmark or peer group, and that is the role of style analysis.

Chapter 24 Use of Derivatives (Matthieu Leblanc)
Derivatives are an ancient commercial practice. In the financial world, those products have become essential tools for any professional investor. Asset managers use them in their investment processes to take advantage of leverage, reactivity, hedging, and low transaction costs. However, the features of these instruments require

technical expertise that is not always part of managers' backgrounds. Investors often fear derivatives because they are poorly understood and sometimes misused. This chapter reaffirms the importance of futures and options and presents the main uses for risk and performance management.

Chapter 25 Performance Presentation (Timothy P. Ryan)

Performance presentation is highly important to investment managers, regulators, and existing clients, as well as prospective clients and their intermediaries. Through performance presentations, portfolio or strategy performance and implementation are clarified in a direct and insightful manner. Presentation content may include the absolute performance of portfolios or strategies, peer-relative performance, index-relative performance, key drivers of performance, asset allocations or exposure weights, ex-post risk-reward characteristics, style analysis, and weighted-average-portfolio characteristics. Performance presentations that are widely distributed and used by prospective clients or their intermediaries usually have specific content and a presentation format that is consistent with industry guidelines and/or required by rules-based regulators. One-on-one presentations and presentations for existing clients on their portfolios typically involve content that is less specific and based on fewer rules and regulator requirements.

SECTION VII. SPECIAL TOPICS

Financial innovations and strategies continue to emerge over time. Chapter 26 shows that exchange-traded funds (ETFs) have provided investors with an alternative to mutual funds as a means of gaining broad market exposure. Chapters 27, 28, and 29 discuss the growing importance of specific alternative investments—hedge funds, private equity funds, and venture capital—in achieving portfolio goals. Chapter 30 focuses on socially responsible investing.

Chapter 26 Exchange Traded Funds: The Success Story of the Last Two Decades (Gerasimos G. Rompotis)

This chapter discusses ETFs, which are one of the most successful financial innovations of the last two decades. A brief historical analysis of the evolution in the ETF market is provided. Next, the unique characteristics and benefits that made ETFs proliferate among investors worldwide are discussed. Several types of ETFs are described as well as the various trading strategies available with ETFs. Then, the chapter focuses on the empirical findings of the literature regarding the competition between ETFs and traditional mutual funds, the tracking ability for ETFs and the factors that usually affect their replication efficiency, and whether the divergence between the trading prices and net-asset values of ETFs indicates future returns.

Chapter 27 The Past, Present, and Future of Hedge Funds (Roland Füss and Sarah Müller)

The finance literature documents that investors can benefit from adding hedge funds as part of the alternative asset class to their asset allocation. By outlining the most important literature, this chapter gives a comprehensive overview on the fundamental characteristics of hedge funds and provides evidence supporting their use in a tactical and strategic portfolio-allocation context. Because the return properties of hedge funds differ from those of traditional asset classes, this chapter discusses appropriate performance measures as well as enhanced portfolio-optimization approaches that can be used when considering hedge funds in mixed-asset portfolios. It also includes information on relevant organizational and regulatory issues. This chapter also focuses on the increased systemic relevance of hedge funds for financial markets, the complex connections they have with other financial institutions, and the implications for future regulatory developments in this industry.

Chapter 28 Portfolio and Risk Management for Private Equity Fund Investment (Axel Buchner and Niklas Wagner)

Private-equity investments make up large portions of institutional investors' risky asset allocations. Hence, the risk of the asset class needs to be properly understood and managed. As private equity represents a relatively opaque and illiquid asset class, standard models are inapplicable. This chapter provides a novel framework based on modeling the stochastic cash flow dynamics of private-equity funds. The model consists of a mean-reverting square-root process, which represents a fund's capital drawdowns, and a geometric Brownian motion with a time-dependent drift, which captures the typical time pattern of capital distributions. The empirical analysis reveals that the model can be calibrated to a given fund's cash flow data. The chapter presents several application examples of the model in the portfolio and risk-management areas.

Chapter 29 Venture Capital (Pascal Gantenbein, Reto Forrer, and Nils Herold)

The venture capital industry has seen tremendous growth over the past two decades. However, research provides mixed results for its investment outcomes and reveals several methodological challenges and constraints arising from the lack of a comprehensive historical data set. Strong evidence suggests that a small number of funds perform extremely well while the majority of venture-capital funds underperform in public stock markets. Furthermore, academic research points out several distinct determinants of investment outcomes. Various studies, for instance, indicate that the experience and skills of both the general and the limited partners behind the fund have a strong effect on its performance. Additionally, evidence of performance persistence exists as well as of the strong impact of macroeconomic conditions. The venture-capital industry exhibits a cyclical pattern characterized by repeated periods of dramatic growth followed by slumps. Yet, whether booms are caused by fundamental factors or constitute an overreaction to perceived investment opportunities is unclear.

Chapter 30 Socially Responsible Investing: From the Fringe to the Mainstream (Hunter Holzhauer)

This chapter provides an introduction into the growing field of socially responsible investing (SRI), which has emerged over the last few decades from a fringe investment activity into the mainstream. With the amount of attention and investment SRI funds have begun to receive, navigating these waters has become extremely important for portfolio managers, pension advisers, charity trustees, corporate executives, and even individual investors. The first half of the chapter analyzes the changing tides of SRI by providing a concise portrayal of the progression of the SRI market, with special attention given to the South African–apartheid and subsequent divestments. The second half of the chapter includes a literature review of empirical findings of SRI performance compared to conventional benchmarks. The review focuses on evidence from equity funds, fixed-income funds, international funds, indices, and "sin" stocks. The chapter concludes with a brief summary of the SRI literature including critiques.

Summary and Conclusions

Since the 1950s and especially during the last few decades, portfolio management has become a more science-based discipline. Numerous theoretical advances combined with empirical research have provided portfolio managers with new concepts, insights, and techniques for making sound investment decisions. Additionally, portfolio managers now have a much larger array of investment products available to them than in the past. Enhancements in technology and evolving market structures have provided new challenges to professional money managers. These changes pose not only challenges but also opportunities for portfolio managers and investors alike.

Both the theory and practice of portfolio management have been moving ahead at a dizzying pace. Thus, gaining an understanding of the key principles and concepts of portfolio management and relevant empirical evidence is more important than ever. Although this is a formidable task, reading this book can help provide a better understanding about the existing state of knowledge and the challenges remaining in the area of portfolio theory and management. Enjoy the journey!

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Section One

PORTFOLIO THEORY AND ASSET PRICING

2

Modern Portfolio Theory

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Introduction

Portfolio theory refers to the design of optimal portfolios and its implication for asset pricing. The theory has undergone tremendous development since Markowitz (1952) first laid out the initial mean-variance framework. Numerous outstanding review articles and textbooks are now available on portfolio theory, such as Bodie, Kane, and Marcus (2011). The purpose of this chapter is to review the foundations of modern portfolio theory and its application when one must estimate parameters such as the expected returns (means) and covariance matrix.

The remainder of the chapter is organized as follows: The first part introduces the fundamentals of the efficient frontier, the capital asset pricing model (CAPM), and the theory of active management. For example, the chapter shows that beta, β, is the sole measure of a security's contribution to the risk of the portfolio that contains it. This result, often associated with the CAPM and believed to apply to large portfolios, is true no matter how small the portfolio and does not require the CAPM to hold. The chapter then reviews how the capital allocation line (CAL) and its slope (the Sharpe ratio) arise. The first part concludes by showing how the CAPM and the theory of active management arise from the same logic, albeit with different assumptions.

A large body of academic research has tackled increasingly complex intertemporal portfolio problems to incorporate realistic features, such as multiperiod investments, transaction costs, or the impossibility of trading in continuous time. In an attempt to improve the fit of the models, researchers also specified alternative utility functions, requiring increasingly complex mathematical tools. Intertemporal dynamic asset allocation hinges on the predictability of the investment opportunity set. The empirical literature documents the predictability of financial asset returns, such as the momentum effect observable for holding periods up to one year in length, the reversal of winners and losers at longer horizons, and the predictive power of some variables such as the dividend yield. Most of these effects are still the subject of disagreements in the literature. The results are somewhat mixed, sometimes strong in sample, albeit with low R squares, but often less convincing in out-of-sample experiments.

In contrast, an uncontested fact is that the investor does not know the parameters used to optimize the portfolio, such as the mean vector and the covariance matrix and sometimes the coefficients of predictive regressions used by quantitative portfolio managers. Parameter uncertainty alters the optimal portfolio allocation. While the pursuit of manageable dynamic asset allocation strategies is of great interest, one must absolutely incorporate parameter uncertainty into the optimization. Therefore, the second part of this chapter extends portfolio optimization to the case of unknown parameters. It first shows that increasing the frequency of sampling improves the estimation of the variance but not the mean. It then explains the predictive density of returns that needs to be considered under parameter uncertainty. In this light, the chapter discusses shrinkage, which reduces the dispersion of estimates, and the use of Bayesian priors to incorporate private views in the optimization. The chapter concludes by demonstrating how to optimally estimate future long-term returns for the purpose of asset allocation.

Optimal Portfolios with Known Parameters

This section first reviews optimal portfolio design in the one-period mean-variance framework, with the key combinations of a risk-free asset and several risky assets, where investors know the values of the relevant parameters. It then derives equilibrium (the CAPM) and active management implications. Finally, the chapter reviews the irrelevance of the horizon in a multiperiod setup with identically independently distributed returns.

BASIC MARKOWITZ MEAN-VARIANCE FRAMEWORK

The basic mean-variance framework assumes a single investment period, risky assets with normally distributed returns, and possibly a risk-free asset whose return is known ex-ante. In this framework, one can derive efficient sets agreed upon by all investors, sharing the same information, and investor-specific optimal portfolios depending on each investor's aversion to risk. A *risk-averse investor* dislikes risk. Given a choice between two investments with equal expected returns, a risk-averse investor chooses the one with less risk, as measured by standard deviation (σ). Normally distributed asset returns are fully characterized by their mean vector and covariance matrix. Therefore, investors only care about the mean and variance of their risky wealth. This is the mean-variance framework, actually plotted in mean versus standard deviation, as the figures in this chapter will demonstrate.

Investors' Preferences

Rational investors are risk averse. That is, they prefer a higher expected (mean) return and a lower variance or standard deviation. To rank all available risky assets, one needs to quantify an investor's trade-off between risk and expected return. The foundations of utility theory rely on fundamental axioms of rational behavior for risky prospects with any general distribution. The investor's *utility function* represents the investor's preferences in terms of risk and return (i.e., her degree of risk aversion). Hence, investor preferences along with the risk-and-return characteristics of available portfolios, serve as the basis for selecting an optimal portfolio for a given investor, the portfolio that maximizes the investor's expected utility.

One can show that under the assumption of normally distributed returns, the risk premium (i.e., the amount of mean return an investor is willing to give up in order to eliminate variance) is proportional to the product of a measure of relative risk aversion (RRA) by variance. The RRA could vary, possibly inversely, with the investor's wealth. Most financial applications assume a constant RRA, which is a reasonable approximation for portfolio applications that do not involve enormous variations in wealth. This is the case for most investments over most horizons.

In summary, with a constant RRA, denoted as γ, the certainty equivalent return (CE) of an asset with mean return μ and variance σ^2 is written as shown in Equation 2.1:

$$\text{CE}(\mu,\sigma) = \mu - 0.5\gamma\sigma^2, \tag{2.1}$$

where the term after the minus sign is the Arrow-Pratt risk premium due to the investor's risk aversion. The investor with risk aversion γ is indifferent between a risk-free CE return and the portfolio with mean μ and variance σ^2. In the mean-versus-standard deviation plot for a given CE, this is a parabola with intercept CE, known as an *indifference curve*. In Equation 2.1, a given value of CE generates one indifference curve, plotted in Figure 2.1. All the combinations of μ and σ on the indifference curve are worth CE to the investor. The investor wants to invest in assets with the highest-possible CE lying on the highest-possible indifference curve. Various key combinations of risky and risk-free assets will now be considered.

One Risky Asset and the Risk-Free Asset

Consider a single risky asset P with mean and variance (μ_P, σ^2) and a risk-free asset with return R_f. An asset allocation with weight w in P has a mean $R_f + w(\mu_P - R_f)$ and standard deviation $|w|\sigma_P$. By the constraint of full investment, the weight in R_f is $1 - w$. Both the mean and the standard deviation are linear in w. Therefore, in the typical case when μ is larger than R_f, the possible combinations with $w > 0$ lie on a straight line, with an intercept R_f and a positive slope $w(\mu_P - R_f)/(w\sigma_P)$; for instance, $(\mu_P - R_f)/\sigma_P$. This investment opportunity set is denoted the *capital allocation line* (CAL). The CAL is the line of possible portfolio risk-and-return combinations given the risk-free rate and the risk and return of a portfolio of risky assets. Negative weights span a mirroring line with a negative slope, which is of no interest because the CAL dominates it everywhere. Figure 2.1 shows CALs for several portfolios, P_1, P_2, and others, in the mean-versus-standard deviation space.

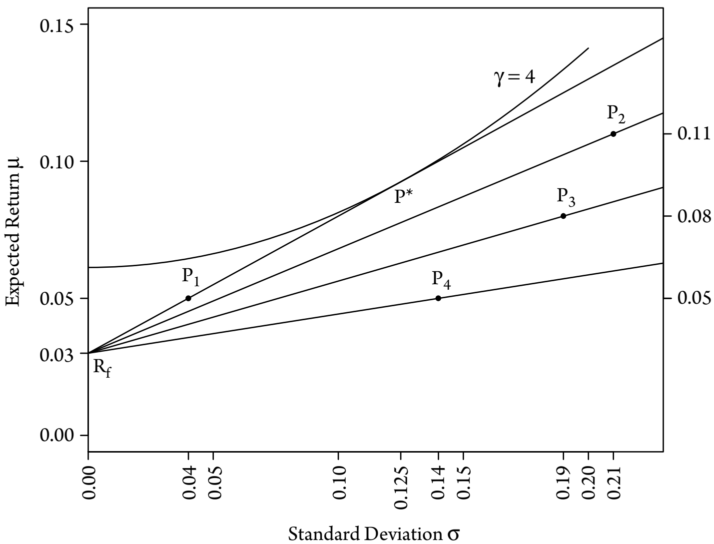

Figure 2.1 Capital allocation lines and Merton's optimal allocation. The figure shows the CALs for four portfolios and the optimal allocation P* in P_1 and R_f for a risk aversion, γ, of 4. The curved line (labeled γ = 4) is the indifference curve that is tangent the most steeply sloped CAL at P*, which represents the optimal allocation.

If these portfolios are mutually exclusive, investors must choose between mutually exclusive CALs. In Figure 2.1, the choice is unanimous because one of these lines, CAL_1, has a steeper slope than the others: it offers more expected return per unit of risk. For any allocation on another CAL, there are allocations on CAL_1 that dominate it unanimously; that is, with lower variance and an equal or higher mean (or with a higher mean and equal or lower variance). All investors agree, irrespective of their risk aversion, to rank mutually exclusive portfolios by the slope of their CAL, also known as the Sharpe ratio (Sharpe, 1966), denoted here as *Sh*:

$$\text{Sh(P)}=\frac{\mu_p - R_f}{\sigma_p}. \tag{2.2}$$

The *Sharpe ratio* is the mean return earned in excess of the risk-free rate per unit of standard deviation. It has become the industry-standard risk-adjusted performance measure due to its simplicity and conceptual appeal. Although the Sharpe ratio is restricted to mutually exclusive investments, later discussion in this chapter will show how to modify the analysis if portfolios can be combined. The Sharpe ratio is also only valid with no transaction cost in the risk-free asset. If the borrowing rate, R_b, is higher than the lending rate, R_L, borrowers ($w > 1$) face a lower Sharpe ratio than lenders ($w < 1$). This difference between the borrowing and lending rates causes a break in the CAL. When the investor has less than 100 percent of her wealth invested in the risky portfolio P ($w < 1$), she is effectively lending at the risk-free rate R_L. To invest beyond 100 percent in the risky asset P ($w > 1$), the investor switches to the higher borrowing rate, and, therefore, is on a CAL with a lower Sharpe ratio. Thus, differential borrowing and lending rates break down the unanimity of portfolio ranking. For example, in Figure 2.1, some investors may prefer P_2 to P_1. The more risk-averse investors and regulated funds that do not use margins are generally unaffected by this problem.

Given the CAL with the highest Sharpe ratio, which optimal allocation w* does an investor with risk aversion γ select? She maximizes her CE in Equation 2.1, where the mean and variance are the functions of the weight w seen above. The straightforward first-order condition yields the well-known optimal asset allocation in mean-variance, also known as Merton's formula (1969), shown in Equation 2.3:

$$w^* = \frac{\mu_p - R_f}{\gamma\sigma^2} \tag{2.3}$$

The curve at the top of Figure 2.1 is the best indifference curve (as in Equation 2.1) achievable by the investor. Its intercept is the maximized CE, which is obtained by investing w^* (from Equation 2.3) in P_1 and $1 - w^*$ in R_f. The indifference curve in Figure 2.1 is that of an investor with a risk aversion γ of 4. A more risk-averse investor would have a steeper indifference curve, and her optimal allocation w^* in Equation 2.3 would be smaller. However, all investors would agree to invest somewhere on CAL_1 because it has the highest Sharpe ratio.

Beta Is the Sole Relevant Measure of Risk

Consider two risky assets with means μ_1 and μ_2, standard deviations σ_1 and σ_2, and correlation ρ_{12}. The mean and standard deviation of a portfolio of these assets can be written as a function of the weight w_1, incorporating the constraint of full investment as $w_2 = 1 - w_1$. One can verify that the possible combinations of μ and σ span a hyperbola in mean versus standard deviation, often referred to as the *bullet*. A remarkable portfolio, located on the nose of the bullet, is the global *minimum variance portfolio* (MVP). In Figure 2.2, the portfolio that is farthest to the left (that has the least risk) is the global MVP.

Figure 2.2 plots the achievable investment frontiers and locations of the MVP for three cases of ρ_{12}. The MVP is remarkable because it marks the start of the positively sloped segment of the investment frontier, the only one of interest for any investor. The weight w_1 of asset 1 in the MVP is shown in Equation 2.4:

$$w_1 = \frac{\sigma_2^2 - \sigma_{1,2}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{1,2}}, \tag{2.4}$$

where $\sigma_{12} = \sigma_1\sigma_2\rho_{1,2}$. Equation 2.4 follows from the minimization of the variance of the portfolio of two assets.

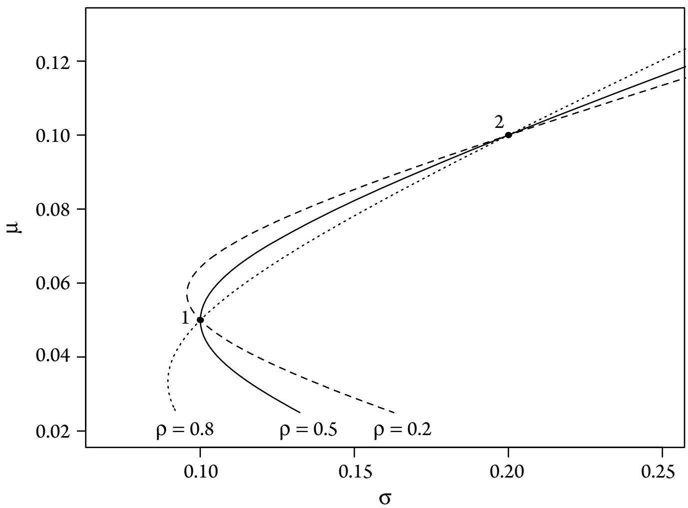

Figure 2.2 Effect of correlation on the minimum variance portfolio. The figure shows the returns and standard deviation for combinations of two assets for three values of their correlation, ρ. The value ρ = 0.5 is equal to the ratio of the two standard deviations, 0.1 and 0.2.

Now, take the view that asset 2 is in fact the investor's current portfolio containing many individual securities. Rename it *P* for convenience. Also rename asset 1 as *i* to denote an individual security, possibly already present in *P*. Then, w_i in Equation 2.4 is the amount of i added to *P*. The investor wants to know whether adding some *i* to her portfolio *P* will increase or decrease its variance. To determine this, one must quantify the effect of a change in the amount of i in P on the variance of *P*. Figure 2.2 shows that ρ, the correlation, is the key. For a low ρ, adding some i to P reduces variance; for a high ρ, it increases it. In a middle case, ρ is such that P is the MVP and there is no need to add or remove any *i*. To find ρ so that adding some i decreases the variance of P, set $w_i > 0$ in Equation 2.4. Note that the denominator is positive because it is the variance of the zero-investment long-short portfolio $R_1 - R_2$. Therefore, a simple manipulation of Equation 2.4 shows that ρ must be smaller than σ_P / σ_i, or $\sigma_{iP} / \sigma_P{}^2$ must be smaller than 1. This ratio is the beta of stock i with respect to portfolio *P*, denoted β_{iP}.

To summarize, if the beta of a stock with the current portfolio is larger (smaller) than 1, then increasing its weight increases (decreases) the portfolio variance. The argument is local because β_{iP} changes with w_i. Nevertheless, the beta of a stock with the investor's portfolio is the sole measure of its contribution to the portfolio variance. This powerful result has nothing to do with diversification and does not require portfolio *P* to be large. Even with a portfolio of two stocks, their beta with the current portfolio is the sole relevant measure of their contribution to its risk.

Another simple way to highlight the role of beta as the sole measure of risk is to note that the portfolio variance is the weighted average of the covariances of each stock i with the portfolio P: $\sigma_P^2 = \Sigma\, w_i\, \sigma_{iP}$. This implies that $\Sigma\, w_i\, \beta_{iP} = 1$. The weighted average of the security betas is 1 by construction for any portfolio. If some stocks have betas above 1, others must have betas below 1. To minimize variance, one decreases (increases) the weights in the high (low) beta stocks. Recall that the betas themselves change with the weights. Then, at the MVP, all the stocks have a beta of 1 with the portfolio.

Key Results in the Mathematics of the Efficient Frontier

The *efficient frontier* can be viewed as a set of minimum variance portfolios, each constrained to produce a desired level of mean return, only considering means above the MVP. While constructing the frontier would seem to require an optimization for each desired mean return, a key result is that if short sales are allowed, the efficient frontier is spanned by any two portfolios on it (Brandt 2009). Indeed, the weight vector of a minimum variance portfolio given a desired expected return μ_0 can be written as shown in Equation 2.5:

$$W_0^* = g + h\mu_0 = (1-\mu_0)g + \mu_0(g+h), \tag{2.5}$$

where g and h are vector functions of μ and V. The first equality in Equation 2.5 is a key result of the efficient frontier: When short sales are allowed, the efficient portfolio weights are linear in the desired expected return. The second equality is a simple manipulation showing that one can choose any two frontier

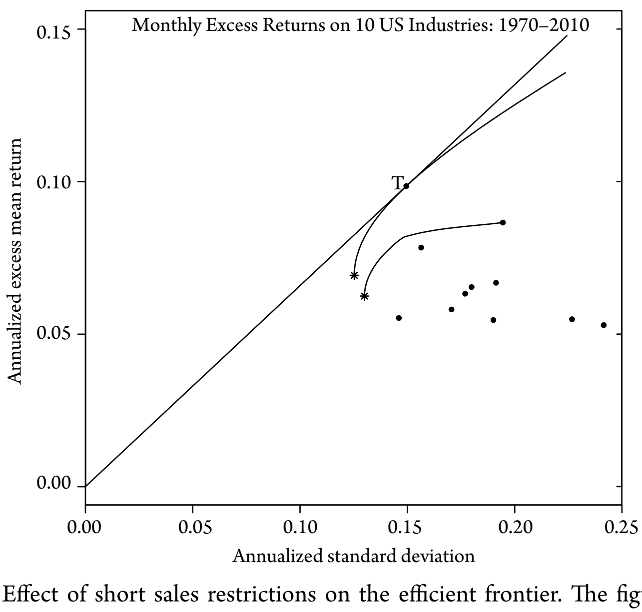

Figure 2.3 Effect of short sales restrictions on the efficient frontier. The figure shows two efficient frontiers for a set of ten US industry portfolios. The mean and standard deviations are annualized estimates. The lower frontier is constrained by a no–short sales restriction. The higher frontier allows short sales. The vertical axis is in excess returns over the risk-free rate.

portfolios (here, with weights g and $g + h$) to span the entire frontier. The efficient portfolio with desired mean μ_0 has weights $1 - \mu_0$ and μ_0 in the two spanning portfolios. In turn, any portfolio of several frontier portfolios is itself a frontier portfolio.

This result breaks down if short sales are not allowed. In this case, most frontier portfolios contain only a subset of the N assets in nonzero weights. Further, each asset appears with nonzero weight in a different subset of the frontier. Consequently, two frontier portfolios cannot possibly span the entire efficient frontier. Only two frontier portfolios (that are close to each other) containing the same assets can span the subset of the frontier between them. The frontier is said to have kinks; at each kink, an asset leaves the frontier and another one may enter. Whether or not short sales are allowed has a strong effect on the efficient frontier. Figure 2.3 shows a plot of the frontiers with and without short sales for 10 US industry portfolios.

Now, consider investors' choices. Even if they all agree on the frontier, each investor selects a personal frontier portfolio that maximizes her CE in Equation 2.1. When short sales are allowed, the first-order conditions of the optimization show that the vector of optimal weights is $(1/\gamma)V^{-1}(\mu - \lambda i)$, where λ is a scalar function of V, μ, and the investor's risk aversion *is* γ.

The introduction of a risk-free rate dramatically alters the previous decision-making process. Investors now consider all possible CALs between the risk-free rate and efficient risky portfolios. They all select the same frontier portfolio resulting in the CAL with the highest Sharpe ratio: portfolio T in Figure 2.3.

In a second step, investors select their individual optimal Merton allocation on the same CAL_T as seen in Equation 2.3. The introduction of the risk-free asset resulted in a two-fund separation, whereby all investors invest in the risk-free asset and the same tangency portfolio T, albeit in different amounts.

THE EFFICIENT FRONTIER AND ASSET PRICING

The previous section detailed the various scenarios of portfolio optimization available to an investor. The chapter now adds the assumptions of homogeneous information about μ, V, R_f, market efficiency, and frictionless and costless trading to show the implications for equilibrium of portfolio theory.

Recall the case with N risky assets and a risk-free asset. This section now shows how the Sharpe-Lintner CAPM (Sharpe, 1964) follows directly. If all investors have the same information μ, V, they all agree on the tangency portfolio, which is T in Figure 2.3. In equilibrium, demand meets supply and this tangency portfolio must be the capitalization-weighted portfolio of all risky assets, also known as the *market portfolio*. Therefore, the cap-weighted market portfolio is the tangency portfolio on the efficient frontier. It is the mean-variance efficient portfolio because no other portfolio has a higher Sharpe ratio. This is the basis for indexing investment. The CAL defined by the market is called the *capital market line* (hereafter, the CML). It is the optimal CAL given the assumptions made at the beginning of the section.

Consider now a risk-free rate R_f and a frontier of two risky assets, i and M. Quadratic optimization shows that the portfolio with the maximum Sharpe ratio, the tangency portfolio, has a weight as shown in Equation 2.6:

$$w_i^* = \frac{(\mu_i - R_f)\sigma_M^2 - (\mu_M - R_f)\sigma_{iM}}{(\mu_i - R_f)\sigma_M^2 + (\mu_M - R_f)\sigma_i^2 - \mu_i + \mu_M - 2R_f)\sigma_{iM}} \tag{2.6}$$

Let us apply this result to the context of equilibrium, with M representing the market portfolio, and i representing any security. In equilibrium, M already contains i in the optimal amount because it is already the mean-variance efficient, tangency portfolio of the frontier of all securities in the economy. Therefore, the weight w_i^* must be zero in equilibrium. Now set the numerator in Equation 2.6 to equal to zero. This immediately yields the well-known CAPM equation

$$\mu_i = R_f + (\mu_M - R_f)\beta_{iM}, \tag{2.7}$$

where beta (β_{iM}) is now considered with respect to the market portfolio. In Figure 2.4, the solid lines show a two-asset frontier of the market and a security P_1. M is the tangency portfolio of that frontier because the expected return of P_1 was set equal to the CAPM.

With no risk-free rate, Black (1972) derives a similar CAPM. With no CAL available, investors choose individual efficient risky portfolios by maximizing their CE. If short sales are allowed, a portfolio of frontier portfolios is on the frontier. Therefore, the demand portfolio of investor portfolios weighted by investors' wealth is on the frontier. In equilibrium, this demand portfolio equals the

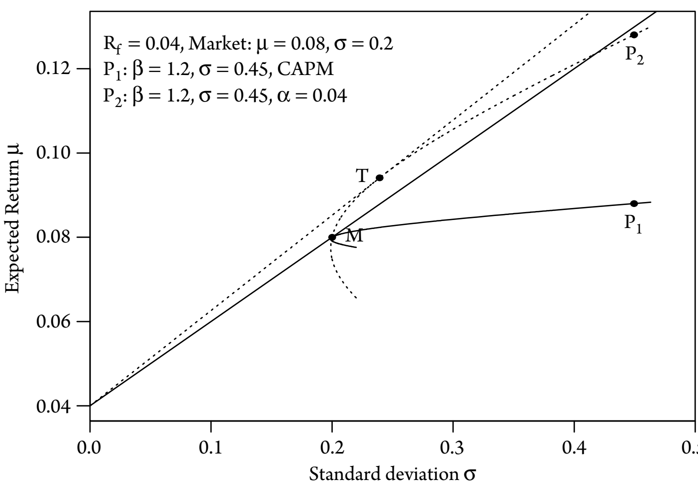

Figure 2.4. The CAPM versus active allocation.
The portfolios P_1 and P_2 have the same beta and standard deviation, but the expected return of P_1 is the CAPM expected return, while P_2 has a Jensen alpha of 0.04. When combining M and P_1, M is the tangency portfolio and has the highest Sharpe ratio. Combining M and P_2 results in attaining a Sharpe ratio higher than M's Sharpe ratio.

supply portfolio, the capitalization-weighted portfolio of all assets. The market portfolio is again on the efficient frontier. But investors do not need to hold it.

Black (1972) then obtains his version of the CAPM pricing equation by invoking two other results of the mathematics of the efficient frontier, given here without proof. First, for any efficient portfolio P, one can find a frontier portfolio with zero covariance with P, denoted Z_P , located on the negatively sloped segment of the frontier. Second, for any security *i*, one can show that

$$\mu_i = \mu_Z + \beta_{iP}(\mu_P - \mu_Z). \tag{2.8}$$

Clearly, a different initial *P* results in different β_{ip}, μ_P, Z_P, and μ_Z. However, it leads to the same μ_i. Black applies these results, using the market portfolio *M* as *P* since *M* is on the efficient frontier in equilibrium. This yields a CAPM in the absence of a risk-free rate, where excess-expected returns are also linear in β_{iM} but are computed in excess of the expected return of the zero-beta portfolio. Note that Black's CAPM is important in situations where investors do not believe that there is a truly risk-free security.

ACTIVE MANAGEMENT AND THE INFORMATION RATIO

This section discusses active management and portfolio performance evaluation. The best-known measure of performance, the Sharpe ratio, discussed in the previous sections, is only valid to rank mutually exclusive investments. The Sharpe ratio does not indicate how to optimally combine competing funds.

The previous section explains how in equilibrium, the capitalization-weighted market portfolio M achieves the best Sharpe ratio. In the active asset allocation framework, the manager identifies securities that may help improve upon the market portfolio's Sharpe ratio. This section introduces the *information ratio*, widely used in quantitative active asset management, which indicates how a security contributes to the Sharpe ratio of a portfolio. The reasoning will parallel the Sharpe-Lintner CAPM proof seen above, incorporating the fact that the expected returns of some securities differ from the CAPM prediction and therefore will improve upon the Sharpe ratio of the market. Departures from the CAPM are modeled via Jensen's (1968) apha, *a*, as shown in Equation 2.9:

$$\mathrm{E}(\mathrm{R}_{\mathrm{i}}) = \alpha_{\mathrm{I}} + R_f + \beta_i \mathrm{E}(\mathrm{R}_{\mathrm{M}} - \mathrm{R}_{\mathrm{f}}) \tag{2.9}$$

Equation 2.9 nests the CAPM, in which case *a* is 0. To estimate alpha and beta, Jensen runs the time series regression shown in Equation 2.10:

$$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{Mt} - R_{ft}) + \varepsilon_{it}, \tag{2.10}$$

where R_{it} is the return on the asset i; R_{ft} is the risk-free rate; R_{Mt} is the market index return; and ε is the random error of the regression, also known as the *unsystematic* or *idiosyncratic return*. The regression in Equation 2.10 also estimates the standard deviation of the idiosyncratic return σ_ε. In fact, it performs the variance decomposition for security *i*, shown in Equation 2.11:

$$\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon,i}^2. \tag{2.11}$$

This decomposition highlights the fundamental intuition of diversification. Adding securities to the portfolio while keeping the beta constant reduces idiosyncratic risk and hence reduces the total variance of the portfolio. In the limit, a fully diversified portfolio bears no idiosyncratic risk. Under the Sharpe-Lintner CAPM, one holds securities in their capitalization weights to eliminate idiosyncratic risk. The active manager departs from this diversified portfolio to increase the weight on securities with an attractive alpha. The cost of this strategy is an increase in idiosyncratic variance. The intuition is readily extended to multifactor models.

The active portfolio manager, with superior information on security *i* in the form of α_i, maximizes her Sharpe ratio by adding some *i* to *M*. The answer is again in Equation 2.7, but the manager does not assume an equilibrium, or w_i, equal to zero. Rather, she uses her superior information by substituting Equations 2.9 and 2.11 into 2.6. The resulting optimal portfolio of *M* and *i* can be shown in Equation 2.12 to have a Sharpe ratio S^* such that:

$$S^{*2} = S_M^2 + \left[\frac{\alpha_i}{\sigma_{\varepsilon i}}\right]^2. \tag{2.12}$$

The second term, $\alpha/\sigma_\varepsilon$, is the information ratio. The maximum contribution of a security to the improvement on the market portfolio Sharpe ratio is proportional to its alpha and inversely proportional to its idiosyncratic risk. This is because the optimal active position on α leads the manager to depart from *M* and to bear the idiosyncratic risk, ε_i. The label *i* can also denote a large active portfolio composed of a number of securities with nonzero alphas.

The dotted lines shown in Figure 2.4 contrast the CAPM and the active allocation. Portfolio P_2 only differs from P_1 by its expected return, equal to the CAPM plus an alpha. The combination of P_2 and *M* leads to a portfolio *T* with a higher Sharpe ratio than *M*. Note how P_2 helps improve on *M*'s Sharpe ratio while it has a Sharpe ratio inferior to that of *M*. This example illustrates that the Sharpe ratio of a security does not predict how that security will contribute to the Sharpe ratio of a portfolio.

Merton's Allocation: Irrelevance of the Investment Horizon

This section concludes by showing the full extent of the Merton optimal allocation result. This result is later revisited to incorporate measurement uncertainty in the mean. Merton (1969) derives the optimal asset allocation between one risky and one riskless asset in continuous time, a generalization of the one-period result in Equation 2.3. Consider an independent and identically distributed lognormal risky asset, where $log(1 + R) \sim N(\mu,\sigma)$.: Its H-period compound return