

Introduction to Portfolio Management and Analytics

Portfolio management is the process of managing money. Other terms commonly used to describe this process are *investment management*, *asset management*, and *money management*. Accordingly, the individual who manages a portfolio of investment vehicles is referred to as a *portfolio manager*, *investment manager*, *asset manager*, or *money manager*. We use these terms interchangeably throughout this book.

In discussing portfolio management, reference is made to the “investor.” The investor is the entity that will receive the benefits from the investment of proceeds that results from managing of the portfolio. Typically, an investor does not make portfolio management decisions. Rather, the investor delegates that responsibility to professional portfolio managers. Professional portfolio managers rely to varying degrees on portfolio analytics for identifying investment opportunities, keeping portfolios aligned with investment objectives, and monitoring portfolio risk and performance.

In this book we review widely used approaches to portfolio analytics and discuss new trends in metrics, modeling approaches, and portfolio analytics system design. This chapter provides an introduction to the portfolio management process. We begin with an overview of asset classes. We then describe the main areas of portfolio management where analytics are used, review trends in systems for portfolio analytics, and explain how the themes in this introduction chapter map to the content of the chapters to follow.

1.1 ASSET CLASSES AND THE ASSET ALLOCATION DECISION

An important decision in portfolio management is the allocation of funds among asset classes. This is referred to as the *asset allocation decision*.

The funds are then managed within the asset classes.¹ In most developed countries, the four major asset classes are (1) common stocks, (2) bonds, (3) cash equivalents, and (4) real estate. How do market participants define an asset class? There are several ways to do so. The first is in terms of the investment attributes that the members of an asset class have in common. These investment characteristics include (1) the major economic factors that influence the value of the asset class and, as a result, correlate highly with the returns of each member included in the asset class; (2) similar risk and return characteristics; and (3) a common legal or regulatory structure. Based on this way of defining an asset class, the correlation between the returns of different asset classes should be low.

The four major asset classes above can be extended to create other asset classes. From the perspective of a U.S. investor, for example, the four major asset classes can be expanded by separating foreign securities from U.S. securities: (1) U.S. common stocks, (2) non-U.S. (or foreign) common stocks, (3) U.S. bonds, (4) non-U.S. bonds, (5) cash equivalents, and (6) real estate. Common stock and bonds are commonly further partitioned into sectors, loosely referred to by some practitioners as asset classes. For U.S. common stocks (also referred to as *U.S. equities*), the following are classified as sectors: market capitalization stocks and value/growth stocks.

A company's market capitalization (or simply market cap) is the total market value of its common stock outstanding. For example, suppose that a corporation has 600 million shares of common stock outstanding and each share has a market value of \$100. Then the market capitalization of this company is \$60 billion (600 million shares times \$100 per share). The convention in the market for classifying companies based on market capital is as follows: mega-cap stocks (greater than \$200 billion), large-cap stocks (\$10 billion to \$200 billion), mid-cap stocks (\$1 billion to \$10 billion), small-cap stocks (\$300 million to \$1 billion), micro-cap stocks (\$50 million to \$300 million), and nano-cap stocks (less than \$50 million).

A publicly traded company's market cap is easy to determine given the market price per share and the number of shares outstanding are known. How are "value" and "growth" stocks defined? These definitions are based on the investment style pursued by portfolio managers for stock selection. Specifically, a growth stock manager seeks to perform better than the broad market by buying companies with high-earnings-growth expectations. It is notable that the growth manager terminology emanates from the

¹Although managing funds within asset classes is the dominant way of approaching the investment decision, more recently there has been a trend toward investing in factors rather than asset classes (see, for example, Hogan, Hodges, Potts, and Ransenberg [2015]). We discuss these trends in more detail in Chapters 9 and 10.

term “growth company.” There is no analog for the value manager—as in “value company.” Accordingly to value managers, two characteristics of value companies are that they trade at a low multiple relative to earnings and that they trade at a low price relative to their book value.

For U.S. bonds, also referred to as *fixed income securities*, the following are classified as sectors: (1) U.S. government bonds, (2) corporate bonds, (3) U.S. municipal bonds (i.e., state and local bonds), (4) residential mortgage-backed securities, (5) commercial mortgage-backed securities, and (6) asset-backed securities. In turn, several of these sectors are further segmented by the credit rating of the issuer assigned by commercial firms referred to as credit rating agencies. For example, for corporate bonds, investment-grade (i.e., high credit quality) corporate bonds and noninvestment-grade corporate bonds (i.e., speculative quality) are treated as two sectors.

For non-U.S. stocks and bonds, the following are classified as sectors: (1) developed market foreign stocks, (2) developed market foreign bonds, (3) emerging market foreign stocks, and (4) emerging market foreign bonds. The characteristics that market participants use to describe emerging markets is that the countries in this group:

- Have economies that are in transition but have started implementing political, economic, and financial market reforms in order to participate in the global capital market.
- May expose investors to significant price volatility attributable to political risk and the unstable value of their currency.
- Have a short period over which their financial markets have operated.

Loucks, Penicook, and Schillhorn (2008, 340) describe what is meant by an emerging market as follows:

Emerging market issuers rely on international investors for capital. Emerging markets cannot finance their fiscal deficits domestically because domestic capital markets are poorly developed and local investors are unable or unwilling to lend to the government. Although emerging market issuers differ greatly in terms of credit risk, dependence on foreign capital is the most basic characteristic of the asset class.

With the exception of real estate, all of the asset classes we identified earlier are referred to as *traditional asset classes*. Real estate and all other asset classes that are not in the list are referred to as *nontraditional asset classes* or *alternative asset classes*. The latter include also hedge funds, private equity, and commodities.

1.2 THE PORTFOLIO MANAGEMENT PROCESS

Regardless of the asset class being managed, the portfolio management process follows the same integrated activities. These activities can be defined as follows:²

1. The investor's objectives, preferences, and constraints are identified and specified to develop explicit investment policies.
2. Strategies are developed and implemented through the choice of optimal combinations of assets in the marketplace.
3. Portfolio performance evaluation is performed; market conditions, relative asset values, and the investor's circumstances are monitored.
4. Portfolio adjustments are made as appropriate to reflect significant changes in any or all of the relevant variables.

In this book we focus on the second activity of the portfolio management process, developing and implementing a portfolio strategy. Our emphasis is on analytics-based portfolio management.

1.2.1 Setting the Investment Objectives

Setting investment objectives starts with a thorough analysis of the investor's investment objectives. Investors can be classified as individual investors and institutional investors. Within each of these broad classifications is a wide range of investment objectives.

The objectives of an individual investor may be to accumulate funds to purchase a home or other major acquisition, to have sufficient funds to be able to retire at a specified age, or to accumulate funds to pay for college tuition for children. An individual investor may engage the services of a financial advisor/consultant in establishing investment objectives.

The investment objectives of institutional investors fall into one of the following two broad categories: nonliability-driven objectives and liability-driven objectives. Those institutional investors that fall into the first category can manage their assets without regard to satisfying any liabilities. An example of an institutional investor that is not driven by liabilities is a regulated investment company. The second category includes institutional investors that must meet contractually specified liabilities. A liability is a cash outlay that must be made at a specific future date in

²This categorization of the portfolio management process is described in Chapter 1 in Maginn and Tuttle (1990).

order to satisfy the contractual terms of an obligation. An institutional investor is concerned with both the amount and timing of liabilities, because its assets must produce the cash flow to meet any payments it has promised to make in a timely way.

Two examples of institutional investors that face liabilities are life insurance companies and defined benefit plans. Life insurance companies have a wide range of products. Some provide for pure life insurance protection while others offer investment-oriented life insurance products. One product that is investment-oriented is a guaranteed investment contract (GIC) whereby the life insurance company guarantees an interest rate over a predetermined time period on the funds given it to by a policyholder. When managing funds for a GIC account, the investment objective of the portfolio manager is to earn a return greater than the rate guaranteed.

In the case of pension funds, there are two types of pension plans offered by sponsors. The sponsor can be a corporation, a state government, or a local government. The two types of pension plans that can be sponsored are a defined contribution or a defined benefit plan. For defined contribution plans, the sponsor need only provide a specified amount for an employee to invest and the employee is then responsible for investing those funds. The plan sponsor has no further obligation. In the case of a defined benefit plan, the plan sponsor has agreed to make specified payments to the employee after retirement. Thus, the plan sponsor has created a liability against itself and in managing the assets of the pension plan, the portfolio manager must earn a return adequate to meet those future pension liabilities.³

Regardless of the type of investment objective, a benchmark is typically established to evaluate the performance of the portfolio manager. The determination of the benchmark to be used is made by the client in consultation with the portfolio manager and/or the client's consultant. As we explain in more detail in Chapter 10, a benchmark can be either a market index or a customized index.

³Institutional investors may have accounts that have both nonliability-driven objectives and liability-driven objectives. For example, a life insurance company may have a GIC account (which as explained above is a liability-driven objective product) and a variable annuity account. With a variable annuity account, an investor makes either a single payment or a series of payments to the life insurance company and in turn the life insurance company (1) invests the payments received and (2) makes payments to the investor at some future date. The payments that the life insurance company makes will depend on the performance of the insurance company's asset manager. Although the life insurance company has a liability, the insurance company does not guarantee any specific dollar payment.

1.2.2 Developing and Implementing a Portfolio Strategy

Typically, an investment policy is developed by the investor in conjunction with a consultant. Given the investment policy, investment guidelines are established for individual managers hired by the investor. The portfolio allocation among different asset classes is usually decided in advance, and then each portfolio manager is hired to manage a specific asset class, or a subset of an asset class. In this book, we discuss the actual implementation of portfolio strategies for two specific asset classes—equities and fixed income securities.

The implementation of the portfolio strategy can be divided into the following tasks:

- Selecting the type of investment strategy.
- Formulating the inputs for portfolio construction.
- Constructing the portfolio.

We explain each task next.

1.2.2.1 Selecting the Type of Investment Strategy Portfolio strategies can be classified as either *active (alpha)* or *passive (beta)* strategies. Between these extremes of passive and active strategies, there are strategies that have elements of both. For example, the core of a portfolio may be passively managed with the balance actively managed.

A *passive portfolio strategy* involves minimal expectational input, and instead relies on diversification to match the performance of some benchmark. In effect, a passive strategy assumes that the marketplace will efficiently reflect all available information in the price paid for securities and it is difficult to earn a return in excess of the benchmark without being exposed to more risk than the benchmark and after taking into account higher management fees and transaction costs. Passive portfolio strategies are also referred to as *indexing* since the typical benchmark is some market index. The strategies are also referred to as *beta strategies* because for historical reasons the term *beta* refers to the risk a well-diversified portfolio (such as an indexed portfolio) faces relative to a market index.

An *active portfolio strategy* uses available information and forecasting techniques to seek a better performance than a portfolio that is simply diversified broadly. These strategies are often referred to as *alpha strategies* because for historical reasons the term *alpha* refers to the return realized in excess of the return offered by the market. Essential to all active strategies are expectations about the factors that have been found to influence the performance of an asset class. For example, with active common stock

strategies this may include forecasts of future earnings, dividends, or price/earnings ratios. With bond portfolios that are actively managed, expectations may involve forecasts of future interest rates and sector spreads. Active portfolio strategies involving foreign securities may require forecasts of local interest rates and exchange rates.

A useful way of thinking about active versus passive management is in terms of the following three activities performed by the manager: (1) portfolio construction (deciding on the securities to buy and sell), (2) trading of securities, and (3) portfolio monitoring. Generally, active managers devote the majority of their time to portfolio construction. In contrast, passive managers devote less time to this activity.

Given the choice among passive and active portfolio strategies, what factors should a client consider in selecting a strategy? Three factors that should be considered are (1) the investor's view of how "price efficient" the market is, (2) the investor's risk tolerance, and (3) the nature of the investor's liabilities. *Marketplace price efficiency* refers to the difficulty a portfolio manager faces in earning a greater return than passive portfolio management after adjusting for the risk associated with a strategy and the transaction costs associated with implementing that strategy. There is a considerable literature in finance dealing with the issue of market efficiency. Given the existence of active portfolio managers and the flow of funds to those managers, clients obviously are not convinced that markets are sufficiently price efficient to warrant pursuing an indexing strategy.

1.2.2.2 Formulating the Inputs for Portfolio Construction Formulating the inputs for portfolio construction in an active portfolio strategy involves forecasting the inputs that are expected to impact the performance of a security and the portfolio as a whole. For example, often of interest are the factors that determine the expected returns of the assets in the portfolio and the covariance structure of the portfolio. Some of these inputs are extrapolated from past market data; others reflect the market's "expectations" that are priced into observed security prices in the market today.⁴ In the end, quantitatively generated forecasts are combined with the manager's subjective evaluation to form the inputs to the portfolio allocation framework.

1.2.2.3 Constructing the Portfolio Given the manager's forecasts and the market-derived information, the manager identifies attractive securities, and

⁴We discuss such asset pricing models in Chapter 9.

assembles the portfolio. The exact portfolio allocation may be based on solving an optimization problem as explained in Chapters 8, 10, 11, and 14, but the ultimate decision is made after careful human evaluation of the portfolio strategy.

In constructing the portfolio, there may be constraints that an investor may impose. For example, an investor may impose a constraint that is a concentration limit (i.e., maximum exposure) to a particular issuer or a particular market sector. When the objective is to outperform a benchmark, there may be a restriction imposed by the investor with respect to the degree to which the portfolio manager hired may deviate from some key characteristics of the benchmark. For example, there are portfolio risk measures that are used to quantify different types of risk that we describe in later chapters. These portfolio risk measures provide an estimate of the exposure of a portfolio to changes in key factors that affect the portfolio's performance. Typically, an investor will not set a specific value for the level of risk exposure. Instead, an investor may impose a maximum on the level of the risk exposure or a permissible range for the risk measure relative to the benchmark.

In addition to constraints that must be considered in constructing a portfolio, an investor may request that the portfolio manager take into consideration taxes. Tax considerations are important for most investors but certain institutional investors such as pension funds, endowments, and foundations are exempt from federal income taxation. Consequently, the asset classes in which they invest will not necessarily be those that are tax-advantaged investments.

1.2.3 Monitoring the Portfolio

Once the portfolio has been constructed, it must be monitored. Monitoring involves two activities. The first is to assess whether there have been changes in the market that might suggest that any of the key inputs used in constructing the portfolio may not be realized. The second task is to monitor the performance of the portfolio.

Portfolio performance is monitored in two phases. The first phase is *performance measurement*, which involves the calculation of the return realized by the portfolio manager over a specified time interval (the *evaluation period*). The second phase is *performance evaluation*, which determines whether the manager has added value, and how the portfolio manager achieved the observed return. The decomposition of the performance results to explain why those results were achieved is called *return attribution analysis*. A detailed example of performance evaluation is described in Chapter 12.

1.2.4 Adjusting the Portfolio

Portfolio management is an ongoing process, and portfolio strategies are in fact performed in a multiperiod context. Portfolio selection strategies are designed to take advantage of market conditions, but those conditions exist temporarily, and as the conditions change, the portfolio manager must perform *portfolio rebalancing*. In doing so, the portfolio manager typically takes the following steps.

By monitoring developments in the capital market, the portfolio manager determines whether to revise the inputs used in the portfolio construction process. Based on the new inputs, the portfolio manager constructs a new portfolio. In constructing a new portfolio, the costs of trading are often evaluated against the benefits of rebalancing.

Specifically, a portfolio manager who wants to adjust the portfolio can do so by changing the risk exposure of each security in the portfolio. When doing so, the portfolio manager must consider the adverse implication of rebalancing the portfolio exposures resulting from the incurrence of transactions costs associated with purchasing and selling securities. Moreover, adjusting a portfolio's risk can have adverse tax consequences. A transactionally efficient vehicle for controlling portfolio risk is to use financial derivatives. These instruments, which include futures, forwards, swaps, and options, are discussed in Chapters 16 through 18, where we also show how they can be used to control a portfolio's risk. The notion that financial derivatives can be used to control portfolio risk may seem contrary to stories in the popular press about how some investors who have used derivatives have incurred major financial losses. It suffices to say at this juncture of our discussion of portfolio management that although financial derivatives can be used for speculative purposes, prudent portfolio management utilizes these instruments to modify a portfolio's risk exposure.

1.3 TRADITIONAL VERSUS QUANTITATIVE ASSET MANAGEMENT

There are two general approaches to portfolio management: traditional and quantitative. Both approaches seek to find the best securities to include in a portfolio in order to construct an efficient portfolio. Our focus in this book is on quantitative portfolio management and we provide the essential portfolio analytics needed to implement the activities of portfolio management described in this chapter.

Let's briefly look at how in general the traditional and quantitative approaches to portfolio management differ. Recall that inputs in constructing a portfolio are the expected return and risk of the securities

under consideration. Given the generated inputs for each security and other attributes that a portfolio manager uses to select potential candidate securities, how that information is used differentiates traditional and quantitative portfolio managers. To illustrate, suppose that a portfolio manager is considering 3,000 securities as potential candidates for creating a portfolio. The first step is screening the 3,000 securities to select potential investments. With the traditional approach, the 3,000 securities would be screened by using certain criteria that are provided by the portfolio manager. Once the 3,000 securities are whittled down to a reasonable number of securities, say, N (which is much less than 3,000), security analysts who are part of the portfolio management team will perform an in-depth analysis of each security, looking at the fundamental characteristics of the security and the security issuer. The determination of N is constrained by the size of the portfolio management team. At the end of this process, the candidate list will be less than N . With quantitative portfolio management, the 3,000 securities would be screened based on quantitative criteria that the portfolio manager believes are drivers of returns to create acceptable securities but the number of candidate securities, N , will be far larger than the candidate list created by the traditional approach. The reason is that the criteria used in the quantitative approach will create a list that is not necessarily further investigated by the portfolio management team. The candidate list will be used as the *trade universe* from which to construct the portfolio.

The next step under both approaches is the selection of the securities from the candidate list, less than N in the traditional approach and N in the quantitative approach. That is, this step involves the selection of the securities and the amount that should be allocated to each. In the traditional approach, this is often done in a somewhat arbitrary manner by the portfolio manager. The portfolio constructed from the candidate list of securities will be structured to obtain the desired risk exposure and potential return. With the quantitative approach, the portfolio is typically created from the N securities using the optimization models described in this book. Doing so will allow for the creation of a portfolio with risk and return attributes based on various risk metrics that we describe in this book.

1.4 OVERVIEW OF PORTFOLIO ANALYTICS⁵

The term *analytics* in the context of investments refers to all the ways in which investments are screened, modeled, tracked, and evaluated. Investment analytics can include:

1. *Market analytics*: analysis of real-time market data, prices, financials, earnings estimates, market research reports.

⁵Based on Pachamanova and Fabozzi (2014).

2. *Financial screening*: selection of investments of interest based on pre-specified financial and nonfinancial criteria.
3. *Quantitative modeling*: asset allocation and trading models.
4. *Financial analytics*: performance evaluation, characteristics and attribution, risk measurement, asset allocation or asset-liability management.

Qualitative and quantitative asset managers rely on quantitative investment models to a different extent. Different modeling tools are used by managers employing active versus passive investment styles. However, utilizing some fundamental level of portfolio analytics is critical for identifying investment opportunities, keeping portfolios aligned with investment objectives, and monitoring portfolio risk and performance. Analytics-based portfolio management enables investment managers to filter information quickly, take advantage of statistical arbitrage opportunities, and smoothen out inefficiencies such as transaction costs incurred during trading and tax consequences of investment decisions.

In this section we review standard paradigms for portfolio analytics and survey recent developments. We also explain the quantitative methodology behind the techniques and the software implementation so that readers can catch a glimpse of the process from beginning to end. To introduce the subject, in this chapter we walk the reader through the analytics methods during the steps of the investment process outlined earlier: (1) market analytics, (2) securities screening, (3) asset allocation and trade timing analytics, and (4) investment strategy testing and performance evaluation. Portfolio analytics is an iterative process, and investment managers often go back and forth between these steps rather than following them in a strict sequence. In Section 1.5, we explain how these topics are addressed in the book.

Before we begin, it is helpful to outline how a typical system for quantitative investment management is structured. A possible structure is outlined in Exhibit 1.1. The fundamental piece of the system is *data*—data can be sourced from external sources, from a data vendor such as Thomson Reuters, FactSet, S&P Capital IQ, or Bloomberg, or from proprietary research. Most generally, there are two types of financial data structures: time series and cross-sectional data. *Time series data* contain records of the values of prices, factors, and market variables over time. *Cross-sectional data* are information collected about multiple factors and companies at a single point in time (so that the data provide a *cross-section* of the companies of interest). Sometimes, data are stored in *panels*: panels contain cross-sectional data collected at different points in time. The cross-sectional data stored in panels may be different at the different points in time—for example, the collection of companies may be different.

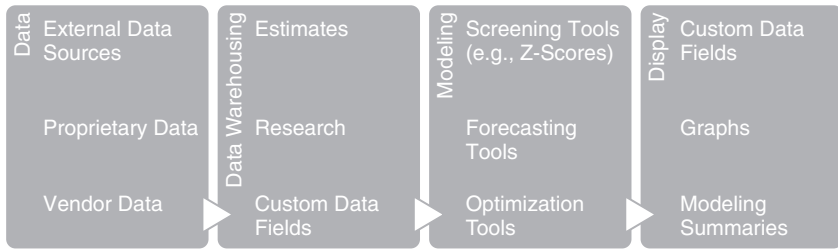


Exhibit 1.1 A typical system for quantitative investment management.

The data then typically get processed through a *data warehousing tool*, which could contain estimates, research, and custom data fields calculated from the original data. Data warehousing is also where the data cleanup and organization occur. On top of the data warehousing tool sit tools that enable *modeling* based on the data, such as statistical and optimization modeling tools. Finally, the results of the analysis are summarized and displayed to aid the investment manager's decision making. The last two stages—modeling and visualization—are often employed in an iterative process of evaluating trends, determining strategies, backtesting, and assessing portfolio performance.

We discuss systems for portfolio analytics later in this chapter, including not only well-established vendors of portfolio management analytics tools but also general principles of building custom systems using cloud-based resources and open-source modeling software such as R.

1.4.1 Market Analytics

A large percentage of investment performance is contributed by trends in the overall market. A successful investment manager constantly analyzes market trends and thinks about ways to capitalize on new market information. Market analysis can be as straightforward as thinking through the implications of news, new market reports, and changes in political or economic conditions. Simple, but effective ways to follow market trends include considering time series plots of important market indices over time, or how market indices and industries move against each other. The latter trends can be analyzed by looking at *relative strength*—the ratio of one sector returns over another sector returns, or the ratio of the returns of one sector over particular indices.

An interesting composite view of the relative strength of multiple stocks or sectors as well as the momentum that exists in the market is provided

by Relative Rotation Graphs (RRGs).⁶ Such graphs enable visualization of the movement of a selected industry relative to the benchmark across a prespecified time period such as 12 weeks. RRGs are now a part of the Bloomberg analytics suite. Because most investment managers measure their performance against a benchmark, knowing which groups of securities are trending toward outperforming or underperforming the portfolio manager's benchmark is valuable information. RRGs summarize multiple time series in such a way that the momentum and relative performance of sectors against the benchmark can all be displayed in one graph. On the horizontal axis of RRGs is the proprietary JdK RS-Ratio. It is a normalized metric of the relative strength of multiple sectors and indices against each other. On the vertical axis is a metric of the momentum of the stock or industry. The concept of momentum has to do with the belief that if the stock or industry had a positive return in the previous time period, it is more likely to have a positive return in the next time period. Depending on the value of their metrics, sectors can be in the "leading" (top right), "weakening" (bottom right), "lagging" (bottom left) or "improving" (top left) quadrant of the scatter plot. The expected movement of sectors in the graph over time is clockwise—an industry becomes "hot," prices rise as investors swarm to invest in it, which decreases relative performance and eventually the industry's relative worth decreases again.⁷ An investment strategy based on the expected behavior in an RRG would invest when an industry is in the upper left quadrant, and sell when the industry is in the lower right quadrant.⁸

Marketing analytics can be as complex as *technical analysis*, which uses statistical and econometric techniques to evaluate market activity, and decides whether to buy a security or increase holdings in an industry based on trends in prices and trading volume. Technicians look for patterns in the time series of the data related to securities in the market. Momentum, briefly explained earlier, is one such pattern identified by technical analysis. Technicians believe that, eventually, prices will adjust to their proper levels, but that in the meantime there are opportunities to make profits.

Making above-average returns in the market is not easy, and should be virtually impossible if one believes a group of theories known collectively as the *Efficient Market Theory*. In its weak form, the Efficient Market Theory

⁶www.relativerotationgraphs.com/.

⁷If the prespecified time periods are small in length, the movement of a particular industry may not follow the expected trend. Weekly observations often provide a stable enough view.

⁸Good illustrations are available from <http://allstarcharts.com/relative-rotation-graph-explained/> and www.scribd.com/doc/119943614/Relative-Rotation-Graph.

claims that current security prices reflect all the information available in previous security prices, so one should not expect technical analysis to lead to increased profits. In its semi-strong form, the Efficient Market Theory claims that security prices reflect all *publicly* available information in the market, so models based on publicly available data should not be helpful for picking out “winners.” Finally, the strong form of the Efficient Market Theory claims that security prices reflect all publicly or privately held information in the market, so inside information should not be helpful in picking out stocks.

While multiple studies have disproved the strong form of the Efficient Market Theory, there is sufficient evidence that the market is at least *very* efficient. Still, one of the reasons the market is so efficient may be that investors are exploiting mispricing to bring market prices to their equilibrium levels. The past decade has witnessed the spread of *algorithmic trading* (also called *algo trading*, *automated trading*, *smart order trading*, *program trading*, and *rules-based trading*), which has taken technical analysis to the next level. Algorithmic trading is the use of electronic platforms to execute trading orders in an automated fashion according to a set of rules that could take into consideration market impact of the trade, execution risk analytics, cost-aware portfolio construction, and the use of market microstructure effects (Fabozzi, Focardi, and Kolm 2010). A special type of algorithmic trading is high-frequency trading, which involves rapid trading so that investment positions are held only for seconds or milliseconds.

More recently, technicians have added text analytics and social media analytics to their toolbox. Mining for the presence of words or phrases that have an impact on prices or the volatility in the stock market can discover opportunities to realize short-term gains. Social media data sources include Twitter, Facebook, YouTube, and Instagram, and involve huge, unstructured data that cannot be handled with spreadsheets and require new tools to process. A variety of data-crawling tools such as IBM InfoSphere, SAP NetBase, and Supermetrics Data Grabber have made sorting through such data more manageable. Database Management Systems (DBMS) such as Oracle and Microsoft SQL Server can be used to store and organize the information, and analytics tools such as R (a free open-source language for statistical computing and data mining), IBM SPSS Modeler, IBM Cognos, RapidMiner, SAS, and SAP Predictive Analytics can be used to mine for interesting patterns. Several instances of automated trading based on reactions to tweets garnered attention recently. For example, it was believed that a “bot” was able to take advantage of information about Intel’s planned acquisition of Altera, a company that makes digital circuits, on Friday, March 27, 2015. Within a second of the headlines

on the possible deal appearing on Dow Jones Newswires, and before Altera's shares were halted, somebody purchased \$110,530 worth of cheap Altera options to realize a \$2.4 million profit by the time humans digested the news.⁹

With the exception of momentum or autocorrelation, tests of technical rules do not confirm a clear advantage of particular strategies. Technical trading also is not exactly comparable to portfolio management because it tries to identify profit-maximizing strategies over the short term while most portfolio strategies are supposed to work for months or years. In contrast to technicians, portfolio managers try to identify factors that are drivers of performance over a longer term. The next section reviews analytical approaches for doing so.¹⁰

1.4.2 Financial Screening

The *screening* of investments typically relies on the identification of important factors that influence investment performance. Such factors may be fundamental, macroeconomic, statistical, technical, analyst views, and social responsibility. Once factors and industries of interest have been identified, specific securities can be selected as candidates for inclusion in the portfolio. A variety of screening methods are used by portfolio managers, including some that rely on simple statistical metrics of a particular security's desirability relative to other securities. Advanced quantitative methods for portfolio construction include using *factor models* built based on multivariate statistical techniques. In addition to helping in the screening process, factor models provide important inputs, such as expected returns, covariances, and possible scenarios for returns, that are then used in asset allocation, portfolio rebalancing, and risk attribution models. Factor model construction from a technical point of view is covered in Chapter 9. Chapters 12 and 14 contain examples of using factor models for equity and fixed income portfolio construction and risk decomposition.

⁹The full story is available from www.slate.com/articles/business/moneybox/2015/04/bot_makes_2_4_million_reading_twitter_meet_the_guy_it_cost_a_fortune.html.

¹⁰The distinction between long-term and short-term is sometimes ambiguous. For example, Northfield Information Services, a vendor of portfolio risk management software, recently incorporated a tool for scoring news about companies into its portfolio risk models. Two vendors of such tools are Alexandria Investment Research and Thomson Reuters. Portfolio risk model vendors have typically targeted longer term investors but in this case, the risk scoring is based on data mining algorithms applied to recent data from news sources found to be significant for prediction.

1.4.3 Asset Allocation Models

When investors research securities, they can separate attractive from unattractive investments. An important part of the investment decision, however, is how much to invest in securities deemed attractive. This decision reduces to finding the “best” weights of the different securities in the portfolio. Some portfolio managers use *ad hoc* methods for determining portfolio weights, while some rely on structured risk-return analysis methods that require employing advanced modeling techniques such as optimization.

1.4.3.1 Ad Hoc Methods for Portfolio Allocation There is a variety of ad hoc and computational methods that investment managers use for portfolio allocation in practice. Simple ways to invest include selecting interesting securities and then investing in them equally. Some researchers (see, for example, DeMiguel et al., 2009) have found after substantial computational tests that in the case of equity portfolios, such a seemingly naïve strategy may actually have merit. Other ad hoc methods imitate the calculation of well-known market indices. For example, some equity portfolio managers may weigh the stocks in their portfolios by their market capitalization, which is how the S&P 500 Index is calculated. This method is referred to as *value weighting*. To obtain the market capitalization for a company, the number of shares outstanding is multiplied by the current market price per share. The market capitalizations of all companies under consideration are added up, and the weight of each company’s stock in the portfolio is determined as the ratio of the company’s market capitalization and the total market capitalization. Other equity investment schemes imitate the *price-weighting* method favored by indices like the Dow Jones Index. The same number of shares is bought from each stock, so that the weight of the stocks in the portfolio is proportional to their price in the market.

1.4.3.2 Asset Allocation as an Optimization Problem More complex analytical weighting methods of securities in the portfolio are based on using optimization algorithms. Such algorithms enable portfolio managers to sort quickly through a vast possible set of investment decisions that often involve conflicting tradeoffs between goals and limited resources or constraints imposed by clients. As we explain in Chapters 6 and 7, optimization problems generally consist of three parts:

1. A list of decision variables that state the quantities under the manager’s control (in the investment management context, these are typically the portfolio weights).
2. An objective function, which states in mathematical terms the goal of the optimization, and expresses it in terms of the decision variables.

3. A set of constraints that represents the requirements and limitations faced by the investment manager.

To implement the optimization, a manager can use directly optimization solvers such as IBM ILOG's CPLEX, or portfolio optimization software provided by vendors such as Bloomberg, Northfield, MSCI Barra, and Axioma. The optimization formulation must be in a form that the software understands.

Before specifying the optimization problem for the software, the manager needs to specify the trade universe, that is, the set of securities that are under consideration for investment. For an active manager, the trade universe may be a set of stocks that were selected based on fundamental research (in the case of equity portfolio management) or credit quality (in the case of fixed income portfolio management), or the securities in a particular industry. For a passive portfolio manager, the trade universe may be the securities in a benchmark index such as the Russell 3000 Index or the Barclays Capital U.S. Aggregate Bond Index.

The optimization software then determines the optimal weights of the securities in the portfolio (when used for portfolio construction), or the optimal trades to accomplish specific targets (when used for portfolio rebalancing).

Many investors take a single-period view of investing, in the sense that the goal of the portfolio allocation procedure is to invest optimally over a single predetermined period of time, such as one month. Even though some investment companies, especially institutional investors, have a long investment horizon, they often treat that horizon as a sequence of shorter period horizons. Risk budgets are often stated over a time period of a year, and return performance is monitored quarterly or monthly.

1.4.4 Strategy Testing and Evaluating Portfolio Performance

Strategy testing and continuous evaluation of portfolio risk and performance are very important elements of a disciplined investment management process. This section discusses issues in backtesting and reviews metrics for portfolio performance evaluation. We should mention that the data quality plays a critical role for the validity of portfolio performance evaluation. We spend more time on data quality issues when we discuss predictive model estimation in Chapter 9 but we provide a few important considerations in this chapter.

1.4.4.1 Strategy Testing The first step in evaluating an investment strategy is to test it on historical data—a process referred to as *backtesting*.

Before running the test, the investment manager needs to make a decision on the time period over which the strategy is to be tested, the rebalancing frequency, and how to assess the results of the backtest. The available data are usually split into *in-sample* (test) data and *out-of-sample* (validation) data. The manager tests a number of models on the in-sample data and when a satisfactory model is found, the manager uses the out-of-sample data to check whether the model performs well. It is tempting to find different interesting models based on the in-sample data, and then pick one from among them that performs the best on the out-of-sample data. However, this procedure may have serious issues.¹¹ To follow a statistically sound methodology, once a model has been picked based on the in-sample data, if it fails on the out-of-sample data, it should be discarded, and the process should not be repeated again with the same data set.

In statistics, this problem is referred to as the *multiple testing problem*, and can be explained as follows (American Statistical Association 1999, guideline #8):

Running multiple tests on the same dataset at the same stage of an analysis increases the chance of obtaining at least one invalid result. Selecting the one “significant” result from a multiplicity of parallel tests poses a grave risk of an incorrect conclusion. Failure to disclose the full extent of tests and their results in such a case would be highly misleading.

Multiple testing combined with partial reporting (that is, reporting of only favorable results) results in *selection bias*. A similarly concerning issue is *backtest overfitting*, which results from selecting a strategy that appears to fit well a realized configuration of security returns but, because such configurations are random in nature, rarely has a chance of repeating itself in the future and can hence lead to very suboptimal investments. Multiple testing problems and backtest overfitting have become hot research topics in statistics in recent years.¹²

1.4.4.2 Evaluating Performance Proper understanding of whether recorded performance was a result of skill or luck is critical for maintaining performance going forward. Popular metrics of portfolio performance are listed below. In this book, we review a number of statistical concepts and methods

¹¹For a discussion of the issues, see Bailey and Lopez de Prado (2014) and Chincarini and Kim (2006).

¹²See Bailey and Lopez de Prado (2014) for a list of references and specific applications to portfolio management.

used for their estimation, including the concepts of variability (standard deviation, quantiles) and model building (in particular, regression). The chapters in which we review the metrics of portfolio performance in more detail are listed in parentheses after the definition of each metric in the list below.

- *Portfolio end-of-year return*: This provides a quick view of the end result of the investment policies. (Chapter 12)
- *Variability of the portfolio returns over the year*: A popular metric of variability is the standard deviation. The higher the standard deviation of returns over the year, the riskier the investment strategy. However, standard deviation is only valid as a measure of risk when returns are symmetrically distributed. Sometimes, portfolio managers use a one-sided risk measure such as semi-standard deviation, value-at-risk (VaR), or conditional value-at-risk (CVaR) to assess the portfolio downside risk. (Chapters 2, 12, 14)
- *Tracking error*: Tracking error focuses on the difference between the portfolio returns and the returns of a benchmark. This difference is referred to as the *active return*. Portfolio performance measurement is concerned with evaluating ex-post (as opposed to ex-ante) tracking error, which is calculated as the standard deviation of active returns, and is reported on an annualized basis. (Chapters 10, 12, 14)
- *CAPM beta (β)*: The investment manager may assess the risk of the portfolio against the market by running a regression with the realized returns on the portfolio as the explanatory variable and the realized returns on the market as the response variable. The CAPM beta (β) is the regression coefficient in front of the explanatory variable, and reflects the risk of the portfolio in relation to the market. (Chapters 4, 9, 12)
- *Alpha*: Alpha is the average difference between the portfolio returns and the returns of a benchmark over a prespecified time period. Alpha is used to measure the value of the investment manager. A positive alpha means that the portfolio manager outperformed the benchmark; a negative alpha means that the portfolio manager underperformed the benchmark.
- *Information ratio*: The information ratio (IR) is the ratio of the excess return or alpha the manager produced and the tracking error incurred relative to the benchmark. The IR is computed by dividing the portfolio returns in excess of the benchmark return (the alpha) by the volatility (standard deviation) of the excess portfolio return (the tracking error). (Chapter 10)
- *Sharpe ratio*: The Sharpe ratio measures the portfolio excess return per unit of risk, where the excess return is measured as the difference

between the portfolio return and the risk-free return (typically, the average return on the one-month or three-month U.S. Treasury bill), and the risk is measured as the standard deviation of the portfolio returns over the time period analyzed. The Sharpe ratio is only useful as a relative metric of performance, but in general, a higher Sharpe ratio is better. (Chapter 8)

- *Maximum drawdown*: The maximum drawdown is measured from a time series of portfolio values. It is reported as a percentage, and is the largest peak-to-trough decline of the portfolio value (as a percentage of the largest peak) before a new peak is achieved. For example, suppose that a portfolio reaches \$20 million, then drops to \$17 million, then climbs to \$18 million, then drops to \$15 million, and then reaches a new peak of \$23 million. In this case, the maximum drawdown is $(\$20,000,000 - \$15,000,000)/\$20,000,000 = 25\%$.
- *Calmar ratio*: The Calmar ratio is the ratio of the portfolio return to the maximum drawdown over a prespecified time period. The lower the Calmar ratio, the worse the portfolio performance over that time period.¹³

As we explained in Section 1.2.3, an important part of portfolio performance measurement is *performance attribution*: breaking down the portfolio return in a way that allows for identifying the individual causes that led to the realized portfolio performance. Multifactor models (explained in Chapter 9) are often used to evaluate exposure to different factors and to monitor performance.

1.4.5 Systems for Portfolio Analytics

As explained at the beginning of this chapter, systems for portfolio analytics typically have four components: data sources, data warehousing, modeling, and visualization. Banks and investment companies structure their systems differently. Data, for example, may be purchased from data providers such as Bloomberg L.P., Thomson Reuters, FactSet Research Systems, or S&P's Capital IQ. Data warehousing may be done in-house or by companies like IBM Algorithmics, Bloomberg, or Xignite. Data modeling and visualization tools can be implemented in-house or purchased from specialized portfolio management software providers like IBM Algorithmics, MSCI

¹³Other Sharpe-like (reward/risk) ratios that substitute drawdown for standard deviation are used as well, such as the Sterling ratio, which uses average drawdown over a given time period instead of maximum drawdown.

Barra, Northfield Information Services, Bloomberg, Axioma, and FactSet Research Systems, among others. More general computing and modeling environments such as MATLAB have also been deployed enterprise-wide.

There have been two major trends in the design of systems for portfolio analytics. The first trend is that portfolio analytics tools are being integrated with data feeds, making the different components of the system compatible and easier to manage for the end customer. Recognizing this trend, companies like Bloomberg and FactSet Research Systems, which had traditionally been providers for real-time news coverage, data feeds, and single security analytics, have added portfolio analytics tools to their suites of buy-side trading systems. Specialized portfolio analytics software providers such as MSCI Barra, IBM Algorithmics, and Northfield Financial Services are also addressing the integration of analytics tools and data feeds, providing services to help customers integrate their data with the modeling tools provided by the companies.

The second trend is that the availability of cheap computing infrastructure through cloud-based resources provided by companies like Amazon, Google, IBM, and Microsoft as well as free open-source modeling tools like the statistical language environment R and the programming language Python have empowered more asset management firms to build such systems in-house. The availability of cloud-based resources has meant that such investment houses do not need to maintain expensive IT solutions in-house, but have access to computing power on as-needed basis for nominal fees. The availability of open-source customizable software for statistical analysis and optimization has also meant that investment management companies have cheap flexible solutions to implementing portfolio rebalancing and trading routines that they consider important even if such solutions are not the industry norm and are not prebuilt by portfolio analytics vendors.

Some companies have moved in to fill intermediary roles. For example, companies such as Xignite that provide financial market data on demand fill the gap between the data layer and the modeling layer. Xignite itself uses the Amazon cloud for delivery of real-time financial information with minimal waste of computing and network resources. Vichara Technologies, a company that specializes in providing technology solutions to institutional capital market participants, uses the cloud to help banks, dealers, portfolio managers, issuers, and technology firms to develop platforms for trading decision support, portfolio management, risk management, securitization, data management and analysis, trading operations, and e-finance. These systems are used to manage multibillion-dollar positions and all aspects of risks.

Large companies that can otherwise provide complete portfolio analytics solutions also take advantage of cloud-based resources. As an example, IBM Algorithmics offers its clients a componentized framework for assessing

portfolio risk that generates scenarios for various factors, uses a list of products provided by their clients, and estimates the risk in a particular client's portfolio based on the combination of the factors in the product list provided by the client. The scenario generation, or simulation piece can be done remotely at IBM instead of the client site using the IBM SmartCloud. This allows for computationally intensive pieces of the risk analysis to be run overnight, using scalable technology. Cloud-based solutions have been offered by Algorithmics since 2006–2007, and IBM's purchase of Algorithmics has made the integration of IBM SmartCloud and Algo portfolio risk management tools smoother and easier.

1.5 OUTLINE OF TOPICS COVERED IN THE BOOK

This book is organized as follows. Part One (Chapters 2–4) lays the statistical foundation for a variety of concepts used in portfolio allocation and risk measurement and decomposition. Part Two (Chapters 5–7) provides background on important modeling techniques such as simulation (used for risk estimation) and optimization (used in portfolio allocation algorithms). Part Three (Chapters 8–10) introduces the classical underpinnings of Modern Portfolio Theory as well as recent developments in portfolio allocation schemes. Parts Four (Chapters 11–12) and Five (Chapters 13–15) provide an overview and practical examples of equity portfolio construction and fixed income portfolio construction, respectively. Part Six (Chapters 16–18) describes the use of financial derivatives for portfolio risk management and return enhancement strategies. Appendix A contains basic linear algebra concepts necessary to understand some of the statistical and optimization formulations in the book. Analytical concepts and techniques are weaved throughout the book.

Many examples are constructed using Microsoft Excel and the open-source modeling language R. There are a variety of online resources for learning both. The R community is very active, and the website www.r-project.org is a wonderful resource for both beginners and advanced users of the software. We attempt to provide enough references to software functions and libraries that can help the reader reconstruct the examples in the book.

We begin by outlining statistical concepts that are critical for representation of risk and return in Chapter 2. We explain the concept of probability distribution, probability mass (density) function and cumulative probability distribution, as well as metrics for summarizing a probability distribution's central tendency (mean, median, mode), variability (variance, standard deviation, coefficient of variation, percentiles), skew (how asymmetric it is), and kurtosis (how "fat" its tails are). We introduce

two important risk measures for portfolio management, value-at-risk and conditional value-at-risk, show how they relate to statistical measures of variability, and explain how they are estimated from data. In the remainder of the chapter, we discuss modeling dependency (correlation, covariance, copula functions), sums of random variables, and concepts from statistical inference such as hypothesis testing (necessary for understanding the concepts in the asset price forecasting and risk estimation chapters), bootstrapping, and confidence intervals.

Chapter 3 reviews observed characteristics of financial return data and introduces important probability distributions that are used for modeling financial returns for the purpose of portfolio risk measurement. We discuss the families of elliptic, stable Paretian and generalized lambda distributions, as well as the families of generalized extreme value distributions and generalized Pareto distributions. The latter two families are used in the context of modeling extreme portfolio risk, also referred to as “risk in the tail.”¹⁴

Chapter 4 takes a different approach to representing observed characteristics of financial return data: it introduces several statistical estimation models that help explain these characteristics by identifying factors that contribute to financial performance and, in some cases, incorporating dynamics in these factors. Regression, factor models, principal component analysis, and ARCH/GARCH models are explained on an intuitive level with examples.

Chapter 5 moves the discussion from statistical modeling to simulation modeling. It illustrates the main idea behind simulation with an extensive example that also demonstrates how the statistical concepts from the preceding chapters aid the construction of simulation models, the interpretation of simulation output, and the decision making of a risk manager when there is uncertainty.

Chapter 6 provides a practical introduction to optimization, a technique with many applications that in the context of portfolio construction is used for determining optimal portfolio allocation and rebalancing strategies. We elaborate on the concept of “difficult” versus “easy” optimization problems and describe intuitively how optimization algorithms work. An illustration of a simple portfolio allocation problem that can be handled with optimization is provided, and its implementation with spreadsheet optimization software (Excel Solver) is outlined.

¹⁴Most undergraduate students and MBA students take a general course in statistics; however, the coverage in such courses is for business students in general. Our motivation for covering the topics in this chapter is that we have observed a need to cover the special statistical properties that have been identified for return distributions of importance in financial modeling in particular.

Classical optimization methods treat the inputs to optimization problems as deterministic and accurate. In reality, however, these inputs are estimated through error-prone statistical procedures or based on subjective evaluation, resulting in estimates with significant estimation errors. Chapter 7 provides a taxonomy of methods for optimization when the input parameters are uncertain. We review the main ideas behind dynamic programming, stochastic programming, and robust optimization, and illustrate the techniques with examples.

Chapter 8 uses the concept of optimization to introduce the mean-variance portfolio optimization framework, which was the first practical analytical framework for portfolio allocation. The mean-variance portfolio model quantified the idea of risk and presented an argument for diversification (that is, distributing the risk) of investments, which is widely accepted in the investment industry. We present an alternative framework for optimization decision making in investments—expected utility maximization—and also discuss recent work in redefining the concept of diversification.

Chapter 9 explains factor models—statistical models that link asset returns to the returns of underlying factors—that were originally suggested as a way to improve the computational properties of the mean-variance optimization framework described in Chapter 8, and now provide the basis for portfolio risk decomposition schemes and new investment strategies. We discuss practical aspects of the construction and selection of factor models in industry, as well as issues with the data used for the estimation of the models.

Chapter 10 builds on concepts from Chapter 8 to introduce portfolio management relative to a benchmark and a range of analytical concepts that come with it, including risk measurement relative to a benchmark and benchmark construction. Concepts from Chapter 9 are used to explain how benchmark construction can be enhanced by taking into consideration factors, and the reader is introduced to a range of what is popularly known as “smart beta” investment strategies.

Chapter 11 reviews recent advances in quantitative equity portfolio management, including common constraints in portfolio optimization and the use of two important risk measures (value-at-risk and conditional value-at-risk) as an objective. We also show how the classical framework for equity portfolio optimization can be extended to include transaction costs and taxes, optimization of trades across multiple client accounts, and robust statistical, simulation, and optimization techniques to minimize the effect of estimation errors in the inputs to portfolio optimization routines.

Chapter 12 continues the discussion of the use of analytics for equity portfolio management from Chapter 11 but focuses specifically on the application of factor models. It lists several important groups of equity factors, shows how to incorporate such factors in stock screens, and provides a detailed example of portfolio risk decomposition, stress testing, performance evaluation, and risk forecasting with simulation.

Chapter 13 introduces fundamental concepts and terminology for fixed income portfolio management in practice. We review the sectors of the bond market, basics of fixed income analytics (yield, duration, convexity) and major sources of risk for bond investors, concluding with a description of the spectrum of bond portfolio strategies.

Chapter 14 integrates the concepts from Chapter 13 in a real-world example of fixed income portfolio construction and risk decomposition using factor models. It also discusses the most common factors used in fixed income portfolio management, and outlines analytical approaches to fixed income portfolio construction and rebalancing.

Chapter 15 focuses on the management of funds to satisfy contractual liabilities. We describe the spectrum of liability-driven investment strategies and discuss strategies used by two major types of institutional investors: life insurance companies and defined benefit pension plans. We provide explicit examples of the use of statistical, simulation, and optimization techniques in the context of asset-liability management.

No discussion of portfolio construction is complete without mentioning derivatives—financial instruments portfolio managers can use for risk management, cost management, and return enhancement purposes. The last three chapters of the book are dedicated to this topic. While the analytics of derivative instruments can be very complex, we keep the discussion at a practical, intuitive level, and wherever appropriate mention how the advanced statistical and modeling techniques from Parts One and Two of the book can be applied for the estimation of risk metrics and important ratios related to the use of derivatives in portfolio construction and management.

Chapter 16 is an introduction to the topic of financial derivatives. It lists the three main classes of financial derivative contracts (futures and forwards, options, and swaps), describes their risk/return characteristics, and outlines approaches for finding the fair prices of such contracts, including the basic model for pricing a futures contract, the Black-Scholes formula for European options, and binomial trees.

Chapters 17 and 18 focus on the applications of derivatives in equity and fixed income portfolio management, respectively. We describe the types of derivatives used for different purposes in each application, and demonstrate some of the difficulties of implementing strategies involving derivatives.

Summary

- In most developed countries, the four major asset classes are (1) common stocks, (2) bonds, (3) cash equivalents, and (4) real estate.
- The asset allocation decision is how to allocate assets among asset classes.
- A company's market capitalization (or simply market cap) is the total market value of its common stock outstanding.
- The two principal characteristics of what are referred to as "value" companies are that they trade at a low multiple relative to earnings and that they trade at a low price relative to their book value.
- U.S. fixed income securities are classified into the following sectors: (1) U.S. government bonds, (2) corporate bonds, (3) U.S. municipal bonds (i.e., state and local bonds), (4) residential mortgage-backed securities, (5) commercial mortgage-backed securities, and (6) asset-backed securities.
- The portfolio management process includes the following activities: (1) the investor's objectives, preferences, and constraints are identified and specified to develop explicit investment policies; (2) strategies are developed and implemented through the choice of optimal combinations of assets in the marketplace; (3) market conditions, relative asset values, and the investor's circumstances are monitored; and (4) portfolio adjustments are made as appropriate to reflect significant changes in any or all of the relevant variables.
- Investment objectives of institutional investors fall into one of the following two broad categories: nonliability-driven objectives and liability-driven objectives.
- A liability is a cash outlay that must be made at a specific future date in order to satisfy the contractual terms of an obligation.
- An active portfolio strategy uses available information and forecasting techniques to seek a superior performance. These strategies are often referred to as alpha strategies, where for historical reasons the term "alpha" refers to the return realized in excess of the return offered by the market.
- A passive portfolio strategy relies on diversification to match the performance of some benchmark. Passive portfolio strategies are also referred to as "indexing" since the benchmark is typically some market index. These strategies are also referred to as "beta strategies" where for historical reasons the term *beta* refers to the risk a well-diversified portfolio (such as an indexed portfolio) faces relative to a market index.
- The decomposition of the performance results to explain why those results were achieved is called return attribution analysis.

- Portfolio rebalancing is the adjustment in portfolio holdings at predetermined intervals or when market conditions change.
 - Traditional and quantitative portfolio managers can be differentiated by how they use information to select potential candidate securities.
 - Portfolio analytics is applied to several aspects of the portfolio management process: (1) market analytics (analysis of real-time market data, prices, financials, earnings estimates, market research reports); (2) financial screening: selection of investments of interest based on pre-specified financial and nonfinancial criteria; (3) quantitative modeling: asset allocation and trading models; and (4) financial analytics: performance evaluation, characteristics and attribution, risk measurement, asset allocation/asset-liability analysis.
 - Systems for portfolio analytics typically have four components: (1) data sources, (2) data warehousing, (3) modeling, and (4) visualization.
 - Market analytics is aided by visualizations that help identify momentum in the movement of securities or sectors. A variety of new tools such as text analytics exist for capturing market information as soon as it becomes available so that investors can take advantage of it quickly.
 - In the process of financial screening of investments, portfolio managers often take advantage of data on company fundamentals and statistical methods for ranking companies and forecasting returns.
 - Asset allocation models and portfolio rebalancing schemes sometimes rely on the application of optimization tools.
 - In evaluating an investment strategy on historical data—a process referred to as backtesting—a portfolio manager needs to be aware of backtest overfitting and selection bias issues.
 - Commonly used metrics of portfolio performance include portfolio return, variability of the portfolio return, tracking error, CAPM beta, alpha, Sharpe ratio, information ratio, maximum drawdown, and Calmar ratio.
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